Age structure of elephants in Liwonde National Park, Malawi

R. BHIMA and J. DU P. BOTHMA

Bhima, R. and J. du P. Bothma. 1997. Age structure of elephants in Liwonde National Park, Malawi. *Koedoe* 40(2): 1–8. Pretoria. ISSN 0075–6458.

The age structure of the elephant population in Liwonde National Park, Malawi was determined for the first time in 1993 and again in 1995 using the photogrammetric method. Sampling was done during a four year-long severe drought from 1991/92 to 1994/95. The drought reached its highest intensity in the first year. Therefore, the study also attempted to assess the impact of the drought on the population. The results show that the population consisted of mostly young animals <5 years old (52.6 % and 44.8 % in 1993 and 1995, respectively). The other age cohorts were as follows: 6–10 years old – 16.1 % and 21.7 %; 11–15 years old – 7.8 % and 9.2 %; 16–20 years old – 5.2 % and 4.7 %; and >20 years old – 18.3 % and 20.5 %. The population is young and growing. The prolonged drought did not have any significant impact on the population.

Key words: Liwonde National Park, Malawi, elephant, *Loxodonta africana*, age structure, drought.

R. Bhima and J. du P. Bothma, Centre for Wildlife Management, University of Pretoria, Pretoria, 0002 Republic of South Africa.* (*To whom correspondence should be addressed. Present address: Department of National Parks and Wildlife, P.O. Box 30131, Lilongwe 3, Malawi).

Introduction

The elephant *Loxodonta africana* population in Liwonde National Park, Malawi, is probably the only one in the country that has grown significantly during the past 20 years. The population has increased from about 200 in 1977 to 400 in 1995 (Bhima *pers. obs.*), representing an increase of 3.6 % per annum. Because of this increase, up-to-date basic information on various population dynamics parameters is necessary for the development and implementation of sound and effective management strategies. This study aims to investigate one such parameter, the age structure.

Age structure is an important parameter in the analysis of population dynamics for several reasons. Not only does it reflect the net fecundity and mortality schedules of a population (Lindeque 1991), but it can also be used as an indicator of population increase. Furthermore, it has value as a basis for comparison between populations in differing environments (Croze 1972). In Tsavo National Park, Kenya, where elephant age structure has been well studied (e.g. Laws 1969; Leuthold 1976; Ottichilo 1986; Poole 1989), its application together with additional criteria has been implemented to study the impacts of drought and poaching pressure, while also being used to formulate proper management strategies. Being such an important basic parameter, this study was firstly conducted to establish a baseline reference for the future, and secondly to assess what impact the 1991/92 drought may have had on the population.

Since Liwonde National Park was established in 1972, the 1991/92 drought was the most serious environmental phenomenon and has been described as the worst in southern Africa in living memory (Hulme *et al.* 1994; Magadza 1994; Zambatis & Biggs 1995). As data for this study were collected

