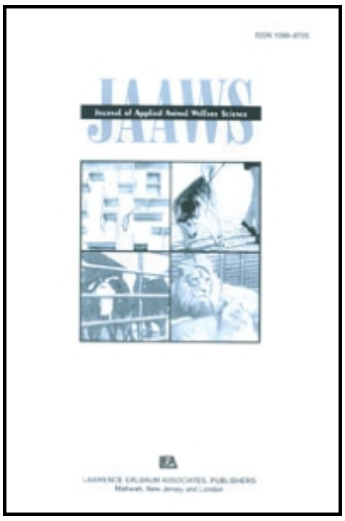

Journal of Applied Animal Welfare Science
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t775648083

The Sizes of Elephant Groups in Zoos: Implications for Elephant Welfare

Paul A. Rees [a]
[a] School of Environment & Life Sciences, University of Salford, United Kingdom

Online Publication Date: 01 January 2009

To cite this Article Rees, Paul A.(2009)'The Sizes of Elephant Groups in Zoos: Implications for Elephant Welfare',Journal of Applied Animal Welfare Science,12:1,44 — 60
To link to this Article: DOI: 10.1080/10888700802536699
URL: http://dx.doi.org/10.1080/10888700802536699

JOURNAL OF APPLIED ANIMAL WELFARE SCIENCE, *12*:44–60, 2009

ISSN: 1088-8705 print/1532-7604 online
DOI: 10.1080/10888700802536699

The Sizes of Elephant Groups in Zoos: Implications for Elephant Welfare

Paul A. Rees
School of Environment & Life Sciences, University of Salford, United Kingdom

This study examined the distribution of 495 Asian elephants (*Elephas maximus*) and 336 African elephants (*Loxodonta africana*) in 194 zoos, most of which were located in Europe (49.1%) and North America (32.6%). Cows outnumbered bulls 4 to 1 (*Loxodonta*) and 3 to 1 (*Elephas*). Groups contained 7 or fewer: mean, 4.28 ($\sigma = 5.73$). One fifth of elephants lived alone or with one conspecific. Forty-six elephants (5.5%) had no conspecific. Many zoos ignore minimum group sizes of regional zoo association guidelines. The American Zoo and Aquarium Association recommends that breeding facilities keep herds of 6 to 12 elephants. The British and Irish Association of Zoos and Aquariums recommends keeping together at least 4 cows over 2 years old. Over 69% Asian and 80% African cow groups—including those under 2 years—consisted of fewer than 4 individuals. Recently, Europe and North America have made progress with some zoos no longer keeping elephants and with others investing in improved facilities and forming larger herds. The welfare of individual elephants should outweigh all other considerations; zoos should urgently seek to integrate small groups into larger herds.

Previous studies of elephants in the zoo populations have been concerned with population management and the assessment of their possible future contribution to conservation (Rees, 2003a; Wiese, 2000; Wiese & Willis, 2006). In spite of recent developments in artificial insemination (Hodgkins,

Correspondence should be sent to Paul A. Rees, School of Environment & Life Sciences and Research Institute for the Built and Human Environment, Peel Building, University of Salford, Salford, Greater Manchester, UK, M5 4WT. Email: p.a.rees@salford.ac.uk

2000; Schmitt, 1998), improved neonatal survival rates, and the demonstration that the life span and longevity of zoo elephants are comparable to those of elephants in the wild (Wiese & Willis, 2004), studies have generally concluded that zoo elephant populations are not self-sustaining, except perhaps the African (*Loxodonta africana*) population in North America (Olson & Wiese, 2000).

The survival of Asian elephants (*Elephas maximus*) in zoos will probably depend upon the importation of additional individuals from range states, but there has been considerable opposition to this (Hedges, Tyson, Sitompul, & Hammatt, 2006). Although the demographic characteristics of zoo elephant populations have been studied in detail, there has been little consideration of the welfare implications of keeping small social groups in captivity.

Almost 25 years ago, Eltringham (1984) suggested that zoos—to achieve self-sustaining populations of elephants—would have to establish large breeding groups and that this would require a specialized approach more like ranching than zookeeping. Such groups would have a higher conservation value than small groups and the potential to improve the welfare of elephants in the zoo. Unfortunately, the zoo community has been slow to respond.

The complex nature of the family relationships that exist within elephant populations has been well known from anecdotal evidence for 50 years (Carrington, 1958; Williams, 1951) and from the work of field scientists for more than 30 years (Douglas-Hamilton & Douglas-Hamilton, 1978; Laws, Parker, & Johnstone, 1975; McKay, 1973). Elephants live in family groups, led by a matriarch and comprised of related adult cows and their offspring. These groups are visited by adult bulls who spend much of their time alone or in bachelor groups, except when in musth (Sukumar, 2003).

In spite of this well-established knowledge, many zoos have traditionally kept elephants in solitary conditions or in small groups. There has been considerable recent concern about the conditions in which elephants are kept in zoos (Clubb & Mason, 2002). Although it has been argued that some welfare compromises are essential if captive breeding programs are to succeed (Rees, 2003b), nevertheless, a number of zoos have stopped keeping elephants and transferred their animals to larger groups, notably in North America and Europe.

This study examines the social structure of the global zoo populations of African and Asian elephants and considers the extent to which elephants are currently being held alone and in inappropriate social groups.

METHODS

Data on the number of elephants kept by zoos were taken from the database held by the International Species Information System (ISIS). This database contains

details of the animals kept by almost 650 member institutions from more than 70 countries. Most of the elephant records held by ISIS relate to traditional zoological gardens and safari parks. The terms "zoo" and "ISIS zoo" are used here to refer to any institution listed by ISIS.

Although there are other sources of information on captive elephants, such as regional studbooks, they do not cover all countries. The ISIS database is a "live" database; although it does not contain data on all zoos, it was considered a reliable record of major zoo holdings at a fixed point in time.

