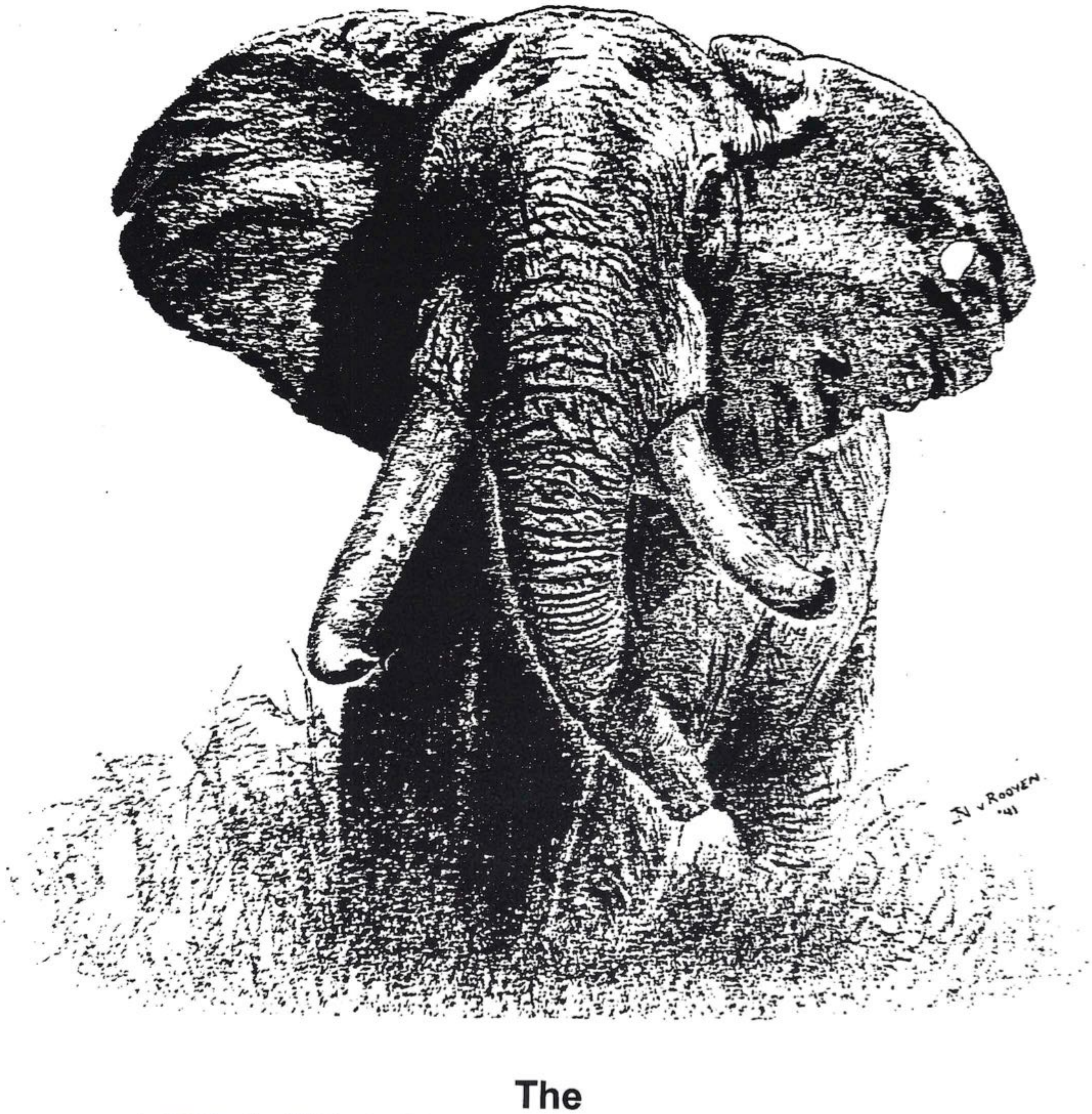


The African Elephant as a game ranch animal

Wildlife Group

South African Veterinary Association

Proceedings

of a Symposium on the

African Elephant as a Game Ranch Animal

Berg-en-dal, Kruger National Park, 29-30 April 1991

Re-edited by J van Heerden and B L Penzhorn

Reprinted 1996

ISBN 1-875088-02-4

TABLE OF CONTENTS / INHOUDSOPGAWE

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

PAST, PRESENT AND FUTURE DISTRIBUTION OF ELEPHANTS IN SOUTHERN AFRICA

H Ebedes[a], C Vernon[b] and Irma Grundling[c]

The problems associated with the conservation of African elephants are frustrating and there are no easy and ready-made solutions. The burning of milions of dollars worth of tusks, as a solidarity act against elephant hunting and the ivory-trade, as happened in East Africa recently, is inconsistent with the concepts of elephant conservation in southern Africa.

In the Republic of South Africa elephants have already been successfully relocated to areas where they previously occurred. Trial relocations have been undertaken to game reserves and game ranches with juvenile animals. It is possible to confine adult elephants to certain areas with the use of well-maintained and reliable electrification systems powered by solar energy. The actions that need to be taken when the electrification breaks down and elephants break out and damage neighbouring property or endanger human lives need to be carefully worked out. The loss of human lives may be of such a nature that even monetary compensation may be insufficient. Where elephants previously occurred, where they are presently found and how they are confined are some of the matters that will be looked at in this paper.

PAST DISTRIBUTION OF ELEPHANTS

Except for the more arid and colder parts of southern Africa, the above statement is authenticated by evidence of elephant remains, place names, Bushman art and reminiscences of encounters with elephants by early explorers, travellers and hunters in the southern part of the continent as illustrated in Maps 1-5. Co-ordinates of the historical evidence were mapped used the PC-based spatial analysis system, SPANS (Tydac Technologies Inc. USA). The past distribution of elephants (Map 5) was simulated by creating travel zones of 50 km radius from the co-ordinates.

Cape Province

According to archaeological evidence and reports by early hunters and historians (Burchell 1824), elephants were widely distributed along the coastal regions of the Cape Province. In the times of Jan van Riebeeck and the Dutch East India Company, elephants were encountered within a day's walk from Table Mountain (Pringle 1982). They were hunted mainly by the Hottentots and ivory was bartered with the settlers. Shortly after white settlement of the Cape, elephants became more scarce because of hunting. Early travellers reported that the Eastern Cape, the Orange River and its tributaries were favourite elephant-hunting areas. The first systematic description of an African elephant was made on an animal shot near the Orange River (Roberts 1951). Le Vaillant (quoted by Roberts 1951) recorded elephant along the Olifants River near Clanwilliam, in Namaqualand and along the lower Orange River during his travels from 1780-1785. In 1822 elephants and bontebok in the Cape were proclaimed "Royal Game" by Lord Charles Somerset. In 1886 farmers were given permission to shoot elephants on their properties without licence or official permission and by 1897 there were only 150 elephant in the Cape (Pringle 1982).

[a] Department of Agricultural Development, Transvaal Region, Private Bag X180, Pretoria 0001, Rep. of South Africa

[b] East London Museum, P O Box 11021, Southernwood, 5213, Rep. of South Africa

[c] Department of National Health and Population Development, Private Bag X828, Pretoria, 0001, Rep. of South Africa

Many of the original roads and passes across the mountain ranges in the south-west Cape were built on age-old well-worn elephant foot paths. The town Franschhoek in the southern Cape was formerly called Olifantshoek and it may be of interest to note that the town presently called Olifantshoek in North West Cape was named after an officer in the British Army called Major Oliphant and not after elephants. There are more than 41 places named after elephant in the Cape Province.

Natal

According to early travellers and hunters (Baldwin 1863; Drummond 1895; Bryden 1903) elephants were distributed over central and northern Natal where there was suitable habitat. Their range became restricted by hunting in the mid-1800's and only a remnant population occurred in the north-east corner of Zululand, between the Black and White Umfolozi Rivers and along the Pongola River. Even this population was unable to hold out against hunting pressures and with the exception of a few elephants that sought protection in the thickly forested Tembe area and the Mozambique border, most elephants were exterminated.

Gingindlovu, a Zulu military stronghold in the time of Zulu Chief Cetshawayo means "the swallower of the elephant". According to the Surveyor-General's office in Natal there are only two places named after elephant, Olifantskop and Olifantshoek.

Orange Free State

Elephants occurred along the Caledon and Orange Rivers in the south and the Vaal River in the north and west in earlier times. There is little archaeological evidence that elephant occurred in the central and eastern parts of the province. In recent historical times they may have occurred in the north western parts near Boshoff and Kroonstad if the names of some farms are considered.

Transvaal

There is an abundance of information and literature to indicate that elephant were well distributed throughout the Transvaal during the previous centuries. Explorers and hunters had frequent encounters with elephants and wrote about the valuable ivory trade. Hunting for ivory was in those days an accepted and legitimate way of making a living. When the first game reserve in Africa was proclaimed in 1894, the Government Game Reserve (17 400 ha) north of the Pongolo River near Swaziland, there were no elephant left to protect in that area (Pringle 1982). Heavy hunting pressure took its toll and the small number of elephant that survived took refuge in the uninhabited, disease-ridden and unexplored far north-eastern Transvaal between the Letaba and Olifants Rivers (present Kruger National Park). There are more than 30 farms and places named after elephants.

Botswana

Up to the middle of the 19th century elephants were well distributed throughout eastern and northern Botswana according to explorers and hunters (Andersson 1856; Livingston 1857; Selous 1881). In a well-researched paper Campbell (1990) gave a historical account of the decline and subsequent increase of the Botswana elephant population.

The following are interesting aspects from the paper:

- at the beginning of the 19th century, the total population could have numbered between 200 000 and 400 000 animals;

- the ivory trade was well established before the arrival of white hunters and most elephant south of Kuruman had already been destroyed;

- by 1865, all elephant south of Makgadigadi were destroyed;

- the period from 1860 to 1890 saw a rapid decline in elephants in all areas that traditionally had vast herds;

- the introduction of guns, horses and wagons were responsible for the rapid depletion of elephant;

- up to 1 000 kg of ivory could be loaded onto a wagon and transported without difficulty;
- a report of 300 elephants being killed in one day;
- the tsetse fly probably saved Botswana's elephant from extinction.

It was of interest to note that ivory was used to barter for weapons that were used for hunting, warfare and for the protection of certain tribes.

Namibia

Before 1900 elephant were distributed over most of Namibia with the exception of the Namib Desert, the sub-arid areas east of the Namib and the sparsely vegetated areas that stretch south and south-west of Windhoek toward the Orange River and the southern border. Sparse vegetation and lack of perennial water were the factors limiting distribution. According to early travellers (Alexander 1838; Anderson 1861; Chapman 1868; Baines 1864; Galton 1853) elephant were encountered south of the present Etosha National Park, east of Outjo, and around Tsumeb, Grootfontein and the Waterberg. They also occurred along the dry river beds of the Kuiseb River, Swakop River and Hoanib River that had lush vegetation and underground water supplies for which the elephants could dig (De Villiers, 1980). Ivory was the main trading item of the Angola farmers and it was estimated that about 2 000 elephant were shot in Kaokoland (formerly Kaokoveld) from 1892 to 1908 (De Villiers 1980).

PRESENT DISTRIBUTION OF ELEPHANTS

The present distribution of elephants is summarized in Table 1 and indicated on Map 6. There are less that 9 000 elephants in South Africa including the independent states and Swaziland. When these numbers are compared to the numbers of elephant in Zimbabwe, Botswana and other countries in Africa one realises how few there are in South Africa (Tables 2 and 3).

Cape Province

The Chief Directorate Nature and Environmental Conservation of the Cape Province does not have a restrictive policy regarding the keeping of the elephant on private land and up to the present there have not been any problems.