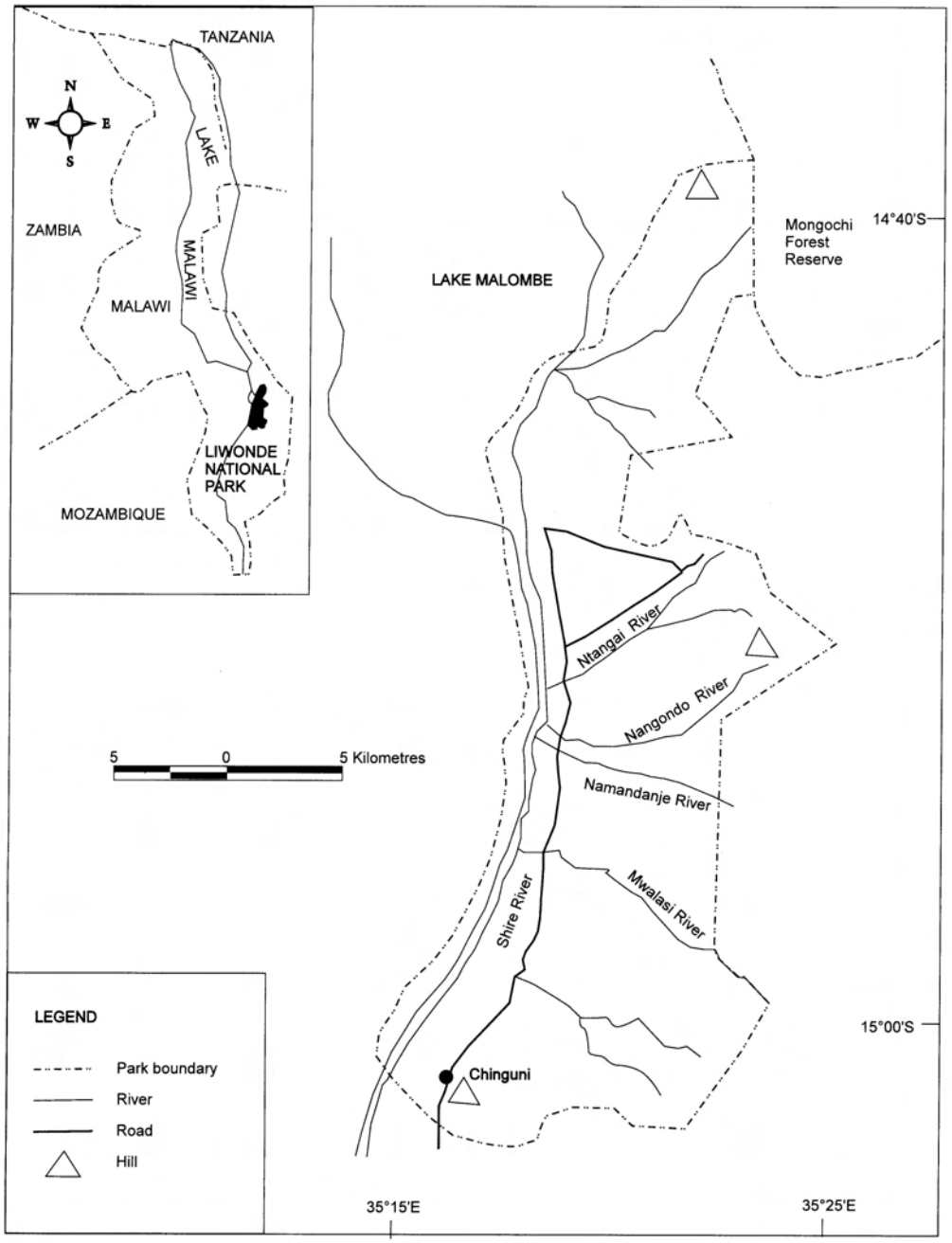

Fig. 1. The Liwonde National Park in Malawi

during the drought period, it was considered imperative to assess the impact of this prolonged drought on the age structure of the resident elephant population of the park. The most vulnerable elephant age cohorts to drought are calves up to 5 years old and old adults 50 years or older (Laws & Parker 1968; Corfield 1973; Leuthold 1976). It was, therefore, hypothesised that in 1995, when the drought was in its fourth year, frequencies of different ages in the 5 year-old or younger age group would generally be lower than in 1993.

Study area

The Liwonde National Park covering 538 km² is located between 14°36'—15°03'S and 35°15'—35°26'E in southern Malawi (Fig. 1). The park is generally a flat, featureless landscape with mean elevation of 500 m above sea level and a mean east-west altitudinal gradient of 4 m/km. The north-south gradient is only 0.015 m/km. The Shire River flows southward along the park's western boundary for about 35 km. It is a dominant physical feature and is the only outlet of Lake Malawi.