This study analyzes data on the holdings of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants at 194 zoos on October 27, 2006 (Anonymous, 2006a, 2006b). The ISIS records for African elephants recognized four subspecies: *Loxodonta africana africana, L. a. knochenhaueri, L. a. oxyotis*, and *L. a. cyclotis*. This last group has recently been reclassified as the separate species *L. cyclotis* and was represented by a single individual. Records for Asian elephants recognized four subspecies: *Elephas maximus maximus, E. m. indicus, E. m. hirsutus*, and *E. m. sumatranus*. Data for all subspecies have been concatenated so that they represent the two species *L. africana* and *E. maximus*. Data collected from the ISIS database in 1999 for *Elephas* (Rees, 2001a) have been compared with the October 2006 data for this species.

The ISIS database recorded individuals as male, female, and unknown (in relation to sex). The ages of individuals were not recorded. Some of the following analysis assumes that each zoo held its elephants as a single group, including those that kept both species.

RESULTS

The Global Distribution of Zoos Holding Elephants

At the end of October 2006, a total of 194 zoos recorded by ISIS held 831 elephants (including 3 of unspecified sex). A total of 104 zoos held African elephants, and 114 zoos held Asian elephants. Most zoos that held elephants either kept the Asian species only (90 zoos) or the African species only (80 zoos). Twenty-four zoos (12.4%) kept both species.

Most of the zoos holding elephants were located in North America or Europe. A higher proportion of the zoos holding African elephants were located in North America (51.0%) than in Europe (40.4%). This situation was reversed for zoos holding Asian elephants, with 47.4% of zoos in Europe and 38.6% in North America. The remaining zoos were distributed across Central America, South America, Australasia, and Southeast Asia (particularly important for the Asian species) with only *Loxodonta* in the listed African zoos (Table 1).

TABLE 1
The Global Distribution of ISIS Zoos Holding Elephants (Anonymous, 2006a, 2006b)

	Loxodonta africana		*Elephas maximus*	
Region	*Zoos*	*%*	*Zoos*	*%*
Europe	42	40.4	54	47.4
North America	53	51.0	44	38.6
Africa	2	1.9	0	0.0
Central America	2	1.9	2	1.8
South America	2	1.9	1	0.9
Southeast Asia	2	1.9	8	7.0
Australia	1	1.0	5	4.4
Total	104	100	114	100

The Global Distribution of Zoo Elephants

Most zoo elephants (81.7%) were located in Europe (49.1%) and North America (32.6%). European and North American zoos held similar numbers of African elephants (167 and 147, respectively, representing 93.5% of the total for this species), but European zoos alone held 48.7% of all Asian elephants. Most of the remaining Asian elephants (Table 2, Figure 1) were held by zoos in North America (25.1%) and Southeast Asia (21.6%).

TABLE 2
The Global Distribution of Elephants in ISIS Zoos (Anonymous, 2006a, 2006b)

	Loxodonta africana			*Elephas maximus*		
Region	*Bulls*	*Cows*	*Sex Ratio*	*Bulls*	*Cows*	*Sex Ratio*
Europe	40	126	1:3.15	51	188	1:3.69
North America	22	125	1:5.68	23	101	1:4.39
Africa	2	4	1:2.00	0	0	—
Central America	1	3	1:3.00	0	4	0:4.00
South America	1	1	1:1.00	1	0	1:0
Southeast Asia	2	5	1:2.50	40	67	1:1.68
Australasia	0	3	0:3.00	4	14	1:3.50
Totals	68	267	1:3.93	119	374	1:3.14
		335[a]			493[b]	
			828			

[a]One *Loxodonta* specimen whose sex was not recorded omitted. [b]Two *Elephas* specimens whose sex was not recorded omitted.

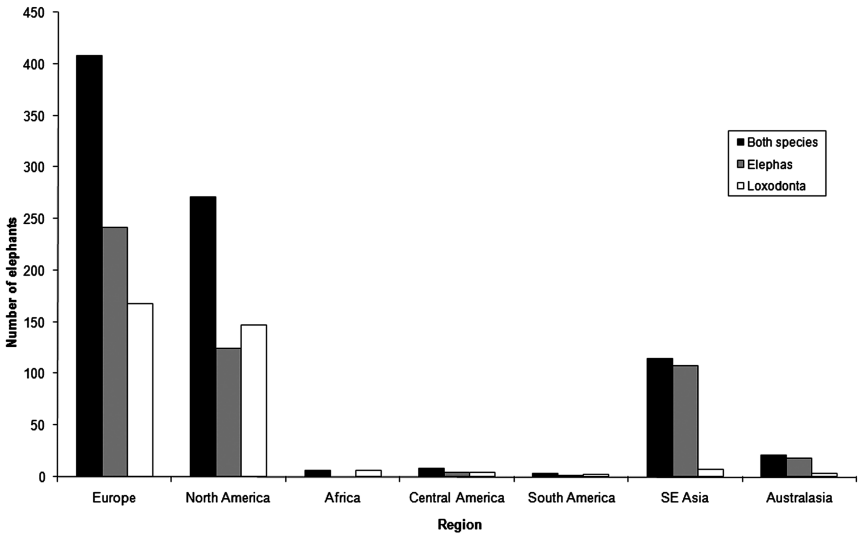

FIGURE 1 Geographical distribution of individual zoo elephants.

Colombo Zoo, Sri Lanka, held 1 African and 69 Asian elephants. Most of these animals were kept at the Pinnewela Elephant Orphanage (some distance from the zoo itself), where they were able to associate in a large group. This group of Asian elephants has been excluded from some of the following analysis because it represents almost 14% of the total number of this species in the study and therefore distorts the overall distribution.