The Armstrong Fence (Addo Elephant National Park) was completed in 1955 and 20 elephants were enclosed in the 2 770 ha elephant camp. Since the completion of the Armstrong Fence two elephants are known to have escaped; one in 1965 and the second in 1971. Both escapees were destroyed. The population increased to 45 in 1965, 60 in 1971 and 160 in 1990. In 1990 additional land enlarged the Park to 8 600 ha and it is now 10 400 ha (Mr N van der Walt, Addo, 1991, pers. comm.). Changes in the botanical composition caused by elephant and the food preferences of elephant were described by Penzhorn *et al.* (1974).

The eight elephants in Mopongo Park, East London, are tame and a "herdsman" takes them daily to graze and browse in the nearby bush. The elephants have adapted well in the new surroundings and have been active in clearing bush (Daphne Burchell, Mopongo Park, 1991, pers. comm.). The elephants are herded back to a boma every afternoon for additional feeding and to sleep. The perimeter fence is not electrified. To date the elephant have not caused any problems.

It is estimated that there are three elephants living in the Harkerville area of the Knysna State Forest (Dr Liza Boomker, Pretoria, 1990, pers comm). Because of the dense vegetation it is difficult to see the animals that are reputed to be abnormally large in size. The elephants are not restricted by special fencing, they are seldom seen and according to the nature conservation authorities do not cause any trouble (Mr Gert van Wyk, Cape Town 1991 pers comm). The future survival of the Knysna elephants as well as the fertility of one of the cows have been questioned (Carter 1974). Attempts by the Wildlife Society of South Africa to obtain additional elephants in 1954 were not supported by the authorities because of difficulties in capture and transport (Pringle 1982).

Natal

Elephants are located in the following areas: Tembe Elephant Reserve, Hluhluwe Corridor, Umfolozi Game Reserve Complex, Itala Game Reserve and on two privately owned game ranches (Rowe-Rowe 1991). Game ranchers may introduce elephant onto their property if the habitat is suitable and there is no objection from the neighbouring farmers. There are no fence specifications (Dr DT Rowe-Rowe, Natal Parks Board, Pietermaritzburg, pers comm.)

Orange Free State

With the exception of two in the Bloemfontein Zoo as far as could be determined there are no elephants at present living in the OFS.

Transvaal

Up to 1982 the distribution in the Transvaal was confined to the Kruger National Park (KNP) and a small population on the border of the Transvaal, Zimbabwe and Botswana at the confluence of the Limpopo and Shashi Rivers (Rautenbach 1982). Most of the South Afican elephants are in the Transvaal and mostly in the eastern part of the Province.

From an estimated 10 animals at the turn of the century, when the Sabie Game Reserve was proclaimed, the population in the KNP increased to 25 in 1912 (Pienaar *et al.*). According to recent surveys elephants occur all over the park. The decision taken by the Board in 1967 to cull surplus elephants was based on scientific research. The goal was to maintain the population at between 7 000 and 7 500.

Elephant bulls especially had a severe impact on the vegetation and that was one of the main reasons for initiating the culling programme.

Apart from the managemental benefits, valuable scientific data about elephant population dynamics was derived from the culling. Smuts (1975) for example found that:

- the sex ratio for foetuses, juveniles, subadults and adults was 1:1 and the sex ratio of breeding herds was 1 male to 1,53 females. This is an important finding and is of practical significance when deciding the sex ratio of groups of young elephant that have to be relocated.
- the mean calving interval was 4 - 4,5 years
- the youngest possible age of conception was 7 years
- full sexual maturity in females was attained at 12 years of age and
- the population level of 0,4 elephant per km^2 or 1,1 elephant per $mile^2$ did not interfere with or reduce the reproductive rate.

From 1978-1990, 285 young elephants were sold and 305 elephants were donated to various conservation authorities in the RSA. In the past year 58 elephants were sold to private individuals. (JJ Kloppers, National Parks Borad, Skukuza, 1991, pers. comm.). A total of 648 young elephants have been relocated from the KNP over the past 12 years.

During 1990, 38 elephants were sold. Of the 90 elephants available during 1991, 46 were ordered by game ranches (JJ Kloppers, pers. comm.). Tender prices range from R9 000 to R12 000 per elephant.

During the most recent census 395 elephants were counted (Dr PA de Villiers, Hoedspruit, 1991, pers. comm.) in the Klaserie Nature Reserve, the largest privately owned nature reserve in the RSA. Periodically there is an immigration from the KNP and at times an estimated 500 elephant have been present in the area. Westward and southward migration from the area is prevented by an electrified fence. The fence is occasionally damaged by one or two lone bulls that have learnt to break the fence and return to the reserve.

A small family herd of 10 cows and calves and several young bulls have settled on the mine property of Phalaborwa Mining Co. Cleveland Game Ranch, which is just south of the mining property, is electrified on the east side and has a resident population of 55 elephants (Christelle Breedt, Phalaborwa, 1991. pers comm.).

The northern and western borders of the Sabi-Sand Game Reserve are electrified. Elephants from the KNP move freely in and out of the reserve and there is a resident population of about 20-40 animals (Mr Michell Giradin, Sabi-Sabi, 1990, pers. comm.).

The estimated elephant population of Timbavati Private Game Reserve fluctuates from 167-220 between the game reserve and the KNP. Elephant bulls frequently move freely to and from the KNP. Migration westward out of the reserve is prevented by an electrified fence.

A number of game ranches have introduced elephants over the past three years. Some of the elephants were from Zimbabwe and some from the KNP.

Elephants have always been popular animals in zoos. Many European and North American zoos as well as the Johannesburg Zoo have successfully bred elephants.

A total of 31 young elephants were released in the Letaba Ranch in an area of 3 000 ha that was electrified specifically to confine the elephants. The electrification system is unique because it consists only of two electrified wires and an earth and is not offset from a gameproof or perimeter fence. During December 1990, a faulty energiser caused a weak current of about 800 to 1200 volt instead of the usual 4 000 to 5 000 volts. The elephants were able to detect the weaker current because they spent a lot of time near the "fence", but at no stage did they attempt to break out. When a section of the electrified wires were removed to enlarge the area they hesitated for several weeks before crossing the non-existant boundary (Mr Ian McFadean, Giyani, 1991, pers. comm.).

The perimeter of Manyeleti Game Reserve is not electrified and the 5 to 15 bulls that are found here often move back to the KNP (Mr D Reynolds, Manyeleti, 1990, pers. comm.). Ten young elephants were introduced to the Andover Game Reserve that is electrified. The elephants seldom come near the fence, stay mostly in the middle of the reserve and have adapted well (Mr Ian Mc Fadean, Giyani, 1990, pers. comm.).

The perimeter fence of the Methethomusha Game Reserve is electrified and has a resident population of eight elephants (Dr J Anderson, Nelspruit, 1991, pers. comm.). During the 1990 census, 42 animals (including two calves born in the reserve) were counted in Pilanesberg National Park. The carrying capacity for elephants is estimated to be about one elephant per 1 000 ha. The park perimeter is not electrified, but is rhino-proof with four strands of steel cable (Dr R H Keffen, Park Veterinarian, Bophuthatswana National Parks). Since the main elephant introductions that go back nine years, there has only been one instance of an elephant leaving the Park. This animal was destroyed after an altercation with a farmer near Brits.

Elsewhere in Southern Africa

The elephant population in Angola is estimated at 18 000 (Mr Clive Walker, Johannesburg, 1991, pers. comm).

The following counts (quoted by Campbell 1990) are for the northern part of Botswana:

1981	39 511
1984	42 792
1987	150 000
1989 (wet)	67 000
1989 (dry)	58 623

Recent aerial surveys completed in April 1990 and September 1990 show there are approximately 54 700 elephant distributed in the water-rich northern regions of Botswana (Craig, 1991). These figures are less than the previous year and probably relate to the recent increases of elephants in

Namibia. The patterns for dry and wet season distribution varies considerably. Elephant concentrate along the perennial rivers during the dry season causing considerable damage to the vegetation. The density of the elephant population is four per km^2 in the dry season and two per km^2 in the wet season (Craig, 1991). Elephants in Botswana roam unrestricted. None of the parks or reserves are fenced. A small section of the north-eastern border with the Transvaal is electrified.

Moçambique has an estimated population of 17 000 elephants (Mr Clive Walker, Johannesburg, 1991, pers. comm.). Tinley estimated less than 10 000 elephants (Dr K Tinley, Pretoria, 1991, pers. comm.). It has been speculated that many elephants have been shot for ivory for bartering for weapons. An attempt during 1990 by an IUCN official to survey elephants in the Maputo Elephant Reserve could not be completed because of the danger of terrorist acitivities (Dr M Woodford, Pretoria, 1990, pers. comm.). Over the past 10 years the country has suffered several severe droughts and many elephants migrated westward into the KNP and Zimbabwe. The completion of the elephant-proof fence on the eastern border of the KNP has effectively curbed further movement into the Park. Restricting this immigration was necessary for efficient control and management of the resident elephant population in the KNP.

The former elephant population of about 3 200 in Namibia has doubled in the past few years most probably because of immigration from neighbouring Botswana (Dr E Joubert, Windhoek, 1991, pers. comm.). Elephant are restricted to the northern parts of Namibia with the main concentration of 2 000 in the Etosha National Park. Some Etosha elephant migrate out of the Park during the rainy season (De Villiers, 1984). Parts of the southern boundary fence have been electrified owing to constant problems with elephant trying to leave the park at these points. The elephant leave the Park to search for fresh water.

According to De Villiers (1980) a substantial number of the elephants counted in 1980 were not protected in a national or any other park and were distributed as follows:

Damaraland	150
Kaokoland	205
Ovamboland	500
Kavango	400
Bushmanland	120

One game rancher, Jan Oelofse of the farm Etjo-Nord in the Kalkveld area near Otjiwarongo, has nine young elephants on his 10 000 ha ranch. The Namibian conservation authority does not have a restrictive policy regarding elephant relocations and will allow candidates with enough suitable vegetation to keep small groups of animals (Dr E Joubert, Windhoek, 1991, pers. comm.).

The Mkhaya and Hlane Game Reserves in Swaziland have 10 elephants. In 3 years there have not been any major breaks or damage to the fences. The elephants were trained to respect electricity in a small boma before release (Mr Ted Reilly, Mkhaya, 1989, pers. comm.). By controlling the gates and stopping the electrical current through the gates it has been possible to alternate the elephant between camps and practise a system of veld management.

The present population in Zambia is estimated to be about 32 000 (C Walker, 1991, pers. comm.). Most of the elephants occur in the national parks and especially in the Kafue National Park and the Luangwa Valley Game Reserve. In the early 1970's there were more elephants in the Luangwa Valley than any other single area of Africa and estimates based on extensive aerial surveys indicated about 100 000 animals in one major population (Hall-Martin, 1986).

Recent surveys in Zimbabwe have shown a population of 67 000 of which *ca.* 57 000 occur in national parks (Dr Rowan Martin, Harare, 1991, pers. comm.). Carrington (1967) considered Wankie (now Hwange) National Park to be one of the greatest elephant sanctuaries in the world and mentioned visitors' cars being held up by elephant herds of up to 250.

FUTURE DISTRIBUTION

Elephants can adapt to wide ranges of habitats and occurred historically over extensive areas of the sub-continent. They are being resettled with some success in parts of South Africa were they previously occurred. Apart form other considerations, elephants play an important role in changing the composition of the vegetation and have been known to restore grassland in degraded areas which became useless because of bush encroachment. Elephants will only act as debushing agents if the encroaching plants are part of their diet (Dr P de Villiers, Hoedspruit, 1991, pers. comm.). They may also exert a negative effect on the vegetation and before any game ranchers or owners of private nature reserves consider resettling elephants on their properties they must be aware of this danger. "Small" elephants grow into adults and "big" elephants are notorious for debarking and uprooting trees or damaging them sufficiently to allow invasion by insects and fungi (Boughey 1963; Glover 1963; Laws 1970; Agnew 1968; Lamprey *et al.* 1977; Penzhorn *et al.* 1974; Watson & Bell 1969).