The climate is characterised by a distinct dry and wet season. The long-term mean annual rainfall for 18 years (1977–1995) was 998.8 mm, but in 1991/92, the annual rainfall was only 401.1 mm, or 40.2 % of the long-term mean. The subsequent years of 1992/93, 1993/94 and 1994/95 all had rainfall below the long-term mean i.e. 803.8 mm, 637.8 mm and 886.5 mm, respectively. Mean temperature minima and maxima range from 12–28 °C in the cool season (June-July) to 20–41 °C in the hot season (September-October).

The dominant vegetation type of the park is dry, deciduous woodland, the dominant tree being *Colophospermum mopane*. Other vegetation types like grasslands, forest thickets and mixed woodlands and floodplains occupy minor areas. However, the Shire River floodplain which occupies about 4 % of the total surface area is the most preferred habitat for elephants in the dry season (Bhima *pers. obs.*).

Methods

Photogrammetric methods based upon the method by Croze (1972) were used to determine age structures of the population in 1993 and 1995. Croze's method is based on the measurement of the dorsal length between the junction of the ears with the head and the apex of the anal flap. Laws (1969) found this parameter to be the least variable of all possible linear measurements and was "almost exactly equal to the shoulder height". Based on this and a number of weighting assumptions for estimating the sex ratios at various ages, Croze (1972) derived a weighted mean growth-curve for an 'average' breeding herd. From this, values of proportions of the asymptotic limit of growth for different age groups were given.

Photographs were taken using cameras with 55 mm lenses during aerial counts with a Skyhawk (Cessna 172) fixed, high-wing aircraft. The entire park was surveyed between 08:30 and 11:00 am in October of 1993 and 1995 during the late dry season. During this time, the elephants congregate on the Shire River floodplain during most of the day. Photographs were taken whenever elephant breeding herds were found. To get a clear view of the elephants, the door on the photographer's side was removed.

Dorsal measurements of all measurable elephants on each photograph were taken under 8x magnification. The magnifying glass in a 45 mm long tube-like holder had a 10 mm long ruler calibrated to the one-tenth of a millimetre, allowing reasonable accuracy. The tube-like holder ensured that the magnifying glass was kept the same distance away from each photograph when it was viewed for measuring.

A mean maximum dorsal length for each photograph was calculated from the largest animals, using a number equivalent to 10 % of the animals in the photograph. This measurement represented the asymptotic dorsal length for that particular photograph. Dorsal lengths of the rest of the individuals measured in the photograph were then divided by the asymptotic length to obtain the ratio of dorsal length : asymptote. This approach obviates the measurement of the distance between camera and elephant, which is very difficult to determine and not worth

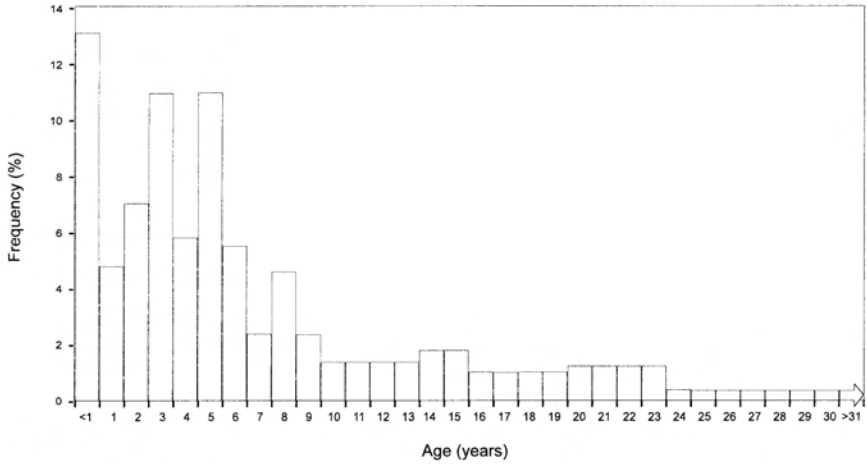

Fig. 2. The age structure (in years) of the elephant population in Liwonde National Park in Malawi in 1993. The frequencies (percentage) for the composite age cohorts, 10-15, 16-23, 24-30 and >30 years old, were divided by 2, 4, 6 and 30 (assuming longevity of 60 years) respectively, to maintain consistency with the frequencies of the <1-9 years old cohorts.