Sex Ratio and Group Composition

Cow zoo elephants outnumbered bulls by almost four to one in *Loxondata* and approximately three to one in *Elephas*. The sex ratio varied considerably on a regional basis, but almost all regions possessed more cows than bulls (Table 2). Five (4.4%) of the 114 zoos holding *Elephas* kept only bulls, 60 (52.6%) kept only cows, and 49 (43.0%) kept both sexes. One zoo kept a single specimen of *Elephas* of unrecorded sex. Overall, 54 zoos (47.4%) kept bulls; 109 zoos (95.6%) kept cows.

Forty-eight (46.2%) of the 104 zoos holding *Loxodonta* kept bulls and 102 (98.1%) kept cows. Two zoos kept only bulls (1.9%), 56 (53.8%) kept only cows, and 46 (44.2%) kept both sexes.

The mean number of bull African elephants held by each zoo ($N = 104$) holding this species was 0.65, ($\sigma = 0.90$), and the mean number of cows was

2.57 ($\sigma = 1.76$). Zoos that kept Asian elephants ($N = 114$) held a mean of 1.04 bulls ($\sigma = 2.85$) and 3.28 cows ($\sigma = 4.14$).

The modal number of elephants kept, for both *Elephas* and *Loxodonta*, was zero bulls and two cows. If zoos that do not keep bulls are excluded, the modal number of bulls was one for both species.

The Distribution of Group Sizes

Most group sizes were small, between 1 and 7 (Figure 2); the mean group size was 4.28 ($\sigma = 5.73$), including mixed-species groups, and ranged from 1 to 70 individuals (Colombo Zoo). There was no statistically significant difference between the group sizes of Asian ($\overline{x} = 4.34$, $\sigma = 6.83$) and African ($\overline{x} = 3.23$, $\sigma = 2.41$) elephants ($t = 1.630$, $df = 216$, two-tailed, $p > .10$). More than 69% of Asian elephant cow groups and more than 80% of African elephant cow groups consisted of fewer than 4 individuals (Figure 3).

The Distribution of Elephants Between Groups

Almost half of Asian elephants (47.9%) and 62.8% of African elephants were held in groups of five or fewer individuals of the same species. When herds of mixed species are considered, 52.6 % of all elephants were kept in groups of five or fewer individuals of either the same species or in a mixed-species herd (Figure 4).

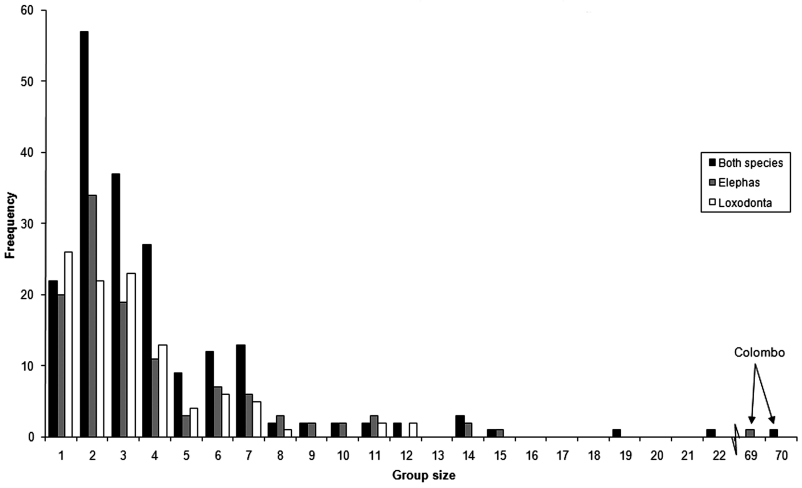

FIGURE 2 Distribution of elephant group sizes. *Note:* The column labeled "both species" indicates the frequency of group sizes when multi-species groups are included.

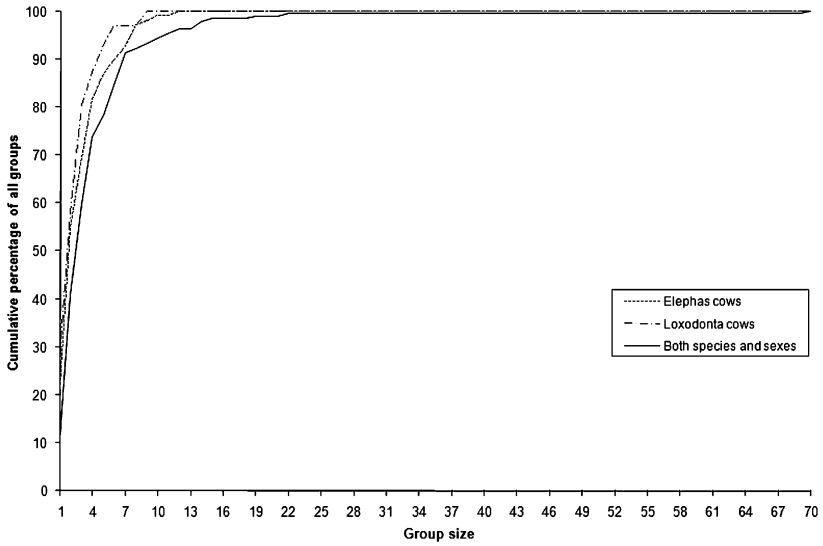

FIGURE 3 Percentage cumulative frequency distribution of elephant group sizes. *Elephas* and *Loxodonta* lines include only zoos that held cows of these species. The line labeled "Both" includes all groups (single and multi-species) and both sexes.

The Global Distribution of Solitary Zoo Elephants

Twenty zoos held a single Asian elephant (4 bulls, 16 cows); 26 zoos held a single African elephant (2 bulls, 24 cows), some of whom had companions of a different elephant species. When these companions are taken into account, only 22 zoos (11.3%) kept lone elephants: 1 bull and 12 cows of *Loxodonta* and 2 bulls and 7 cows of *Elephas*. Nineteen (86.4%) of these solitary elephants were located in Europe and North America.