ACKNOWLEDGEMENTS

Several people all over Southern Africa helped with the collection of information that was necessary for the writing and presentation of this paper. Meaningful discussions were held with conservationists and colleagues and their information is used in the text. The authors are grateful for all the help received and hope that the paper will give a better perception of the problems of the African elephant. The authors hereby acknowledge the assistance of the following: Dr A Venter, Mr F van Aswegen, Mr M Filter, Miss Jocelyn Ball, Mrs Annie Bam, Mr Eben van Zyl, Mr Peter Mentz and Mr C van der Spuy of Agrivaal; Dr P Mulder, Mr Vis Visagie, Mr A van W Lampbrechts and Dr PA de Villiers of Transvaal Directorate of Nature Conservation; Miss Elmarie Booysen, Miss Lorna Stanton, Mr JJ Kloppers, Dr G de Graaff and Dr P van der Walt of National Parks Board; Mr Pete Hancock and Dr and Mrs L Patterson of Botswana; Dr E Joubert, Namibia Department of Conservation; Dr Gert van Wyk, Cape Department of Nature Conservation; Dr DT Rowe-Rowe and Dr P Rogers of Natal Parks Board; Miss KA Herbert of the National Museum; Mr CA Esterhuizen of the Surveyor Generals Office, Cape Town; Mr Chris van der Spuy of Pretoria Colour Centre; Miss Zoe Henderson of the Bloemfontein Museum and R R van der Veen of Bloemfontein and finally the Librarians at the Transvaal Museum and the Department of Agriculture

REFERENCES

Agnew, A.D.Q. 1968. Observations on the changing vegetation of Tsavo National Park. *East African Wildlife Journal* 6: 75-80

Alexander, J.E. 1838. *An expedition of discovery into the interior of Africa*, Vol 1 and 2. London: Henry Callum.

Andersson, C.J. 1856. *Lake Ngami*. London: Hurst and Blackett

Andersson, C.J. 1861. *The Okavango River*. London: Hurst and Blackett

Baines, T. 1864. *Explorations in South West Africa. An account of a journey in the years 1861 and 1862 from Walfisch Bay, on the west coast, to Lake Ngami and the Victoria Falls*. London: Longman, Roberts and Green.

Baldwin, W.C. 1863. *African hunting and adventure from Natal to the Zambezi including Lake Ngami, the Kalahari Desert, etc. from 1852-1860.* London: Richard Bentley and Son.

Bosman, P. & Hall-Martin, A.J. 1986. *Elephants of Africa.* Cape Town: Struik.

Boughey, A.S. 1963. Interactions between animals, vegetation and fire in Southern Rhodesia. *Ohio Journal of Science* 63(5): 193-209

Brown, L. 1965. *Africa - a natural history*. Random House Inc.

Bryden, H.A. 1899. *Great and small game of Africa.* London: Rowland Ward

Burchell, W.J. 1822 and 1824. *Travels in the interior of South Africa.* London: Longman, Hurst, Rees, Orme, Brown and Green.

Campbell, A.C. 1990. History of elephants in Botswana. *In:* **Hancock, P.** (ed.) *The Future of Botswana's Elephants.* Proceedings of Kalahari Conservation Society Symposium on Elephants held in Gaborone, Botswana, 10 November 1990.

Carrington, R. 1967. *Great National Parks*. London: Weidenfeld and Nicolson.
Carter, N. 1971. *The elephants of Knysna*. Cape Town: Purnell.
Carter, N. 1974. Whatever happened to the Knysna Elephants? *African Wildlife* 28(4): 6-7.
Chapman, J. 1868. *Travels in the interior of South Africa*. London:
Craig, G.C. 1991. Present population and distribution of elephants in northern Botswana. *In:* **Hancock, P.** (ed.) *The Future of Botswana's Elephants*. Proceedings of Kalahari Conservation Society Symposium on Elephants held in Gabarone, Botswana, 10 November 1990.
De Villiers, P. 1980. Geskiedkundige oorsig van die verspreiding van olifante in Suidwes-Afrika. Finale verslag. Natuurbewaringsafdeling, Departement van Landbou en Natuurbewaring
Drummond, W.H. 1895. *The large game and natural history of south and south-east Africa*. Edinburgh: Edmonston and Douglas
Galton, F. 1853. *The narrative of an explorer in tropical South Africa*. London: John Murray
Glover, J. 1963. The elephant problem at Tsavo. *East African Wildlife Journal* 1: 30-39.
Lamprey, H.F., Glover, P.E., Turner, M.I.M. & Bell, R.V. 1967. Invasion of Serengeti National Park by elephant. *East African Widlife Journal* 5: 1-166
Laws, R.M. 1971. The Tsavo elephants. *Oryx* 11(1): 32-34
Livingstone, D. 1857. *Missionary travels and researches in South Africa*. London: John Murray
Penzhorn, B.L., Robbertse, P.J. & Olivier, M.C. 1974. The influence of the African elephant on the vegetation of the Addo Elephant National Park. *Koedoe* 17: 137-158
Pienaar, U. de V., van Wyk, P. & Fairall, N. 1964. An aerial census of elephant and buffalo in the Kruger National Park, and the implications thereof on the intended management schemes. *Koedoe* 9: 40-107
Pringle, J. 1982. *The conservationists and the killers*. Cape Town: TV Bulpin and Books of Africa.
Rautenbach, I.L. 1982. Mammals of the Transvaal. *Ecoplan Monograph* No 1.
Roberts, A. 1951. *The mammals of South Africa*. Trustees of "The Mammals of South Africa" Book Fund and Central News Agency.
Rowe-Rowe, D.T. 1991. Distribution, status, biology and conservation importance of the ungulates of Natal. Natal Parks Board. Unpublished Manuscript.
Selous, F.C. 1881. *A hunter's wanderings in Africa*. London: Richard Bentley and Son.
Skead, C.J. 1980. *Historical mammal incidence in the Cape Province. Vol 1 The western and northern Cape.* Department of Nature and Environmental Conservation of the Cape of Good Hope, Cape Town
Smuts, G.L. 1975. Reproduction and population characteristics of elephant in the Kruger National Park. *Journal of the South African Wildlife Management Association* 5: 1-10
Thomson, P.J. 1975. The role of elephants, fire and other agents in the decline of a *Brachystegia boehmii* woodland. *Journal of the South African Wildlife Management Association* 5: 11-18
Watson, R.M. & Bell, R.H.V. 1969. The distribution, abundance and status of elephant in the Serengeti region of Northern Tanzania. *Journal of Applied Ecology* 6: 115-132

Table 1: 1989 African elephant estimates

	AREA (km^2)	POPULATION	ELEPHANT/km^2
CENTRAL			
Cameroon	253 000	22 000	0,09
Central Afr. Rep.	346 000	23 000	0,07
Chad	202 000	2 100	0,01
Congo	214 000	42 000	0,20
Eq. Guinea	23 000	500	0,02
Gabon	249 000	74 000	0,30
Zaire	1 420 000	112 000	0,08
TOTAL	2 708 000	277 000	0,10
EAST			
Ethiopia	139 000	8 000	0,05
Kenya	413 000	18 000	0,04
Rwanda	3 000	50	0,02
Somalia	56 000	2 000	0,04
Sudan	372 000	22 000	0,08
Tanzania	501 000	61 000	0,12
Uganda	16 000	1 600	0,10
TOTAL	1 500 000	110 000	0,07
SOUTH			
Angola	458 000	18 000	0,04
Botswana	93 000	68 000	0,74
Malawi	19 000	2 800	0,15
Moçambique	248 000	17 000	0,07
Namibia	141 000	5 700	0,04
South Africa	23 000	7 800	0,35
Zambia	211 000	32 000	0,15
Zimbabwe	114 000	52 000	0,46
TOTAL	1 304 000	204 000	0,16
WEST			
Benin	20 000	2 100	0,10
Burkina Faso	36 000	4 600	0,12
Ghana	22 000	2 800	0,13
Guinea	11 000	500	0,07
Guinea Bissau	400	40	0,13
Ivory Coast	51 000	3 600	0,07
Liberia	17 000	1 300	0,06
Mali	50 000	840	0,02
Mauretania	6 000	100	0,02
Niger	6 000	440	0,09
Nigeria	29 000	1 300	0,04
Senegal	10 000	140	0,01
Sierra Leone	3 000	380	0,13
Togo	7 000	380	0,06
TOTAL	286 000	19 000	0,07
GRAND TOTAL	**5 781 000**	**609 000**	**0,11**

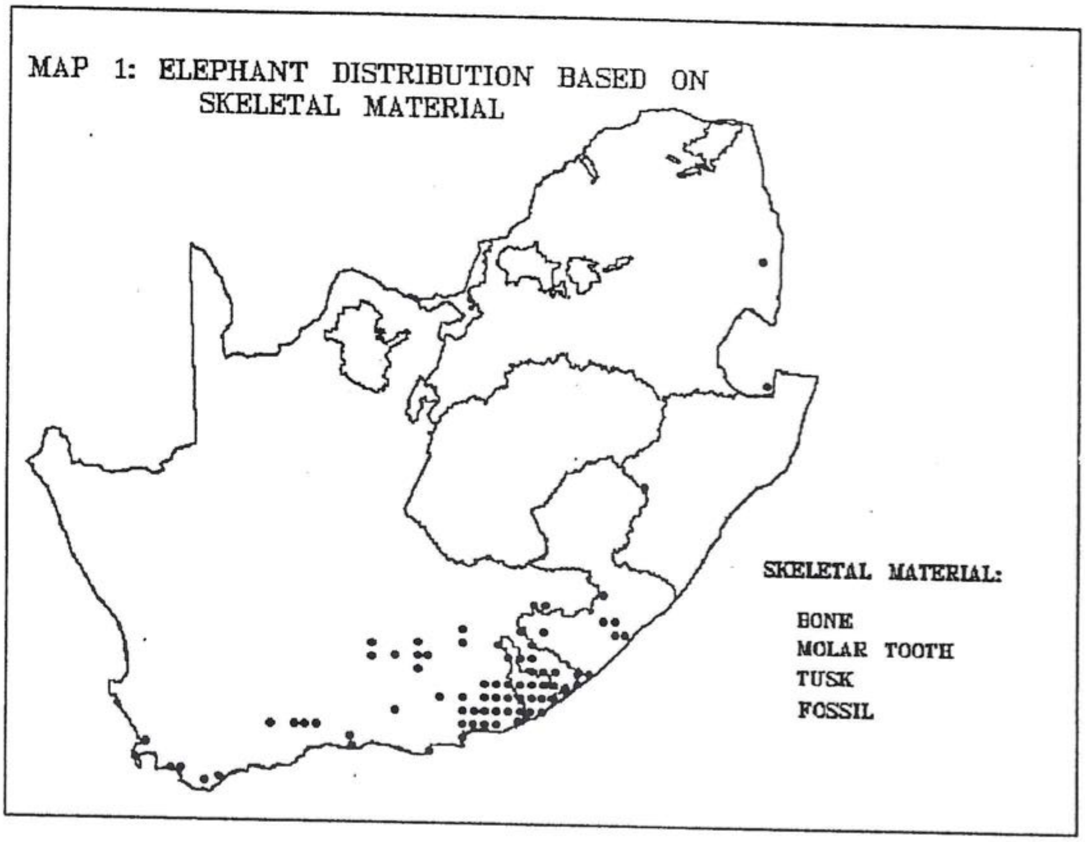
NB: Number above 5 000 are rounded to the nearest thousand
Numbers 5 000 - 1 000 are rounded to the nearest hundred
Numbers below 1 000 are rounded to the nearest ten