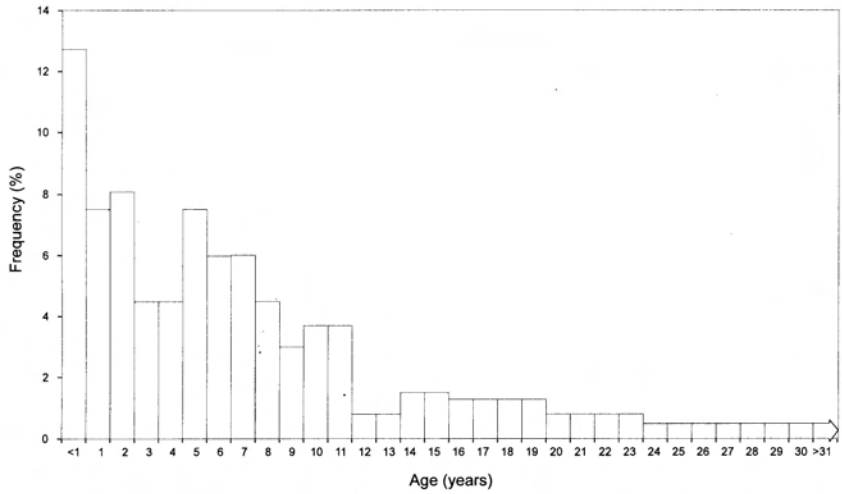

Fig. 3. The age structure (in years) of the elephant population in Liwonde National Park in Malawi in 1995. The frequencies (percentage) for the composite age cohorts were treated as in Fig. 2.

standardising in practice. The problem of scaling is thus circumvented (Lindeque 1991). Reference was then made to Croze's (1972) table to assign the appropriate age class for every value of the dorsal length : asymptote ratio. The age structure for 1993 was compared with that for 1995 using the Kolmogorov-Smirnov two-sample test.

In his procedures, Croze (1972) excluded adult bulls from the assessment of age structure. However, as it was difficult to tell the bulls with certainty in the photographs used in the present study, Lindeque's (1991) procedure of discarding photographs in which the ratio of the smallest individual to the largest in the group was less than 0.4 was followed.

After Leuthold (1976), Ottichilo (1986) and Lindeque (1991), the photogrammetric errors described by Croze (1972) were not corrected for because it was assumed that these errors cancel out over large samples and are minor considering the inaccuracies in age-length procedures.

To assess the impact of the 1991–1995 drought on the elephant population, the frequencies of the 5 year-old and younger cohort in 1993 and 1995 were compared using the one-tailed Kolmogorov-Smirnov two-sample test to decide if they were statistically similar or not.

Results

The aerial counts of 1993 and 1995 were total counts with 349 and 414 elephants being counted respectively. In the photogrammetic analyses, 84 individuals in 1993 (24.0 % of the total count) and 134 in 1995 (32.4 % of the total count) were used.

The population age structures for 1993 and 1995 are shown in Figs. 2 and 3 respectively. In 1993, the 5 year-old and younger age cohort represented 52.6 % of the total population, the 6–10 years old cohort 16.1 %, the 11–15 years old cohort 7.8 %, the 16–20 years old cohort 5.2 % and the >20 years represented 18.3 %. In 1995, the frequencies of the same cohorts were 44.8 %, 21.7 %, 8.3 %, 4.7 %, and 20.5 % respectively. The Kolmogorov-Smirnov two-sample test showed that there was no significant difference between the two age structures ($P > 0.05$). The age structures show that the elephant population was mainly made up of young animals of up to 10 years old, 68.7 % in 1993 and 66.5 % in 1995. The binomial test showed that, in both years, this cohort was significantly larger than the rest of the population (1993: $z = -3.38$; $P < 0.001$; 1995: $z = -2.50$; $P < 0.01$).