Almost one fifth of all elephants were kept alone or with a single companion of the same species. Forty-six elephants (5.5%) were being kept without any companion of the same species and 112 (13.5%) with a single conspecific companion. When companions of either species are taken into account, the number of elephants considered to be kept alone approximately halved to 22 individuals; 114 were kept with a single companion of either species.

Changes in the Zoo Asian Elephant Population Between 1999 and 2006

The number of ISIS zoos holding Asian elephants fell from 135 in 1999 to 114 in 2006, a decrease of 15.6%. There was no statistically significant change in

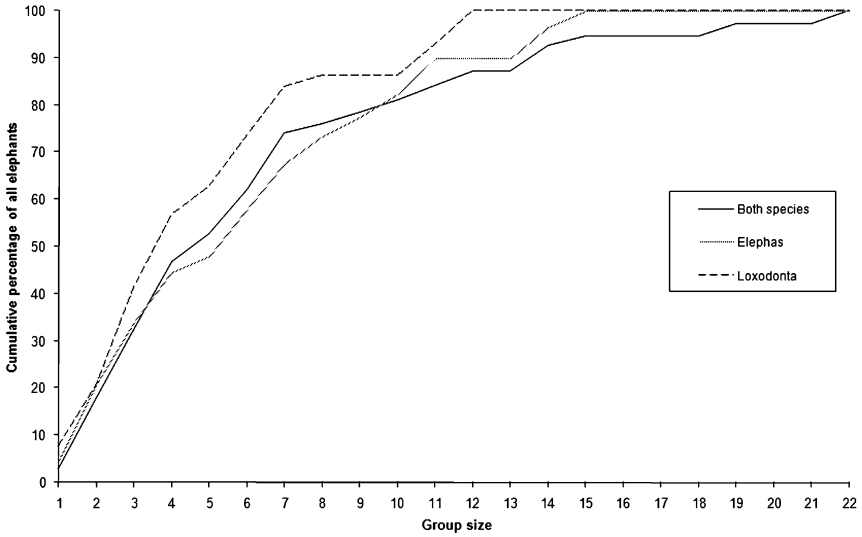

FIGURE 4 Percentage cumulative frequency distribution of elephants within different group sizes. All lines exclude Colombo Zoo.

the mean group size between 1999 ($\overline{x} = 3.56$, $\sigma = 2.95$) and 2006 ($\overline{x} = 4.34$, $\sigma = 6.83$) ($t = 1.13$, $df = 247$, two-tailed, $p > .10$). There was little change in the distribution of group sizes between 1999 and 2006 (Figure 5). However, the cumulative frequency curve for 2006 (Figure 6) is located slightly to the right of that for 1999 and suggests a trend toward increased group sizes. There was a decrease in the number of zoos holding just 1 or 2 elephants (Figure 7). In 1999, the three largest herds each consisted of 15 animals. By 2006, the largest herd contained 69 animals (Colombo Zoo); however, only one of the herds of 15 remained.

Between 1999 and 2006, the total number of Asian elephants increased by about 3% (from 481 to 495). However, the proportion of bulls increased from 18.1% in 1999 to 24.0% in 2006 (from 87 to 119 individuals).

DISCUSSION

This study examined the distribution of 495 Asian elephants and 336 African elephants living in 194 zoos in October 2006. Most of these animals were in zoos in Europe (49.1%) and North America (32.6%). Cow zoo elephants outnumbered bulls by almost four to one in *Loxodonta* and approximately three to one in *Elephas*. Most group sizes were small (between one and seven) with a

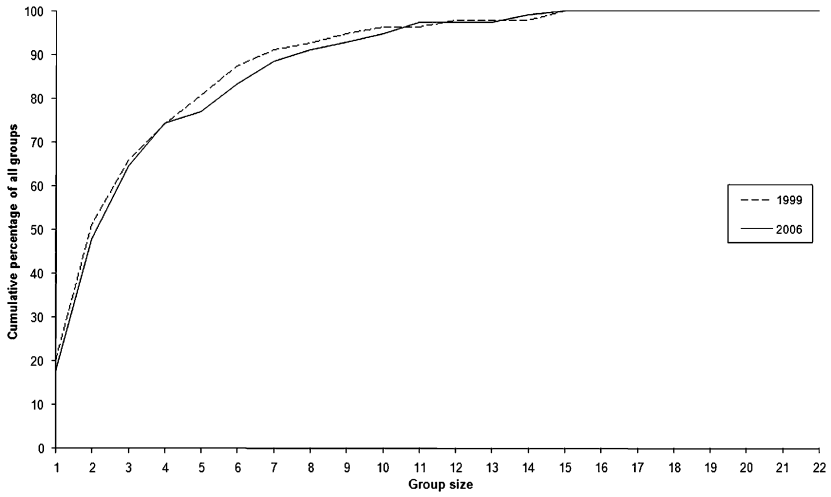

FIGURE 5 Percentage cumulative frequency distribution of Asian elephant group sizes (1999 and 2006). Colombo Zoo excluded from 2006 data.