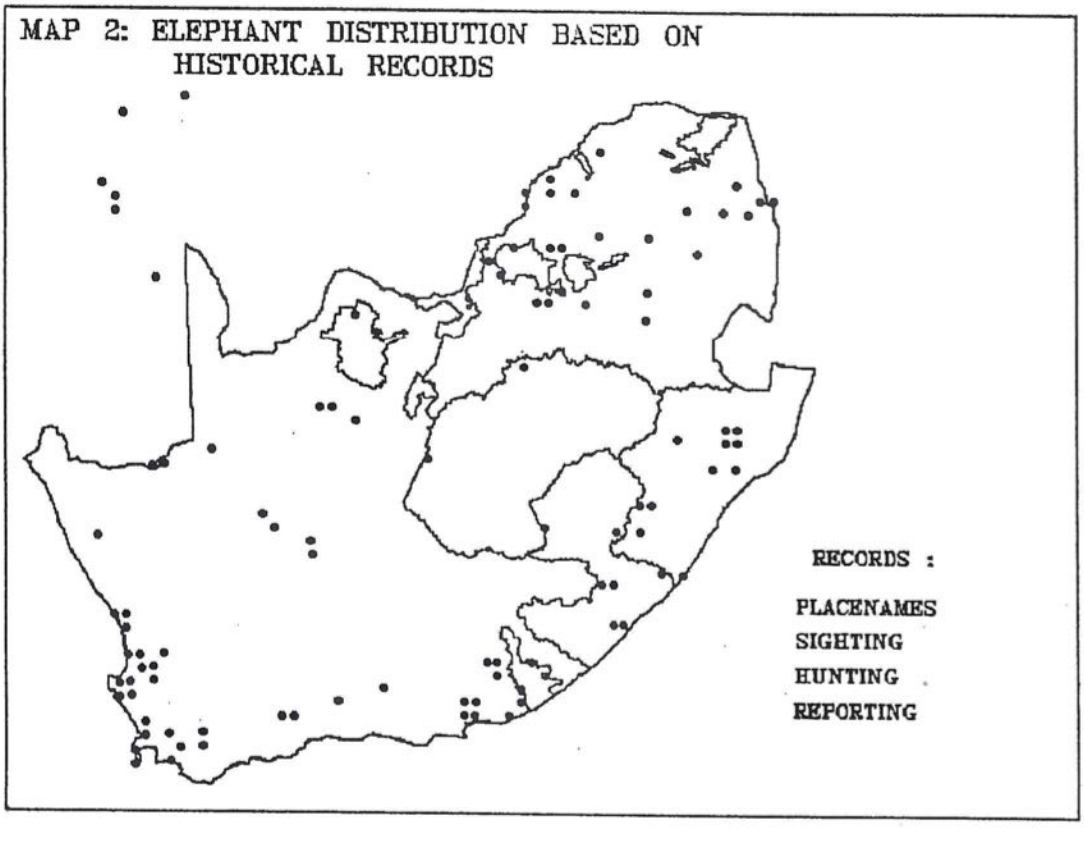
Table 2: Present distribution and estimated numbers of elephants in South Africa

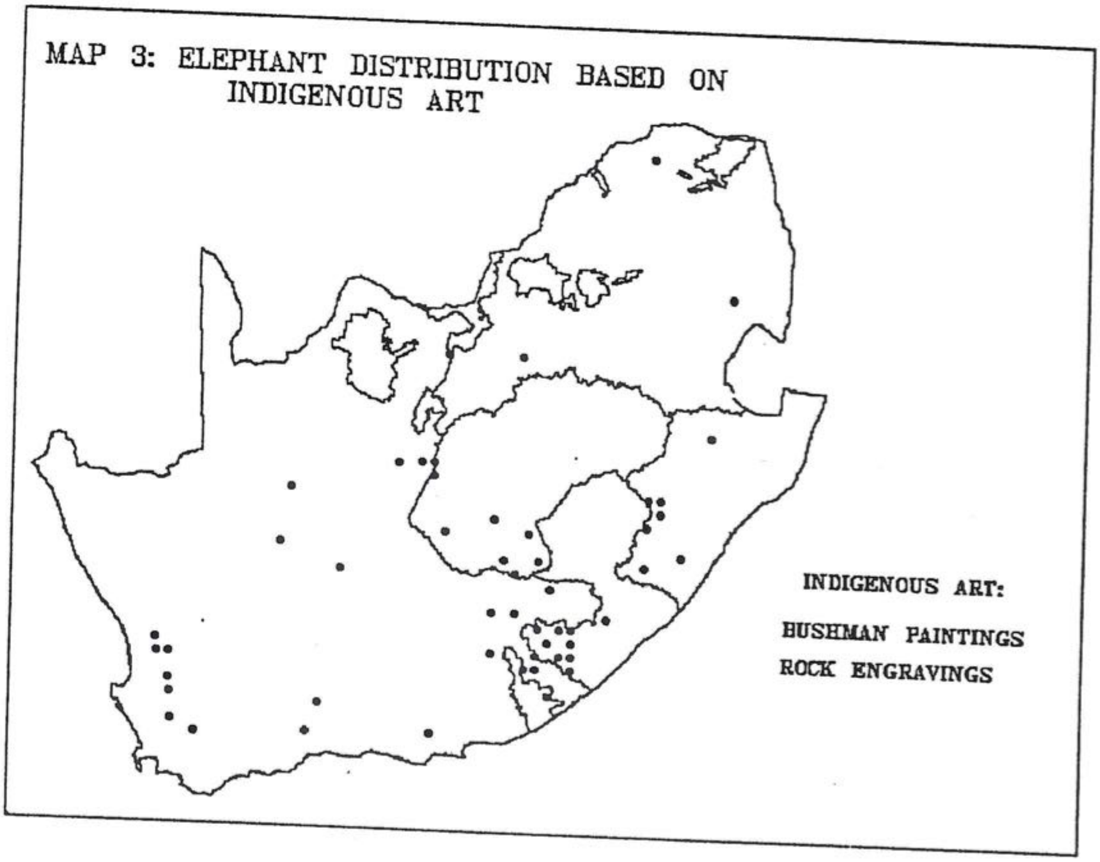
PLACE	AREA	SIZE (ha)	EST. NO.	MAP 6
Addo	Cape	10 400	160	2
Knysna	Cape	?	3	1
Mopongo Park	Cape	1 620	8	3
Tembe	Natal	19 000	80	7
Hluhluwe	Natal	90 000	146	5
Itala	Natal	30 000	11	6
Karkloof	Natal		3	4
Game ranches	Natal		8	8
Kruger N P	Transvaal	1 865 000	7 500	9
Klaserie	Transvaal	84 000	395	10
PMC	Transvaal	1 700	65	11
Sabie-Sand	Transvaal	57 000	55	14
Timbavati	Transvaal	40 000	220	13
Kwalata	Transvaal	4 700	7	23
Mabula	Transvaal	9 000	5	21
Touchstone	Transvaal	7 500	10	24
Tshukudu	Transvaal	5 000	2	15
Vosdal	Transvaal	11 500	3	22
Zoos (Pta & Jhb)	Transvaal		5	
Letaba Ranch	Gazankulu	42 000	31	12
Manyeleti	Gazankulu	22 700	16	
Andover	Gazankulu	7 100	17	
Pilanesberg	Bophuthatswana	58 000	48	20
Mthethomusha	Kangwane	7 500	8	18
Mkhaya & Hlane	Swaziland		20	19

Table 3: Elephant numbers in Zimbabwe

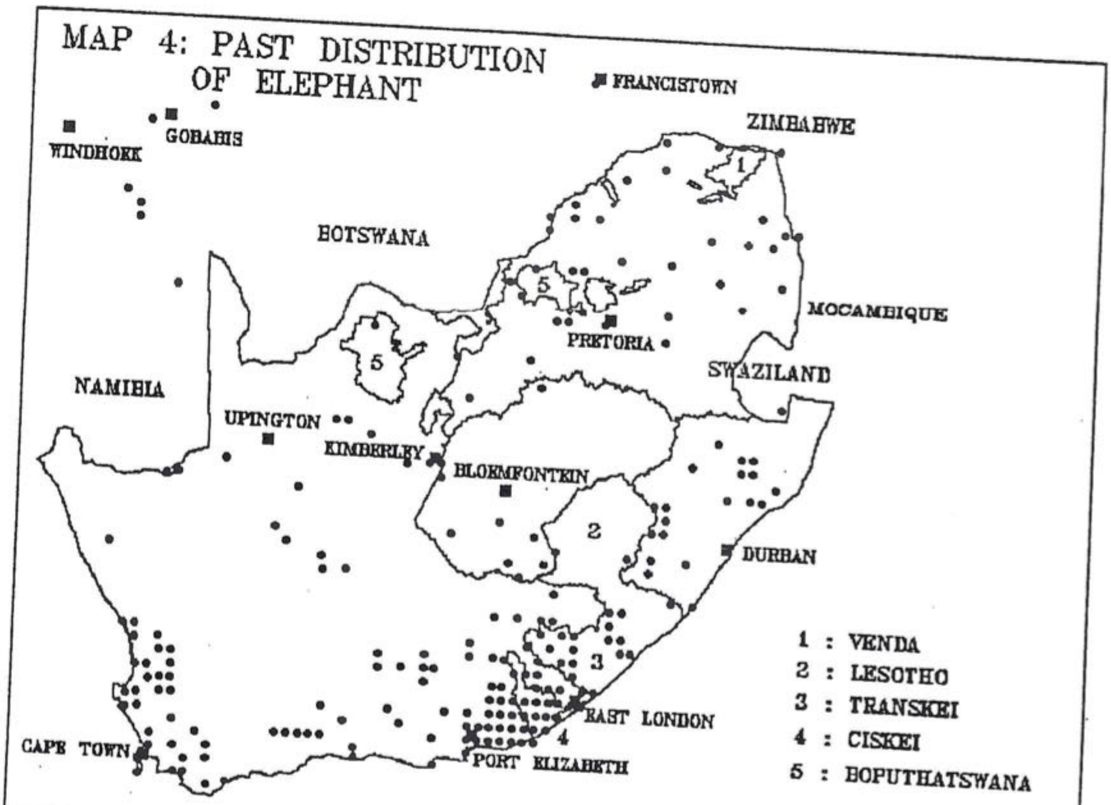
AREA	ELEPHANT NUMBERS	SIZE (km²)
Hwange National Park	27 000	15 130
Zambezi Valley	13 600	11 800
Ghona el Rezou	5 200	5 200
Matetsi	1 500	1 500
Cheti	1 000	1 000
Matsierie	1 500	4 200
Cheredsi	2 750	1 700
Communal Land	7 500	
Commercial Land	1 500	
Other commercial farmland	1 500	
Forestry, etc.	100	