Although there appeared to be some differences in the frequencies of calves in the 5 year-old and younger cohort between 1993 and 1995, these differences were not significant ($P > 0.05$). The hypothesis that age frequencies in this cohort in 1995 were less than those in 1993 was therefore rejected.

Discussion

The detailed age structures of the elephant population for 1993 and 1995 were not significantly different ($P > 0.05$). Both structures showed that the population was mainly made up of animals 10 years old, or younger. The age structures were both classical pyramid-shaped and Croze (1972) described structures of similar shape in Kidepo National Park, Tanzania. This shape is indicative of a young and growing population. This result conformed with the other parameters of the population dynamics that Bhima & Bothma (*pers. obs.*) have reported for the same population, i.e. a short calving interval, a young age of first parturition and a high rate of increase, all of which should characterise a young and increasing population. Factors that have contributed to this status include low poaching, generally good rainfall for many years and low intra-specific competition due to low densities. These factors have previously been noted to be among the most important factors influencing age distribution and numbers (e.g. Croze 1972; Corfield 1973; Ottichilo 1986; Poole 1989).

The proportion of animals 10 years old or younger in Liwonde is higher than in most other areas. Proportions of 54.0 % and 63.4 % have been recorded in Kidepo National Park, Tanzania, (Croze 1972), about 50.0 % in Tsavo, Kenya (Leuthold 1976) and about 54.0 % in Etosha, Namibia (Lindeque 1991). The high proportion of "young animals" in the Liwonde population has been noted in the past by Stead & Dudley (1977) and Simons *et al.* (1991), though no age structure was constructed. When the park was established in 1972, the elephant population had few adults because of hunting for ivory that used to take place in the area since the last decade of the 19th Century (Stead & Dudley 1977). There were, therefore, probably very few breeding males in the population in 1972. In the early years of the park, therefore, the population went through a formation phase, initially growing slowly. This slow beginning could possibly explain the

slow growth rate of 3.6 % estimated from all counts conducted in the park (Bhima & Bothma *pers. obs.*). Further, the high proportion of the 10 year-old and younger cohort has been perpetuated until now by a spate of poaching in 1988 in which at least 32 adult elephants were killed within three months (Unpubl. records, Liwonde Wildlife Research Unit). This represented 9.1 % of the population then estimated at 350.

The observed frequencies of calves <1 year old in Liwonde National Park were on the higher side when compared with frequencies observed in several other areas in normal rainfall years, e.g. 8–9 % in Queen Elizabeth National Park, Uganda (Buss & Savidge 1966), approximately 8.5 % and 9.5 % in Etosha National Park, Namibia in May 1984 and August 1985 respectively (Lindeque 1991) and 10.1 % in Kruger National Park, South Africa in 1995 (Anon. referee *pers. comm.*). They were, however, less than or comparable to estimates of 14.4 % and 12.5 % in Kidepo National Park, Tanzania (Croze 1972), 11 % in Tsavo National Park, Kenya (Leuthold 1976), 14 % in Kasungu National Park (Jachmann 1986) and approximately 12 % in Etosha in December 1984, May 1985 and September 1987 (Lindeque 1991). The observed frequencies for Liwonde National Park, although high, were quite normal.

With a calving interval of 2.8 years (Bhima & Bothma *pers. obs.*), one in every 2.8 adult females is expected to conceive each year. In contrast, bulls will be ready to mate each year (Barnes 1982). Proportions in the population from 10 years and older, the age at which females become sexually reproductive (Moss 1983 In: Poole 1989), were 32.7 % and 36.8 % in 1993 and 1995, respectively. With a sex ratio of 42.6 % males to 57.4 % females (Bhima & Bothma *pers. obs.*), there were 18.8 % and 21.1 % breeding females in the population and only one in 2.8 of these (i.e. 6.7 % and 7.5 %) could have been expected to conceive in 1993 and 1995 respectively. However, the observed frequencies of calves of 1 year old were nearly double these frequencies. The major reason for this would be higher than normal breeding resulting from aggregation in the floodplain. Group formation patterns and the operational sex ratio play an important role in mate searching (Barnes 1982; Poole 1989; Poole & Moss 1989). In Liwonde National Park, elephants aggregate in the floodplain in the dry season, with mean group size of 17.43 and 19.78 in the wet season (Bhima, *pers. obs.*). The dry season mean is larger than what has been observed in several other places (e.g. Poole & Moss 1989; Jachmann 1992; Dublin 1996).