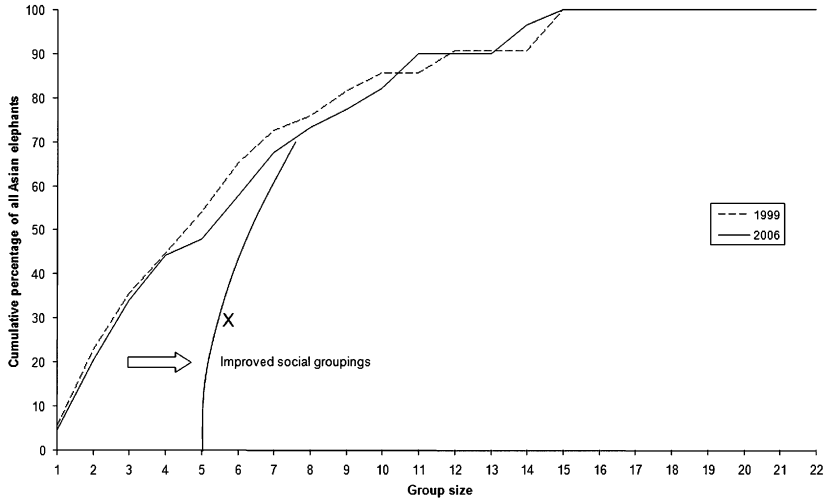

FIGURE 6 Percentage cumulative frequency distribution of Asian elephants within different group sizes. Line X indicates the approximate position the curve might occupy if a minimum group size of five is achieved.

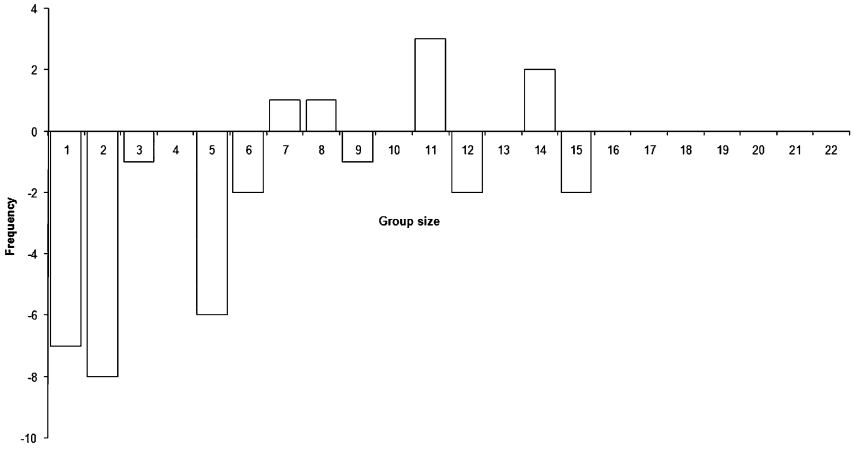

FIGURE 7 Change in Asian elephant group size distribution, 1999–2006. Excludes Colombo Zoo.

mean of 4.28 ($\sigma = 5.73$), including mixed-species groups; 19% of all elephants were kept alone or with a single companion of the same species. Forty-six elephants (5.5%) were being kept without any companion of the same species.

Modern zoos attempt to enrich the environments of their elephants with a variety of techniques and devices, many of which involve encouraging exploratory or feeding behavior (Gilbert, 1994; Green, 1993; Haight, 1993). However, interaction with other elephants provides the single most significant form of enrichment to the lives of those animals kept in appropriately structured social groups (Rees, 2000).

In the wild, elephant social structure is complex. Laws et al. (1975) suggested that the largest stable population unit (or the smallest discrete unit) averaged 5–6 elephants in Murchison Falls Park, South in Uganda. The mean group size recorded was 11.6 (range 2–29). Although the basic family unit has an average of 3 members consisting of a cow and her 1–2 offspring (Spinage, 1994), huge megaherds of several hundred and up to 1,000 individuals have been observed in Africa (Laws et al., 1975).

Asian elephants live in family groups that typically contain one adult cow and between one and five immature offspring (Sukumar, 1994). Larger groups may contain two or more adult cows. Groups sometimes contain three generations.

A group of elephants with more than one adult cow has been called an "extended family unit" (Douglas-Hamilton & Douglas-Hamilton, 1978) or a "joint family" (Sukumar, 1994). Larger groups of related animals have been called "kin groups" (Douglas-Hamilton & Douglas-Hamilton, 1978) or "bond

groups" (Moss, 1988), the latter term not necessarily implying relatedness. Moss and Poole (1983) have described a multitiered network of relationships within the elephants in Amboseli—the population being divided into subpopulations that are further divided into clans, then bond groups, family units, and mother-offspring units. The complexity and flexibility of elephant social organization in the wild have been discussed at length by Sukumar (2003).

For the purposes of comparing the size of elephant groups in European zoos with those found in the wild, Clubb and Mason (2002) suggested that cow elephants form stable groups of between 6 and 8 animals in the Asian species, on average, and between 4 and 12 in the African species. However, Hutchins (2006) has argued against using "nature" as a yardstick for measuring the adequacy of zoo management because elephant society is highly variable with regard to group size and composition and adapts to prevailing environmental conditions, such as food supply. He suggests that—if elephants are exhibiting a broad range of natural behaviors and not showing high levels of aggression, agitation, lethargy, or stereotypic movements—it might be reasonable to conclude that their social needs were being met, regardless of group size. Nevertheless, he concedes that it is unacceptable to keep adult cows alone or in pairs.

Approximately 48% of all elephants in zoos are currently kept in social groups of 5 or fewer animals (regardless of species composition). The larger we assume the normal group size of wild elephant families to be, the greater the number of zoos that will fail to achieve this. Almost 60% of zoos fail to achieve a group size of 4 animals (of single or mixed species); this rises to about 91% if the group size is 8 and to more than 95% if it is 12.

The European Endangered Species Programme (EEP), Species Survival Plan (SSP) in North America, and Australian Species Management Program (ASMP) recommend keeping elephants—as far as possible—in matriarchal intact family groups (Conservation Breeding Specialist Group, 2004; European Association of Zoos and Aquaria, 2004; Lees, 2004). In 2001, the American Zoo and Aquarium Association (AZA) recommended that institutions should hold at least three cows (AZA, 2001). At a meeting held in January 2005, the Elephant Directors of AZA institutions agreed that breeding facilities should strive to hold 6 to 12 elephants, with capabilities for 2 or more bulls, and that holding facilities should strive to maintain 2 to 6 elephants, with capabilities for all bulls (Reed, 2005).