MAP 1: ELEPHANT DISTRIBUTION BASED ON
SKELETAL MATERIAL
SKELETAL MATERIAL:
BONE
MOLAR TOOTH
TUSK
FOSSIL


MAP 2: ELEPHANT DISTRIBUTION BASED ON
HISTORICAL RECORDS
RECORDS :
PLACENAMES
SIGHTING
HUNTING
REPORTING

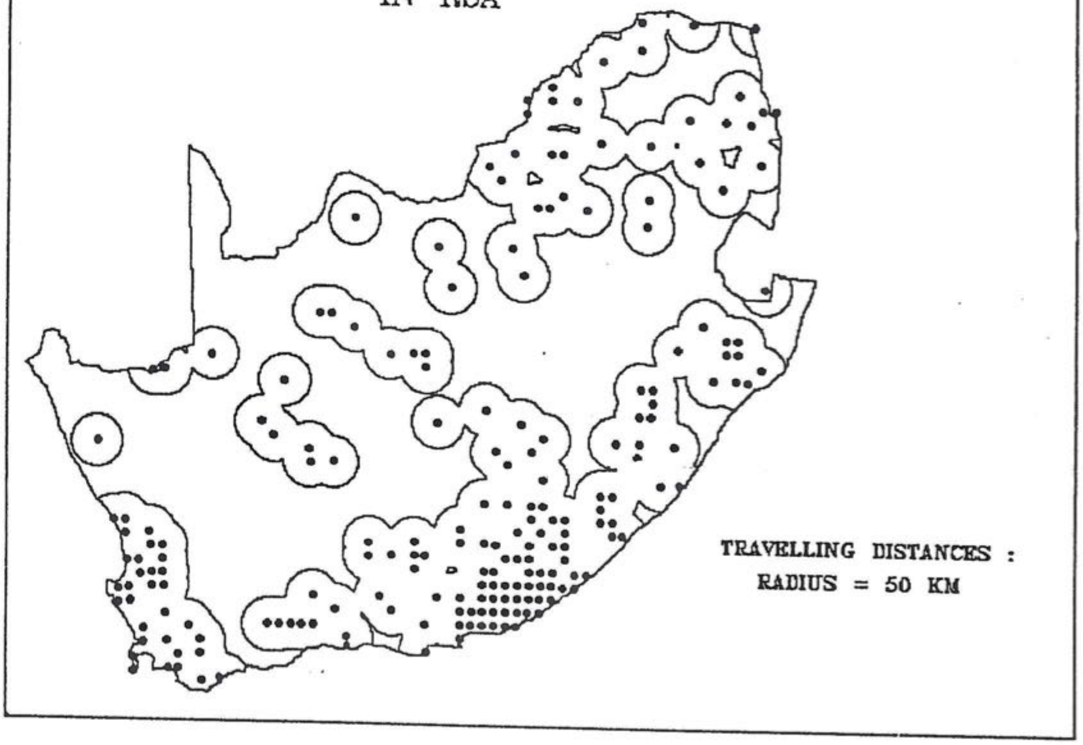


MAP 3: ELEPHANT DISTRIBUTION BASED ON INDIGENOUS ART

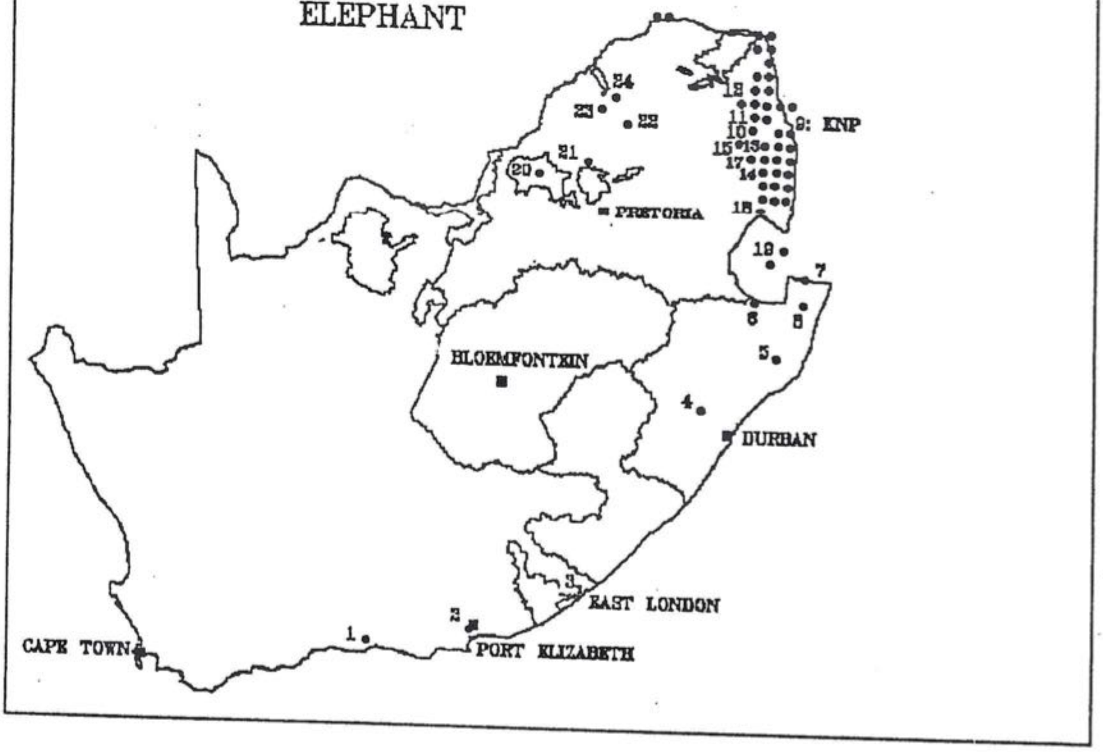


MAP 4: PAST DISTRIBUTION OF ELEPHANT

MAP 5: PAST DISTRIBUTION OF ELEPHANT IN RSA



MAP 6: PRESENT DISTRIBUTION OF ELEPHANT



Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

ELEPHANTS AND HABITATS

P J Viljoen[a]

Abstract: In the absence of man, the African elephant is one of the most successful mammals on the African continent. They are regarded as unspecialised herbivores with a high adaptability. Their optimum habitat can be described as mixed woodland and grassland with an adequate supply of fresh food and water. Generally, they fit well into the ecology and their influence can be to the advantage of other forms of wildlife. Continuous browsing by elephants keep most trees within reach of low-level feeders and at the same time stimulates coppicing. Germination success of *Acacia* seeds is improved by the elephant's digestive system and the seeds in elephant dung are a food source for gamebirds. By eating plants relatively unpalatable to other mammals, elephants also prevent thicket formation at the cost of more palatable plants. Elephants also open up paths through dense vegetation to choice food spots, enabling other animals to follow. During droughts many animals depend on waterholes dug and maintained by elephants.

INTRODUCTION

Elephants are generally regarded as woodland and forest inhabitants (Smith 1985) and they are notorious for their habitat destruction (Laws 1970). In this paper we will examine the above popular conceptions about elephants in more detail.

HABITAT REQUIREMENTS

Today's living representatives of the Proboscideans probably evolved from an ancestor in the West African forest (Laws 1970). The subsequent world-wide dispersal of the Proboscideans during the upper Pleistocene may well have coincided with the greater extension of forest areas which would have provided ready passages over the continents. Later, as the forest areas declined, the animals which displaced to the peripheral portions of the original range had to deal with increasingly demanding environmental conditions. As the conditions changed the animals in a specific area required the development of special modes of behaviour, which caused certain physiologic and morphologic adaptations. This was only possible for animals with appropriate adaptabilities.

The success of such adaptations can be seen in the African elephant *(Loxodonta africana)* which can no longer be regarded as restricted to forest areas. Indeed, until fairly recently, elephants could be found over the whole of Africa, from the "fynbos" of the Cape (Skead 1980) to the Sahara Desert in North Africa (Laws 1970). It was only through the interference of man that the elephants' distribution range became restricted. However, notwithstanding their present restricted distribution, elephants can today still be found in virtually every conceivable habitat that the African continent can offer. A notable exception is the strictly grassland biomes. They occur in country as diverse as the tropical forests of Central Africa to the extremely harsh conditions of the Namib Desert. They can still be found from sea level up to the mountains of Kilimanjaro, 3 300 m above sea level. They survive in areas with less than 150 mm of rainfall per annum and appear to be equally at home in areas with an annual rainfall of 2 000 mm or more.

---

[a] Game Production Ecology Unit, Grassland Research Centre, Private Bag X05, Lynn East, 0039, Rep. of South Africa

In addition, the African elephant is catholic in its choice of food plants and will eat what is available, being able to switch from browsing to grazing as conditions demand. Although the elephants have their preferences, most species lists of food plants are incomplete as the elephants will eat practically all plants and all parts of plants in an area. For instance in the northern Namib Desert, all plants recorded for the area were eaten at some stage with the notable exception of the poisonous *Euphorbia* spp (Viljoen 1990). Elephants are bulk feeders with a relatively inefficient digestive system and therefore require large quantities of food. They consume about 6% of their live weight in food on a daily basis. An average adult bull would require about 300 kg per day and an adult cow about 170 kg (Laws 1970).

The most important factor affecting or limiting year-round elephant distribution is water availability and distribution (eg. Laws 1970; Poche 1974). Most authors reported that elephants move a maximum distance of between 8 and 24 km from the nearest water supply (eg. Laws 1970; Young 1970; De Villiers 1981). In most studies it was also found that elephants drink regularly on a daily basis or even more often (Laws 1970; Poche 1974; De Villiers 1981), the exception being the elephant of the Kruger National Park where Young (1970) observed a mean drinking interval of 43,4 hours. It is also generally agreed that elephants are capable of going for long periods without water and a maximum of up to 72 hours is known (Young 1970; Poche 1974). However, recently it has been revealed that elephants in the northern Namib Desert (Viljoen 1989) can move up to 70 km (mean = 25,7 km) from the nearest water point and have drinking intervals of between 19 and 96 hours. Thus, coupled to the elephants' mobility (Viljoen 1989), there is a wide range in the drinking tolerances of elephants according to conditions of the area they occupy, resulting in a highly flexible survival strategy. This makes elephants less dependent on the proximity of water to food than other large mammals.

Elephants need large areas, as indicated by the observed home ranges for family groups which varied between 1871,6 km^2 in the northern Namib Desert with a rainfall of less than 150 mm per year (Viljoen 1989), to as little as 14 km^2 in Lake Manyara with an annual rainfall of 1 270 mm (Douglas-Hamilton 1972). In more moderate areas, for instance in the Middle Zambezi Valley with an annual rainfall of 802 mm, home ranges varied between 94 and 263 km^2 (Dunham 1986).

From the above it may be concluded that the optimum habitat for elephants would consist of a large area with mixed woodland and grassland and an adequate supply of fresh water together with large shade trees. The actual biotype as well as the species of food plants and the placing of waterholes is of less importance as the elephants can easily adapt to different conditions.

ECOLOGICAL SIGNIFICANCE

The African elephant is notorious for its destruction of habitat and there are many accounts of their destructive nature (eg. Laws 1970; Caughley 1976; Barnes 1983). Virtually all the cases of habitat destruction have been the result of human intervention by restricting elephant movements, causing overpopulation conditions. Notwithstanding, elephants are still popularly regarded as destructive creatures which generally are detrimental to their environment. This may have led to the overlooking of the more positive aspects of elephants and the fact that there are other natural factors of tree mortality, and that trees are not immortal. For example, Spinage & Guinness (1971) found that wind is a significant factor in the felling of mature trees whilst lightning causes damage to branches and crowns. In the northern Namib Desert, trees that were killed by floods and high winds were also erroneously attributed to elephants (Viljoen & Bothma 1990).

This paper then investigates other factors, apart from the popular view, arising from the elephants' presence in the environment as indicators of their role in the ecology of a region. For this purpose we will look at the experiences in the northern Namib Desert (Viljoen 1988) where the elephants' influence is more conspicuous than that of their conspecifics in the higher rainfall areas where most elephant studies have been conducted to date.