Such high productivity was maintained during the drought period probably because the elephants aggregated even more in the floodplain. The population counts were highest in 1995 (414) than in any other year. All 414 elephants were counted in three large congregations and one small group of six in the floodplain. Following the 1970/71 drought in the Tsavo National Park, Kenya, elephants aggregated in large herds in several areas leading to a proportion of calves <1 year old of 11 % in the age structure in 1974 (Leuthold 1976). This was thought to be temporarily higher than normal. Poole (1989) noted that in open areas in East Africa where elephants respond to poaching pressure by aggregating, like in Murchison Fall, Queen Elizabeth and Serengeti National Parks, conception rates may be less affected than in areas where they do not, like in Selous, Mikumi and the Luangwa Valley (Zambia). The same is likely to have happened in Liwonde during the drought. The high frequency of the <1 year old calves may also be an indication that the population has now passed the formation phase.

Comparison of the most vulnerable age cohort to drought (5 years old and younger) in 1993 and 1995 showed no significant difference ($P > 0.05$). This probably showed that the drought did not have any significant impact on the population. To begin with, the frequencies of calves <1 year old suggest that reproduction may not have been affected in 1991/92 when the drought was most

severe and later in 1995 when it was in its third consecutive year, but had become milder. This implies that the impact of the drought on the population was minor. After a drastic decline in elephant numbers due to drought in Tsavo National Park, Kenya, Ottichilo (1986) found a frequency of 6 % for calves <1 year old. In Liwonde National Park, when the drought was at its peak in 1991/92, the elephants spent almost all their time in the floodplain, close to the Shire River. The floodplain had palatable forage for some time and the Shire River provided permanent water throughout the drought period. Also, some elephants crossed the Shire River to the west bank for the first time, initially a group of 32, and later several other groups. This suggests that the forage on the eastern bank could have been depleted by over-use and trampling and crossing to the west bank where there had been no elephant activity since the establishment of the park, was a survival strategy.

The observed minimum impact of the drought on the population is also supported by the lack of evidence of carcasses in the field. One could, however, argue that this was probably because of scavengers dragging the carcasses away as has been noted in other areas (Jachmann 1986; Eberhardt 1985; Wells 1989). Further argument could be that errors incurred in the age estimation method could have led to a wrong conclusion. Lindeque (1991) noted that the use of frequency distributions of numbers of individuals in each year group to indicate changes in age structure could be misleading because age estimation methods for elephants are presently not sufficiently accurate to show changes other than gross perturbation in a series of structures. When photography from the air is being done for the first time and with limited resources as was the case in Liwonde, some problems should be expected. This is why only 24.0 % and 32.4 % of the animals counted could be used in the estimation of age structure.

Conclusions

The current elephant population in the Liwonde National Park mainly consists of young animals below the age of 10 years. The population is, therefore, young and increasing and has the potential to increase rapidly now that it seems to have gone through its formation phase. The drought of 1991/92 had little impact on the population. The Shire River that provided water throughout the drought period played an important role in saving the situation. It is recommended that age structure data should, in future, be collected regularly to monitor the population as it grows. The same should be done in all national parks in Malawi. Photography should be done routinely as part of all aerial surveys which are now a regular feature of the Wildlife Research Unit.