Clubb and Mason (2002) found that 61.1% of European zoos holding Asian elephants kept three individuals or fewer (in 1999) and that 59.5% of zoos holding African elephants housed four elephants or fewer (in 2001). In 2006, 64.0% of ISIS zoos held three or fewer Asian elephants and 80.8% of zoos held four or fewer African elephants.

The British and Irish Association of Zoos and Aquariums recommends that cows should be kept in groups of at least four animals more than 2 years old (Stevenson & Walter, 2002). This analysis has shown that over 69% of Asian

elephant cow groups and 80% of African elephant cow groups (including animals under 2 years) consisted of fewer than four individuals (Figure 3).

Zoos' elephant groups often consist of unrelated individuals. This is because they have originated from a number of different sources, including logging camps, other zoos, circuses, and the wild. Because of the risk of inbreeding, zoos do not generally keep several generations together; in any event, relatively few herds contain second-generation offspring bred in captivity.

In a zoo environment, the keeping of related animals together is a lower priority than moving them between institutions for breeding purposes. However, the formation of groupings of unrelated individuals is preferable to the keeping of elephants alone or in very small groups. Even unrelated individuals may form strong bonds. Friendships are important to elephants, and there is evidence that they form special relationships with particular individuals in zoos (Garai, 1992). Allomothering is well known in elephants in the wild (Lee, 1987) and is generally considered to involve close relatives of the mother. However, it is also important in zoo elephants (Rapaport & Haight, 1987) where both related and unrelated adult cows may act as allomothers (Rees, 2001a).

Contact with members of their own species is important if elephants are to develop normal behaviors. There is some evidence that the development of normal sexual behavior in juvenile bull elephants may depend upon exposure to reproductively active adults (Rees, 2004); when given the opportunity, very young calves show considerable interest in the sexual activity of adults (Rees, 2003c). This is not surprising in animals who are typical *K*-strategists and as such make a large investment in each of their offspring (Southwood, 1981).

Zoo elephant social groups inevitably change due to births and deaths. However, in recent years they have also been changing because some zoos have decided to stop keeping elephants, either following the death of their last individual or because they have taken the decision, on welfare grounds, to move their lone animals or small groups to join elephants in other zoos or in sanctuaries. Such transfers may cause stress to the animals who are moved and to the members of the receiving group; however, there is some evidence that this stress is neither prolonged nor severe (Schmid, Heistermann, Ganslosser, & Hodges, 2001). Sometimes elephants are moved as a result of conflict within a group (Rees, 2001a), and it has been suggested that group compatibility might be more important to elephant welfare than group size (Hutchins, 2006). Veasey (2006) has argued that single young cows should not be moved unless incompatibilities occur and that new herds should be created from a nucleus of trios or more of compatible, related elephants.

In the United Kingdom, London Zoo moved its three Asian elephants to Whipsnade Park in 2001; Dudley Zoo and Longleat Safari Park sent their African elephants to zoos in France in 2003. Zoos in Bristol, Edinburgh, Cricket St. Thomas, and the Welsh Mountain Zoo no longer keep elephants. In the United

States, Detroit Zoo, Frank Buck Zoo (Texas), Mesker Park Zoo (Indiana), Henry Villas Zoo (Wisconsin), Chehaw Wild Animal Park (Georgia), Alaska Zoo, and the Louisiana Purchase Gardens and Zoo all sent their animals to elephant sanctuaries between 1998 and 2007. Sacramento Zoo and San Francisco Zoo no longer keep elephants; others, like the Smithsonian's National Zoological Park, will not replace their remaining elephants. Some of these elephant movements were the result of public pressure; in at least one case (London) elephants were moved following the death of a keeper.

Since the listing of Asian elephants and most populations of African elephants in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973 (Convention on International Trade in Endangered Species of Wild Fauna and Flora), it has become extremely difficult for zoos to obtain elephants from their range states. There is opposition among conservationists to the importation of elephants into nonrange states because the conservation benefits of such movements are unproven (Hedges et al., 2006). However, importation is still considered essential in the short term to increase the reproductive potential of animals in the EEP, SSP, and the ASMP (Hutchins & Keele, 2006; Wiese & Willis, 2006).

Some zoos have invested in new elephant facilities: Chester (England); Köln (Germany); and, in the United States, the North Carolina and Pittsburgh (Pennsylvania) Zoos. These zoos intend to increase the size of their herds (A. Bloomsmith, personal communication, April 20, 2007; Rees, 2001b). The facility at Köln is particularly impressive—with an area of 20,000 m^2—and is designed to hold up to 15 cows and their offspring plus several bulls (Nogge, 2004). In the United States, a number of AZA zoos are planning to upgrade from holding to breeding facilities, creating 8 additional breeding facilities for *Loxodonta* and 12 for *Elephas* (Keele, 2006). These new facilities will undoubtedly deliver welfare benefits to the individual elephants within the enlarged groups and increase their potential to contribute to captive breeding programs. However, the scarcity of suitable animals within the existing worldwide zoo populations will hinder future attempts to form larger elephant groups, and there are significant legal, political, and other barriers to further importation of animals from their range states (Hedges et al., 2006; Hutchins & Keele, 2006).

In spite of the current attempts by some zoos—notably in the United States and Europe—to create larger elephant herds, as yet there is little evidence that zoos intend to establish very large elephant herds managed according to the ranching methods envisaged by Eltringham (1984). However, it has been proposed that regional elephant reserves should be developed in North America particularly to increase zoos' capacities to hold bulls (Keele, 2006).