FEEDING

Feeding observations revealed that elephants almost invariably browse by breaking branches or stripping leaves from the trees and shrubs. Only occasionally are trees felled and small shrubs pulled or kicked out of the ground. Therefore, the elephants' major mode of feeding probably results in the formation and maintenance of low-growing shrubs. These low-growing trees and shrubs not only provide food for low-level browsers such as the greater kudu *(Tragelaphus strepsiceros)* and steenbok *(Raphicerus campestris)*, but also act as a refuge for smaller animals and as a reservoir for grass seeds. The latter was conspicuous in the desert in the 1981 drought when the only grasses and herbs that reached maturity in the dry river courses, grew within the perimeter of the low-growing shrubs while the surrounding area was grazed bare by other herbivores. Also, during the drought, domestic goats benefitted from the presence of elephants in an area by utilizing branches broken off by the elephants which would normally be out of reach for the goats.

The crude pruning effect of the elephants' feeding behaviour, by breaking off branches and stripping leaves, conceivably reduces the transpiration surface of the plants. As the browsing of woody plants usually coincides with the dry seasons (Viljoen 1989), this reduction in transpiration surface could enable especially evergreen plants to survive on the limited amount of water available during the dry periods. Browsing by elephants is also mainly outside the plants' growing period when fewer photosynthetic products are needed to produce new growth. With the onset of the wet season the elephants move out of the river courses to the flood plains (Viljoen 1989) and surrounding areas where they rely mainly on a grass diet (86% of all feeding observations, n = 236). The result is that the woody vegetation in the river courses is given a respite from browsing when entering its growth period. Also the crude pruning effect of the elephants during the dry season stimulates coppicing which leads to an increase in browse production (Barnes 1983) during the growth period.

Virtually all plants, with the exception of poisonous ones, are utilized by the elephants at some stage (Viljoen 1990). This includes plants, relatively unpalatable to other large mammals, which tend to form dense thickets at the cost of more palatable species. Especially in the drainage areas, the relatively unpalatable plants tend to form dense thickets on the edges, thus preventing animals from access to the lower-lying areas with food and water. By utilizing thicket-forming plant species the elephants prevent thicket formation to a considerable degree. The elephants also opened up paths through these thickets, enabling other large mammals to gain access to the inner food plants and water.

SEED UTILIZATION AND GERMINATION

Elephants show a high feeding preference for *Acacia* pods of which the seeds themselves seem to be little affected by the elephant's digestive system (only the pods are digested). Tests have shown that seeds in fresh elephant dung have a germination success as high as 58% against that of undigested pods with only 13% germination. The reason for this is that *Acacia* seeds have a hard testa which needs weathering or some sort of damage before water can penetrate (Carr 1976). This hard testa probably accounts for the low germination success of seeds from undigested pods. Seeds from elephant dung had the testa softened by the elephant's digestive fluids which facilitated water penetration and therefore germination. Since pod production and their utilization by elephants usually coincides with the wet season, seeds from fresh elephant dung are immediately ready and available for germination during the wet season. The new seedlings' root systems can resist flooding and by the time that the soil has dried out again the seeds from dung could already be established seedlings. The seeds from pods are unable to germinate during the first wet season and will be washed away or otherwise destroyed.

Many other animals also utilize *Acacia* pods. However, it would be reasonable to assume that the dying-off of partially germinated seeds in the smaller dung of the other herbivores would be more rapid due to a faster drying rate. The larger bulk and thus slower drying rate of elephant dung will ensure that the newly germinated seeds have moisture available for at least four days (personal observation) by which time their roots could have penetrated the soil underneath. In addition, during the dry season, the seeds in elephant dung are not wasted as many birds such as the red-billed francolin *(Francolinus adspersus)*, helmeted guinea-fowl *(Numida meleagris)* and rock pigeons *(Columba guinea)* eat them. These birds seem to be unable to open up the fresh pods to gain access to the seeds. Especially the francolin seemed to rely on this food source during the 1981 drought in the desert and were observed to wait patiently for the elephants to defaecate, after which they immediately scratched open the dung to eat the seeds.

The curious phenomenon of *Acacia albida* trees that often grow in short straight lines of five or more trees in the dry river beds of the northern Namib Desert is of interest and might also be ascribed to elephant action. This is especially conspicuous in the Hoanib and Hoarusib Rivers where elephants occurred in abundance (Viljoen 1987). During the first flood of a season, elephants often leave deep tracks (0,2 to 0,7 m) in the river mud. During further floods these holes conceivably act as seed traps which are subsequently filled up with silt; an ideal microenvironment for seed germination. Since the tracks left by elephants in the mud are usually in a relatively straight line, this may explain the common occurrence of short rows of *Acacia albida* trees in these river beds.

WATERHOLES

Apart from Hartmann zebras *(Equus zebra hartmannae)* (most of which either died or migrated east during the drought), and to a lesser extent the black rhinoceros *(Diceros bicornis)*, the elephant was the only other animal in the northern Namib Desert able to dig for its water to a considerable depth. In the sandy river beds, holes which were started by the elephants using the front feet were further excavated with the trunk to a depth of 2 m. In some areas these waterholes dug by the elephants provided the only drinking water for a radius of 40 km or more. Numerous animals depended on these waterholes for survival, and in cases where the sandy holes collapsed, birds and other small mammals could often be seen waiting around these holes for the elephants to return to open them up again.

Open waterholes were sometimes soiled by the elephants wallowing and urinating in them. However, the elephants themselves apparently prefer clean drinking water as they almost invariably dug fresh waterholes next to the soiled ones. As a result there was almost always fresh drinking water available to other animals in such an area.

The likely importance of elephant-dug waterholes to other forms of wildlife can be illustrated from the northern Kaokoveld where the extermination of elephants in 1980 (Viljoen 1987) coincided with the disappearance of the black-faced impala *(Aepyceros melampus petersi)* (Viljoen 1982a) in that area. In this area the elephants used to dig and maintain waterholes in the dry river beds. With the extermination of the elephants in this area this no longer happened and this might well have been one of the reasons for the disappearance of the water-dependent black-faced impala in that region.

CONCLUSIONS

The African elephant can be regarded as an unspecialised herbivore which can easily adapt to different environmental conditions. Its large size protects it from virtually all predators (except man) and this together with its mobility (Viljoen 1989), intricate social system and high adaptability make it one of the most successful mammals on the African continent. The African elephant's adaptability was clearly illustrated in the northern Namib Desert which is regarded as unsuitable for elephant. Between 1977 and 1981 the region experienced one of the worst droughts in human memory when the annual rainfall averaged between 31 and 100 % below the annual long-term mean. The magnitude of this drought is well illustrated by the fact that more than 80 % of the other large mammals in the desert died (Viljoen 1982b). As far as could be ascertained not one desert-dwelling elephant died as a result of this drought. It was during this drought that the elephants' role in the desert environment became conspicuous.

Thus, they can survive in virtually any habitat type and there can be no preconceived 'recipe' to restrict the elephant to a specific habitat type. The view of some people that the Knysna forest is unsuitable for elephant is refuted by the successful occupation of the tropical forests of central Africa by elephants. In the latter area, similar conditions regarding nutrients prevail and these elephants appear to be well adapted to the forest conditions. True, the Knysna forest on its own is perhaps not the ideal habitat since the elephants are prevented from utilizing the ecotone areas but is is highly unlikely that poor nutrition was the cause of the population decline. All over Africa it has been shown that the decline in elephant numbers is mostly because of human interference and not because of adverse environmental conditions. Human interference in the form of direct killing and disturbance, but mostly by habitat destruction and by restricting elephants to a specific area is probably the root cause of the decline in elephant numbers. This is borne out by the spectacular recovery of elephant populations in most game reserves where human disturbances have been eliminated.

Generally elephants fit well into the environment and probably are a vital link in the ecology of an area. As Spinage & Guinness (1971) rightly pointed out, apart from the spectacular impact of the elephants on the vegetation, the more positive aspects of the elephant's influence on their environment is often overlooked and it is not generally considered that elephants might well play a vital role in the ecology of a given environment. It is not the aim of this paper to exonerate elephants from all blame of habitat destruction, but to draw attention to other factors arising from the elephants' presence in an area which certainly justifies investigation, before attributing only negative influences to the elephants.

ACKNOWLEDGEMENTS

This study was conducted under the auspices of the Eugene Marais Chair of Wildlife Management of the University of Pretoria. I would also like to thank the Grassland Research Centre of the Department of Agricultural Development for allowing me to deliver this paper.

REFERENCES

Barnes, R.F.W. 1983. The elephant problem in Ruaha National Park, Tanzania. *Biological Conservation* 26: 127

Carr, J.D. 1976. *The South African Acacias*. Johannesburg: Conservation Press. 323 pp

Caughley, G. 1976. The elephant problem - an alternative hypothesis. *East African Wildlife Journal* 14: 256-283

De Villiers, P.A. 1981. *Eto-ekologiese aspekte van olifante in die Nasionale Etoshawildtuin, SWA.* MSc thesis, University of the Orange Free State, Bloemfontein. 130 pp

Douglas-Hamilton, I. 1972. *On the ecology and behaviour of the African elephant.* D.Phil thesis, Oxford University. 339 pp

Dunham, K.M. 1986. Movements of elephant cows in the unflooded Middle Zambezi Valley, Zimbabwe. *African Journal of Ecology* 24: 287-291

Laws, R.M. 1970. Elephants as agents of habitat and landscape change in East Africa. *Oikos* 21: 1-15

Poche, R.M. 1974. Ecology of the African Elephant in Niger, West Africa. *Mammalia* 38: 367-380

Skead, C.J. 1980. *Historical mammal incidence in the Cape Province. Volume 1.* The Department of Nature and Environmental Conservation of the Provincial Administration of the Cape of Good Hope Publication. 903 pp

Smith, S.J. 1985. *The atlas of Africa's principal mammals.* Fourways: Natural History Books. 241 pp

Spinage, C.A. & Guinness, F.E. 1971 Tree survival in the absence of elephants in the Akagera National Park, Rwanda. *Journal of Applied Ecology* 8: 723-728

Viljoen, P.J. 1982a. The distribution and population status of the larger mammals in Kaokoland, SWA/ Namibia. *Cimbebasia* 7: 5-33

Viljoen, P.J. 1982b. *Western Kaokoland, Damaraland and the Skeleton Coast Park aerial game census.* Namibia Wildlife Trust Publication. 30 pp

Viljoen, P.J. 1987. Status and past and present distribution of elephants in the Kaokoveld, SWA/ Namibia. *South African Journal of Zoology* 22: 247-257

Viljoen, P.J. 1988. *The ecology of the desert-dwelling elephants Loxodonta africana of western Damaraland and Kaokoland.* DSc dissertation, University of Pretoria. 335 pp

Viljoen, P.J. 1989. Spatial distribution and movements of elephants *(Loxodonta africana)* in the northern Namib Desert region of the Kaokoveld, SWA/Namibia. *Journal of Zoology, London* 219: 1-9

Viljoen, P.J. 1990. Habitat selection and preferred food plants of a desert-dwelling elephant population in the northern Namib Desert, SWA/Namibia. *African Journal of Ecology* 27: 227-240

Viljoen, P.J. & Bothma, J. du P. 1990. The influence of desert-dwelling elephants on vegetation in the northern Namib Desert, SWA/Namibia. *Journal of Arid Environments* 18: 85-92

Young, E. 1970. *Water as faktor in die ekologie van wild in die Nasionale Krugerwildtuin.* DSc(Wildlife Management) dissertation, University of Pretoria. 192 pp

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

FACTORS THAT MAY INFLUENCE THE ESTABLISHMENT OF NEW ELEPHANT POPULATIONS ONTO PRIVATE LAND

C H Walker[a]

With the recent decision to allow private landowners to introduce young elephants onto their properties, the potential for the National Parks Board of South Africa to find additional markets locally for young elephants resulting from culling operations, has been considerably enhanced.