Acknowledgements

This study was part of a larger study of the Liwonde elephants partly funded by the South African High Commission in Malawi. In 1993 photographs were taken by Andrew Rollins with his camera. In 1995, the aerial count was funded by the Elephant Surveys and Monitoring Programme (ELESMAP) and Mr P. Hankin of GITEC Consult, Liwonde lent us his camera. The magnifying glass used for estimating elephant dorsal lengths belonged to Dr. F von Roenne, GTZ Technical Advisor at Liwonde Hospital. We are grateful to all these people for making the study possible. Dr. S. Munthali commented on the initial draft of the manuscript and the Director of the Malawi Department of National Parks and Wildlife gave permission to publish this paper.

References

BARNES, R.F.W. 1982. Mate searching behaviour of elephant bulls in a semi-arid environment. *Animal Behaviour* 30: 1217–1223.

BUSS, I.O. & J.N. SAVIDGE. 1966. Change in population numbers and reproductive rate of elephants in Uganda. *Journal of Wildlife Management* 27: 36–53.

CORFIELD, T.F. 1973. Elephant mortality in Tsavo National Park, Kenya. *East African Wildlife Journal* 11: 339–368.

CROZE, H. 1972. A modified photogrammetric technique for assessing age structures of elephant

populations and its use in Kidepo National Park. *East African Wildlife Journal* 10: 91–115.

DUBLIN, H.T. 1994. Elephants of the Masai-Mara, Kenya: Seasonal habitat selection and group size patterns. *Pachyderm* 22: 25–35.

EBERHARDT, L.L. 1985. Assessing the dynamics of wild populations. *Journal of Wildlife Management* 49(4): 997–1012.

HULME, M., D. CONWAY, P.M. KELLY, S. SUBAK & T.E. DOWNING. 1994. The impact of climate change on Africa. A chapter contribution to the SEI/ACTS Project "Climate and Africa—an assessment of African policy and options." 3rd draft. 53 pp.

JACHMANN, H. 1986. Notes on the population dynamics of the Kasungu elephants. *African Journal of Ecology* 24: 215–226.

LAWS, R.M. 1969. The Tsavo Research Project. *Journal of Reproduction and Fertilisation*, Supplement 6: 495–531.

LAWS, R.M. & I.S.C. PARKER. 1968. Recent studies on the elephant population in East Africa. *Symposia of the Zoological Society of London* No. 21: 319–359.

LEUTHOLD, W. 1976. Age structure of elephants in Tsavo National Park, Kenya. *Journal of Applied Ecology* 13:435–444.

LINDEQUE, M. 1991. Age structure of the elephant population in the Etosha National Park, Namibia. *Madoqua* 18(1): 27–32.

MAGADZA, C.H.D. 1994. Climate change: some likely multiple impacts in southern Africa. *Food Policy* 19(2): 165–191.

MOSS, C.J. 1983. Oestrus behaviour and female choice in the African elephant. *Behaviour* 86: 167–196.

OTTICHILO, W.K. 1986. Age structure of elephants in Tsavo National Park, Kenya. *African Journal of Ecology* 24: 69–75.

POOLE, J.H. 1989. The effects of poaching on the age structure and social reproductive patterns of selected East African elephant populations. Final report to the African Wildlife Foundation, Nairobi. Typescript. 30 pp.

POOLE, J.H. & C.J. MOSS. 1989. Elephant mate searching: group dynamics and vocal and olfactory communication. *Symposia of the Zoological Society of London* No. 61: 111–125.

SIMONS, H.W., P.M. ROGERS, E. CHIWONA, R. BHIMA & H.M. BANDA. 1991. *Large mammal inventory, Malawi: 1989–1990.* Lilongwe Malawi: Govt. of Malawi/F.A.O. Wildlife. (Management and Crop Protection Project. Field Document No. 9.)

STEAD, D. & C.O. DUDLEY. 1977. Liwonde National Park, Part II: the mammals. *Nyala* 3(2): 29–38.

WELLS, M.P. 1989. The use of carcass data in the study and management of African elephants: a modelling approach. *African Journal of Ecology* 27: 95–110.

ZAMBATIS, N. & H.C. BIGGS. 1995. Rainfall and temperatures during 1991/92 drought in the Kruger National Park. *Koedoe* 38(1): 1–16.