Very large groups may not be essential for the social welfare needs of elephants, but it remains to be seen if the planned breeding groups of up to 12 animals in AZA zoos will increase reproductive success sufficiently to pro-

duce self-sustaining populations such as those modeled by Faust, Thompson, and Earnhardt (2006) for *Elephas.* Unless reproductive rates increase significantly—which will require significant changes to promote the sociosexual competence of captive elephants—or more animals are imported, zoo elephant populations face global extinction within a few decades (Olson & Wiese, 2000; Rees, 2003a; Wiese, 2000).

A 2005 survey of 78 AZA-accredited zoos with elephants found that 40 zoos planned to expand or build new elephant exhibits (AZA, 2007). However, this transition will be difficult, and it will take time to raise the necessary funds. There are few healthy, reproductively viable elephants available to grow captive herds; in addition, some individuals are incompatible, often due to a history of inadequate care in circuses or substandard zoos. These difficulties are compounded by the poor reproductive performance of zoo elephants. This may be due to the following:

1. Reproductive pathologies in cows (caused by delaying reproduction);
2. Lack of maternal competence;
3. Reproductive suppression;
4. Overnutrition and lack of exercise causing rapid fetal growth and dystocia; and
5. A historical tendency to separate bulls from cows to prevent unwanted male offspring (Hutchins, 2006; Hutchins & Keele, 2006).

Zoos that intend to continue keeping elephants need to be clear about their conservation function. This is far from obvious. Some authorities still consider zoos' elephants a "reservoir for threatened *in-situ* populations" (Faust et al., 2006); however, it is not at all clear that this can be justified in the context of the current decline in zoo populations and their small size compared with the relatively large number of elephants still remaining in the wild. Hutchins and Keele have claimed that *ex-situ* elephant programs can assist field conservation through public education, technology development, training and technology transfer, and fund-raising to support *in-situ* conservation initiatives. This may be true for the best zoos; however, too many elephants are being kept in zoos where their welfare is compromised by their lack of social contacts and their indirect contribution to conservation is negligible.

CONCLUSION

The welfare of elephants in zoos is a legitimate concern of the public, governments, and the zoo community. However, much of the recent concern in Europe has been generated by a report (Clubb & Mason, 2002) that was based on

inaccurate data—including an apparent overestimate of the size of the European elephant population of 17%—and has been highly criticized by the European Elephant Group (Endres et al., 2004). If welfare concerns are to be taken seriously, they must be based on hard evidence, accurate statistics, and appropriate analyses.

Many zoos are failing to comply with the minimum requirements for the sizes of groups of captive elephants recommended by their own regional organizations. The overall position is likely to improve as more zoos invest in new elephant facilities and further movements occur between zoos. Births and future importations of elephants may also have beneficial impacts on group sizes. Individual zoos need to assess their own position carefully and either phase out the keeping of elephants or commit themselves to improving their facilities and increasing elephant group sizes.

ACKNOWLEDGMENTS

This study is based on data collected by the International Species Information System that is made freely available to the public via the Internet. I am grateful to two anonymous reviewers who suggested improvements to an early draft of the manuscript and to Dr. M. A. Bloomsmith (Zoo/Wildlife section editor, *Journal of Applied Animal Welfare Science*) for her helpful comments and guidance.

REFERENCES

American Association of Zoos and Aquariums. (2001). *AZA standards for elephant management and care*. Silver Spring, MD: American Association of Zoos and Aquariums.

American Association of Zoos and Aquariums. (2007). *Top ten AZA elephant success stories: 2005 a banner year for elephants in AZA accredited zoos*. Retrieved April 23, 2007, from http://www.aza.org/Newsroom/PR_Top10ElephStories/

Anonymous. (2006a). *ISIS abstracts:* Elephas maximus. *International species information system*. Retrieved October 27, 2006, from https://app.isis.org/abstracts/abs.asp

Anonymous. (2006b). *ISIS abstracts:* Loxodonta africana. *International species information system*. Retrieved October 27, 2006, from https://app.isis.org/abstracts/abs.asp

Carrington, R. (1958). *Elephants.* London: Chatto & Windus.

Conservation Breeding Specialist Group. (2004). *AZA elephant management strategic planning workshop* (Draft report). Apple Valley, MN: IUCN/SSC Conservation Specialist Group.

Convention on International Trade in Endangered Species of Wild Fauna and Flora. (1973, March 3). Her Majesty's Stationery Office, Treaty Series Nos. 101 (1976), Cmnd.6647.

Clubb, R., & Mason, G. (2002). *A review of the welfare of zoo elephants in Europe. A report commissioned by the RSPCA*. Oxford, UK: University of Oxford, Department of Zoology, Animal Behaviour Research Group.

Douglas-Hamilton, I., & Douglas-Hamilton, O. (1978). *Among the elephants*. Glasgow, UK: William Collins Sons & Co. Ltd.