In the light of the world's present concern for the African elephant and the decline in the international ivory trade, the loss of revenue to the National Parks Board is likely to be considerable and whilst there is no possibility, we are led to believe, of large numbers of elephants being offered for sale, it will nevertheless fill part of the vacuum. The sale of young elephants is not likely to match the income from ivory sales, but it will provide an alternative source of revenue.

New populations have been established in the Umfolozi/Hluhluwe complex, Sabie-Sand Game Reserve, Pilanesberg National Park (which first saw serious efforts to re-establish elephant) and now recently, Itala Game Reserve in northern Natal, under the control of the Natal Parks Board and the Letaba Game Reserve, which is adjacent to the Kruger National Park. Private reserves have begun introductions in both Mabula and Touchstone in the Waterberg Mountains, to name a few, and are amongst the first under the new legislation, which requries a minimum-sized property and the perimeter fences electrified, in the Transvaal.

In the light of the enormous interest and widespread fear about the demise of the African elephant outside of southern Africa, some interesting questions and suggestions are posed.

We know of the intelligence and social structure within elephant societies and more recently their ability to communicate subsonically. However, there are clearly many aspects relating to elephants that science still has a good deal to learn about. How much money, if any, has ever been spent either by South Africa or Zimbabwe on for instance studying the psychological aspects of culling and its possible effects on elephant populations? South Africa has been culling elephants for nearly two decades and whole generations have grown up into this system. If elephants are able to communicate subsonically and if researchers are correct, over some considerable distance, then surely the possibility exists for elephants to know something about culling? The fact that whole family units are wiped out in order to destroy the memory of the act, would surely not apply as not all elephants die.

Do we know enough about these aspects and if not, could funds not be derived from the sale of young elephants and applied in this direction? I posed similar questions regarding the psychological and behavioural aspects on culling to Dr Anthony Hall-Martin many years ago and enquired if any research had ever taken place. The answer at the time was negative and I have no reason to believe that this situation has since changed. The trauma of culling cannot be minimised and the effects of this are no doubt carried over into their move to a new home. Young elephants between the ages of three and four years, are certainly not going to have the benefit of their mother's wisdom and experience once this element is removed. Certainly they do tame down in captivity, but once released into the wild without parental influence, it must have some effect upon them.

One recognises that they are adaptive creatures and learn quickly, but do we know enough of their ability to adapt under these circumstances? It would seem to me that the use of older elephants such as the two who came back from the United States of America and were introduced to

[a] Rhino and Elephant Foundation, PO Box 381, Bedfordview, 2008, Rep. of South Africa

Pilanesberg, has some merit. These animals assumed the matriarchal role and have had considerable influence over the introduced offspring of culled elephants. Lapalala Wilderness introduced three young elephants between the age of five and six years, during December 1989. This could have proved a good case study for the introduction of younger, far wilder elephants; however, legislation had not come into effect in time and being unable to keep them, a golden opportunity was lost. Touchstone Game Reserve acquired ten elephants early last year and these animals displayed the usual fear, nervousness and aggression. However, these emotions were gradually to subside whilst they were housed in bomas to the point where they would feed from one's hand. The interesting point here will be to see how they respond now that they have been released into a larger tract of wild country. It may very well be impractical to have foster parents for all introductions and far too costly to maintain them in bomas for indefinite periods of time. My point is that if this is to become an ongoing practice and I have no doubt that it will, I believe ways should be sought to minimise trauma and to ensure that translocations of young elephants are far less stressful. If larger elephants can be moved around for shows, book launches, promotions, etc. then could they not be used in translocations?

It is clear that we have the potential in southern Africa to re-establish elephants in many new areas especially on private land. Before proceeding with my topic, let us look at South Arica's 17 elephant ranges:

i) **National Parks**
Proclaimed under the National Parks Act of the South African Parliament

Kruger National Park	1 948 528 ha	
Addo Elephant National Park	8 596 ha	**1 957 124 ha**

ii) **National Parks or Game Reserves**
Proclaimed under legislation of independent or self-governing states within South Africa

Pilanesberg Nat Park, Bophuthatswana	58 000 ha	
Tembe Elephant Park, Kwazulu	29 878 ha	
Makuya Nat Park, Venda	18 500 ha	
Letaba Ranch, Gazankulu	40 000 ha	
Andover Game Reserve, Gazankulu	7 100 ha	**153 478 ha**

iii) **Game Reserves**
Proclaimed under legislation of Provincial Governments

Hluhluwe/Umfolozi Game Reserve, Natal	90 000 ha	
Itala Game Reserve, Natal	30 000 ha	**120 000 ha**

iv) **Forestry Reserve**
Proclaimed under legislation of the South African Parliament

Knysna Forest Reserve	30 000 ha	**30 000 ha**

v) **Privately owned land**
Proclaimed as private nature reserves

Foskor/Phalaborwa Mining	4 100 ha	
Sabie-Sand Private Nature Reserve	57 200 ha	
Klaserie Private Nature Reserve	62 818 ha	
Timbavati Private Nature Reserve	78 495 ha	
Mabula Lodge	10 000 ha	
Mpongo Park	2 500 ha	
Touchstone Game Ranch	2 000 ha	**217 113 ha**
	TOTAL	**2 477 715 ha**

The potential to increase elephant populations on both State and private land is good:

Addo Elephant National Park	1 633 ha
Vaalbos National Park	25 000 ha
Kransberg National Park	25 000 ha
Touchstone Game Ranch	16 000 ha
Lapalala Wilderness	24 000 ha
Venetia	30 000 ha
Rooipoort	42 000 ha

to name a few.

It is in the private sector area that good potential still lies over the next decade.

The regulations governing the introduction of elephants onto private land specify a minimum size of 2 000 ha and the electrification of the perimeter of the sanctuary in question. The number of animals suggested is five or six. I have a problem here in that some very fundamental issues are not being addressed. Two thousand hectares strikes me as being far too small, for once they are fully grown and commence breeding, problems are eventually going to be experienced. A full-grown bull elephant is difficult to move over any great distance, thus minimising the chance of translocation. What are the effects on the habitat, which is the reason the family unit was culled in the first place?

The Rhino and Elephant Foundation are interested in supporting a PhD project by Marion Garai, dealing specifically with behavioural aspects of translocated elephants with some of the following questions being sought:

I. *Behavioural - ecological questions*
How have the translocated elephants adapted to their new habitat? How do the groups learn about seasonal (or daily) feeding areas since no matriarch was present to teach them? Is there a breeding season and if so, how is it related to the ecological and climatic factors? How is breeding related to these factors?

2. *Group formation*
How have the elephants grouped themselves; how is leadership assumed and who assumes it when no matriarch is present? Is the average group size larger or smaller than would be expected and is there a dominance hierarchy and how is it established?

3. *Stability*
Are the groups short-termed and more flexible than usual family units? Are newly-translocated individuals integrated into existing groups and if so, how? (aggression, bonds or coalitions). Or do they form their own groups and are these stable or flexible?

4. Do certain individuals form special relationships as compensation for non-existing relatives? Are these bonds long-termed and do the partners help each other in danger and infant care?

5. Assuming that increment is inversely correlated to population density, do females breed earlier and is there a shorter intercalving period than in the areas where the elephants originated (eg Kruger Park)? Or is the breeding age higher or lower due to absence of old cows or old bulls?

6. Is there a higher infant mortality due to lack of suitable helpers, or have the elephants compensated for this by forming special relationships?

7. Assuming a lack of old experienced cows, how do infants and juveniles learn the mechanisms of intricate social life? Is there more communication between young group members, does each individual learn by trial and error, or do certain individuals communicate

newly-acquired abilities to other group members (perhaps using the mechanisms occurring from mother to infant)?

I believe there is an important case for looking into these aspects. I also believe that if indeed we are serious about elephant conservation, then we must consider these factors; here I am talking specifically about the private landowner.

In addition to the above, serious thought must be given to ecological factors. For instance, the habitat and the effects by elephants on the available resource and of course the possibility of certain species of plants disappearing completely. Having a few elephants wander around your private game reserve sounds nice and will no doubt impress one's guests, but could hardly be termed as elephant conservation and I would like to think the authorities would firstly consider these aspects before anyone is granted a permit to keep these animals or before selling them in the first place.

ACKNOWLEDGEMENTS

The author wishes to thank Dr A Hall-Martin of the National Parks Board of South Africa, for assisting in the preparation of this paper and Dr H Ebedes of the Department of Agricultural Development, as well as Marion Garai, for additional data.

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

THE INTRODUCTION OF ELEPHANT INTO MEDIUM-SIZED CONSERVATION AREAS

J L Anderson[a]

INTRODUCTION

There is no clear definition as to what constitutes a medium-sized reserve, so for the purposes of this paper it will be regarded as being reserves greater than 5 000 ha but smaller than 100 000 ha. There are currently a number of reserves in South Africa which fall into this size category. As most of these have habitats suitable for elephant, it can be appreciated that there is considerable potential for the re-distribution of the species in the region.

JUSTIFICATION FOR THE INTRODUCTION OF ELEPHANT

The re-introduction of elephant should only be considered if one of the objectives of the reserve is to re-establish the wildlife community which formerly occurred in the area, and that sufficient grounds exist to accept that the species did formerly occur. Once this has been established, there are secondary reasons which should be considered, namely the ecological importance of the role elephant will play in the system and the enhanced value of the species for visitors.

Recent evidence has indicated (Whateley & Wills *in press*) that the prolonged absence of elephant from the Hluhluwe/Umfolozi Complex has been a major reason behind the vegetation succession towards thicket and close woodland. It is possible that further investigation will show that this phenomenon is more widespread.

It is considered very acceptable that elephant are re-established primarily for their visitor appeal. Revenues generated from tourism are becoming increasingly important in assuring the viability of conservation areas and if the re-introduction of elephant is likely to be a positive factor in "balancing the budget", their re-introduction should be automatic.

The experiences of the large-scale re-introductions into Pilanesberg National Park and the Hluhluwe/Umfolozi Complex perhaps encapsulate all the problems that are likely to be involved in a project of this nature.

PILANESBERG NATIONAL PARK

The first introduction of elephant into Pilanesberg was not preceded by a specific plan for the operation. Four animals of between three and five years of age were introduced from Addo National park. As the perimeter fence of the Game Reserve had not been completed, they were released into a holding camp of approximately 700 ha. Shortly after their release, an incident occurred during which the animals were harassed and one young male broke through the perimeter fence. Three days later, it had travelled over 50 km and was involved in the tragic death of a farmer.

The remaining animals were recaptured and held in a small boma to await the completion of the perimeter fence. During this period they were fed contaminated food and a second animal died. The two survivors were immediately released into the original holding camp. This was in September when food quality and availability were at their lowest and was compounded by the fact that the holding camp was heavily stocked with other ungulates. Within days one of the two had died of

[a] KaNgwane Parks Board, PO Box 1990, Nelspruit, 1200, Rep. of South Africa

starvation and the lone survivor was recaptured and again transferred back to the boma. This was followed by a change in senior management of the Park, and the animal was released in December when food quality and availability were optimal. Thereafter, no further problems were experienced with the animal.

After the perimeter fence had been completed, a further introduction was planned with animals to come from the Kruger National Park. A large and substantial boma was constructed in the centre of the Park, and the animals which were received in June were held until November before their release.

Several of these animals had been selected for overseas export when captured and were considered to be small for release into the wild. However, with the cancellation of their purchase, they were included with the animals to be introduced. It was not surprising that of these smaller animals did not survive the following winter.

Table 1: The introduction of elephant to Pilanesberg National Park and known mortality.