Eltringham, K. (1984). Elephants in zoos. *Biologist, 31*(2), 108–111.
Endres, J., Haufellner, A., Haufellner, B., Schilfarth, J., Schilfarth, M., & Schweiger, G. (2004). *Documentation 2002: Elephants in European zoos and safari parks. European Elephant Group.* Münster, Germany: Schüling Verlag.
European Association of Zoos and Aquaria. (2004). Revised EAZA elephant TAG recommendations. *EAZA News, 47*, 44.
Faust, L. J., Thompson, S. D., & Earnhardt, J. M. (2006). Is reversing the decline of Asian elephants in North American zoos possible? An individual-based modeling approach. *Zoo Biology, 25*, 201–218.
Garai, M. E. (1992). Special relationships between female Asian elephants *(Elephas maximus)* in zoological gardens. *Ethology, 90*, 197–205.
Gilbert, J. (1994). Elephant feeder balls. *The Shape of Enrichment*, *3*(4), 3–5.
Green, C. (1993). Enriching an elephant's environment. *The Shape of Enrichment, 2*(1), 5–6.
Haight, J. (1993). Playing with their food—Ideas for elephants. *The Shape of Enrichment*, *2*(2), 9.
Hedges, S., Tyson, M. J., Sitompul, A. F., & Hammatt, H. (2006). Why inter-country loans will not help Sumatra's elephants. *Zoo Biology, 25*, 235–246.
Hodgkins, L. D. (2000). *AZA annual report on conservation and science 1997–98 (Vol. II): Member institution conservation and research projects*. Silver Spring, MD: American Zoo and Aquarium Association.
Hutchins, M. (2006). Variation in nature: Its implications for zoo elephant management. *Zoo Biology, 25*, 161–171.
Hutchins, M., & Keele, M. (2006). Elephant importation from range countries: Ethical considerations for accredited zoos. *Zoo Biology, 25*, 219–233.
Keele, M. (2006, February). The future of elephants is upon us. *Communiqué* (American Association of Zoos and Aquariums), 6–8.
Laws, R. M., Parker, I. S. C., & Johnstone, R. C. B. (1975). *Elephants and their habitats. The ecology of elephants in North Bunyoro, Uganda*. Oxford, UK: Clarendon.
Lee, P. C. (1987). Allomothering among African elephants. *Animal Behaviour, 35*, 278–291.
Lees, C. (2004). *Captive management plan for Asian elephant* (Elephas maximus). Sydney, Australia: Australasian Regional Association of Zoological Parks and Aquaria.
McKay, G. M. (1973). Behaviour and ecology of the Asian elephant in southeastern Ceylon. *Smithsonian Contribution to Zoology, 125*, 1–113.
Moss, C. J. (1988). *Elephant memories.* London: Elm Tree Books.
Moss, C. J., & Poole, J. H. (1983). Relationships and social structure of African elephants. In R. A. Hinde (Ed.), *Primate social relationships: An integrated approach* (pp. 315–325). Oxford, UK: Blackwell.
Nogge, G. (2004). Elefanten in Köln [Elephants in Köln]. *Zeitschrift des Kölner Zoo, 47*(3), 95–108.
Olson, D., & Wiese, R. J. (2000). State of the North American African elephant population and projections for the future. *Zoo Biology, 19*, 311–320.
Rapaport, L., & Haight, J. (1987). Some observations regarding allomaternal caretaking among captive Asian elephants (*Elephas maximus*). *Journal of Mammalogy, 68*(2), 438–442.
Reed, M. C. (2005, March). From the president. *Communiqué* (American Association of Zoos and Aquariums), 5.
Rees, P. A. (2000). Are elephant enrichment studies missing the point? *International Zoo News, 47*, 369–371.
Rees, P. A. (2001a). Captive breeding of Asian elephants (*Elephas maximus*): The importance of producing socially competent animals. In B. B. Hosetti & M. Venkateshwarlu (Eds.), *Trends in wildlife biodiversity, conservation and management* (Vol. 1, pp. 76–91). Delhi, India: Daya Publishing House.
Rees, P. A. (2001b) The history of the National Elephant Centre, Chester Zoo. *International Zoo News, 48*, 170–183.

Rees, P. A. (2003a). Asian elephants in zoos face global extinction: Should zoos accept the inevitable? *Oryx, 37*(1), 20–22.

Rees, P. A. (2003b). RSPCA elephant welfare recommendations would compromise captive breeding programmes. *International Zoo News, 50*, 86–90.

Rees, P. A. (2003c). Early sexual experience in the Asian elephant. *International Zoo News, 50*, 200–206.

Rees, P. A. (2004). Some preliminary evidence of the social facilitation of mounting behavior in a juvenile bull Asian elephant (*Elephas maximus*). *Journal of Applied Animal Welfare Science, 7*, 49–58.

Schmid, J., Heistermann, M., Ganslosser, U., & Hodges, J. K. (2001). Introduction of foreign female Asian elephants (*Elephas maximus*) into an existing group: Behavioural reactions and changes in cortisol levels. *Animal Welfare, 10*, 357–372.

Schmitt, D. L. (1998, June). *Report of a successful artificial insemination in an Asian elephant.* Proceedings of the Third International Elephant Research Symposium, Springfield, MO.

Southwood, T. R. E. (1981). Bionomic strategies and population parameters. In R. M. May (Ed.), *Theoretical ecology: Principles and applications* (2nd ed., pp. 30–52). Oxford, UK: Blackwell Scientific Publications.

Spinage, C. (1994). *Elephants*. London: T. & A. D. Poysner Ltd.

Stevenson, M. F., & Walter, O. (2002). *Management guidelines for the welfare of zoo animals: Elephants* Loxodonta africana *and* Elephas maximus. London: British & Irish Association of Zoos & Aquariums, Regent's Park.

Sukumar, R. (1994). *Elephant days and nights: Ten years with the Indian elephant*. Oxford, UK: Oxford University Press.

Sukumar, R. (2003). *The living elephants: Evolutionary ecology, behavior and conservation.* Oxford, UK: Oxford University Press.

Veasey, J. (2006). Concepts in the care and welfare of captive elephants. *International Zoo Yearbook, 40*, 63–79.

Wiese, R. J. (2000). Asian elephants are not self-sustaining in North America. *Zoo Biology, 19*, 299–309.

Wiese, R. J., & Willis, K. (2004). Calculation of longevity and life expectancy in captive elephants. *Zoo Biology, 23*, 365–373.

Wiese, R. J., & Willis, K. (2006). Population management of zoo elephants. *International Zoo Yearbook, 40*, 80–87.

Williams, J. H. (1951). *Elephant Bill*. London: Rupert Hart-Davis.