YEAR	NUMBER	AGE	SOURCE	RECORDED DEATHS
1980	4	Juvenile	Addo Elephant NP	3
1981	18	Juvenile	Kruger NP	5
1982	2	Adult	Kruger NP	0
1983	14	Juvenile	Kruger NP	1
1983	2	Juvenile	Namibia	0
TOTAL	**40**			**9**

The following year two circus-trained animals, both 18-year-old females originally from the Kruger National Park, were successfully re-introduced (Moore & Munnion 1989). The re-acclimatization to the wild was a gradual process accomplished most successfully by their trainer and owner Randall Moore. On their release, these animals took over the leadership of the younger animals released the previous year and behaved as wild elephants.

In 1983 the introduction of a further 14 animals from Kruger National Park took place, these were larger than those in the first introduction and only one animal was lost. This animal was suspected of having been killed by a rhino. On their release these joined the group led by the two adult females.

During the same year a further two tame Namibian bull elephants, approximately five years of age, were donated by the SA Police. These both settled down without any problem.

The first calf was born in 1989 to one of the animals from those introduced directly from Kruger. A second was born during 1990, and a third early in 1991.

The Pilanesberg elephants have remained fairly shy and keep to the wilderness zone of the Park. Recently, a group of 10 young bulls formed which ranges more widely than the females and young[b]. After the debacle of the first release, the re-introduction must be considered as being highly successful. The mortalities in the Kruger National Park introductions were perceived as being because several of the animals were considered too young to survive without supplementary feed.

[b] R Keffen, 1991, Pilanesberg National Park, PO Box 1201, Mogwase, 0302, Rep. of South Africa.

HLUHLUWE/UMFOLOZI COMPLEX

The re-introduction of elephant into the Hluhluwe/Umfolozi Complex commenced in 1974 with a detailed motivation from the Field and Research staff. After satisfactorily resolving the concerns of the Parks Board's senior management, and drawing up a detailed plan for the introduction and subsequent monitoring, the first animals were re-introduced in July 1981.

They were released into a holding boma 20 m x 20 m in extent and after five days let into a 200 m square paddock for two months.

By November 1985, 30 animals had been introduced to Umfolozi with 27 surviving and 26 to Hluhluwe with 18 surviving.

With the experience of the existing introduction, much of the official concern about animals breaking out of the complex was allayed. Greater importance was placed on the role an elephant population would play in the vegetation management of the area. This resulted in a strong motivation to increase the numbers to 150 animals to be introduced[c]
. This was implemented in subsequent years and these introductions are summarised in Table 2.

Table 2: The introduction of elephant into the Hluhluwe/Umfolozi Complex and known mortality

YEAR	HLUHLUWE	UMFOLOZI	RECORDED DEATHS
1981	8	-	4
1983	8	-	4
1984	10	-	1
1985	-	30	7
1986	6	-	1
1987	18	-	0
1988	-	34	5
1989	35	-	0
1990	-	23	0

FACTORS TO BE CONSIDERED IN ANY RE-INTRODUCTION

Habitat evaluation and stocking levels

Woodland is considered to be an essential element as it was favoured by all the introduced populations. Allowing for the fact that the introduced population would eventually have to be managed, the number introduced to Pilanesberg was that which had been set as being the desired carrying capacity. In the Hluhluwe/Umfolozi re-introduction, the possible beneficial impact of elephant in the control of thicket encroachment was highlighted as one of the major reasons supporting the introduction.

Attitude of neighbours

The attitude of a reserve's neighbours towards any proposed re-introduction of elephant must be considered. This attitude will be affected by the type of land-use being practised, and the socio-economic situation of the community. For example, sugar farmers will view the introduction

[c] A Wills, 1986, Bophuthatswana Parks Board, P/Bag X2078, Mafikeng, 8670, Rep. of South Africa, pers comm.

of elephant in a different light to cattle ranchers. To avoid any adverse attitudes, the introduction should be preceded by an information programme in the community informing the people of the details of the operation, the reasons behind it and the measures which will be taken to safeguard their interests.

Fencing

The standard of the perimeter fence must be addressed. As a general rule, the smaller the reserve, the more substantial the fence required. This is because in smaller reserves, there is likely to be greater degree of contact with the fence.

Some reserves, such as Pilanesberg, have erected fences which are strong enough to prove to be a physical deterrent. However, more recently the eletrification of fences has shown that such impenetrable barriers are not essential provided animals are "trained" to respect a fence.

Bomas

In all the re-introductions into medium-sized reserves, the animals have been held for varying lengths of time prior to release. It is advisable to have the training boma appear as similar as possible to the boundary fence, although it may be substantially stronger.

In Pilanesberg and in Hluhluwe/Umfolozi the bomas were not electrified but were stronger than the boundary fence to which they bore little resemblance. In Mthethomusha, KaNgwane, the boma was closer in appearance to the perimeter fence but was electrified. Also, on the release into the boma in Mthethomusha, the fence was visually strengthened with game capture plastic which was only removed four days after the animals settled down and had already been in contact with the electric wires.

A month in the bomas should be considered as a minimum period for the animals to be held before release. The release itself should be accomplished by simply opening the bomas and allowing the animals to find their own way out. Disturbance at the release should be kept to a minimum.

Timing the release

The phenology of the vegetation must be taken into account in the release of the animals. Wherever possible, the release should be timed to occur when there is widespread water and food quality is higher, i.e. shortly after commencement of the rainy season.

Genetic considerations

In their objectives most conservation areas take cognisance of the World Conservation Strategy, and its goal to "preserve genetic diversity". In addition to this, considerable attention has been taken of the need to preserve the genetic integrity of species populations. In Pilanesberg, the first animals to be introduced were from Addo. When the remaining bull from this population was to be joined by a larger introduction from the Kruger National Park, serious consideration was given to removing him to avoid mixing Addo and Kruger genes. It was then concluded that historically there would have been contact between these populations, and to allow them to mix would allow for the restoration of a gene flow which existed before the populations were fragmented. Similarly the later introduction of two males from Namibia was viewed in the same light.

All other introductions into medium sized reserves have been confined to animals from the Kruger National Park. These populations will not improve the genetic diversity of the Kruger population.

Animal size

The larger the animals are, the greater their chances of survival. Currently, the National Parks Board are successfully catching and relocating animals 2 m high at the shoulder. The trained adult animals introduced into Pilanesberg added a new dimension to re-establishing elephant populations.

Group size and leadership

With their close-knit matriarchal social structure, there is considerable stress on young animals which are relocated. Large animals in a group are followed by the younger ones as a substitute for the parental leadership. The leadership given by the two adult cows in Pilanesberg to a large group of young animals was a graphic illustration of the need for this.

The view expressed by Wills that larger groups experience lower mortality than smaller ones should be noted, especially where animals are to be introduced into areas which carry lion and spotted hyena.

ACKNOWLEDGEMENTS

I am grateful to the Bophuthatswana Parks Board and the Natal Parks, Game and Fish Preservation Board for providing most of the information used above. Also to Dr Bob Keffen and Alf Wills for their comments and assistance, and to Rose Friend who typed the manuscript.

REFERENCES

Moore, R.J. & Munnion, C. 1989. *Back to Africa*. Johannesburg: Southern Books. 155 pp
Whately, A. & Wills, A. Succession in a sub-tropical woodland. *South African Journal of Ecology* 2 (in press)

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

THE AFRICAN ELEPHANT: LEGISLATION AND MANAGEMENT

P F S Mulder[a]

INTRODUCTION

The African elephant is presently one of the most controversial forms of life on our planet. Its survival has become a symbol of the dire consequences of the population explosion, resulting environmental degradation and human greed. Over the last five years it has become the subject of highly emotional debate and in the process utilized as a vehicle for political gains and to a large extent an issue to fill the coffers of societies and organisations who exploit human conscience and emotions. Too often carefully selected facts and individual views cloud the real issue which is to ensure the future of these magnificent animals in the most practical manner. In an African context this is best summed up by the following quotation:

> "However, the prescriptions now being put forward as panaceas for the salvation of Africa's wildlife, threaten to be hazardous for both the wildlife and people of Africa if they fail to take into account the social context in which they are to be applied. For its part the public at large must temper its enthusiasm for conservation with a sober understanding of the politics of conservation and the history of outside intervention" (McGregor 1989).

LEGISLATION AND MANAGEMENT

Between the extreme view of setting aside all land for the increasing human populations and the puristic view that renewable resources are sacrosanct, the modern day conservationist has to legislate and devise policies to safeguard the future of all threatened species. This of course is an enormous undertaking when considering the social, ecological and financial implications.

The South African experience is that the following basic principles form the basis for sound legislation and represent compromises to satisfy all involved.

Consumptive utilization

The utilization of renewable resources is an internationally accepted principle and forms an integral part of the conservation strategy in most countries. South African legislators have afforded the elephant protected or specially protected status and strict measures govern the utilization of the species and its products.

These include the mandatory registration and marking of all legal stocks of ivory, the hunting of specific quotas of elephant based on scientific surveys and controlling the international trade in accordance with the Convention.

Adequate penalties for transgressions

The lucrative illegal trade in ivory and resulting indiscriminate poaching of elephant are major concerns in countries with resident populations. Penalties of a R100 000 fine and/or 10 years imprisonment have been, or are in the process of being, implemented in South Africa by the conservation authorities. It is also supplemented by mandatory forfeiture of the products and

[a] Transvaal Chief Directorate: Nature and Environmental Conservation, Private Bag X209, Pretoria, 0001, Rep. of South Africa

compensation in respect of damages resulting from the loss of the animals concerned. Whether these represent adequate deterrents is debatable when compared to measures in other countries. In Namibia fines of R100 000 and/or 20-year terms of imprisonment can be imposed. If poaching does become a threat in South Africa these penalties will obviously be reviewed.

Private sector and community involvement

In terms of the South African Common Law, game is termed as *Res nullius* which means that ownership can only be acquired when taking legal possession of the animal.

As custodians of this renewal resource, the various conservation authorities are empowered to legislate for the protection of species and to provide for the legal utilisation thereof. Legislation to facilitate the responsible utilization of elephant in this country has largely contributed to enhancing the viability of existing populations and expanding the distribution of herds. Except for the populations in the Kruger National Park (KNP) and Pilanesberg National Park, all other populations occur on private land. More than 250 young elephant have been distributed from the KNP and many thereof have been introduced on private land. An annual quota of between 5 and 18 elephant is hunted in the areas adjacent to the KNP and the income thereof is utilized for conservation projects and community development. This important concept is also enshrined in Zimbabwe's Parks and Wild Life Act (1975), which gives private landowners the responsibility for the conservation and use of wildlife subject to certain broad controls.

The non-utilization of this very valuable resource in countries such as Kenya will no doubt have a serious backlash. The unhindered growth will doom these populations more surely than selective killing for profit (Walsh 1991).

It can be predicted that the entrustment of elephant to landowners would result in the same success as was achieved with the rhino. At present more than 80 % of the growing rhino population in the Transvaal is in private hands and South Africa is virtually the only country in the world where the species can be hunted legally.

Infrastructure and expertise

Protective legislation is meaningless if it is not effectively enforced. South Africa is fortunate in that trained manpower is present throughout the country. The four provinces alone employ more than 700 nature conservators and foresters (backed by more than 150 nature conservation scientists) capable of law enforcement and to provide extention services. Special units have already been established to concentrate on the illegal utilization of rare and endangered species. Technology has kept abreast of specific problems associated with the trade and isotope sourcing and age determination of ivory are techniques available to combat the problem. Backed by various universities and scientific institutions, census techniques and in- depth studies on the ecology of the species have resulted in comprehensive data bases being available for decision making. There is no doubt that South Africa is a leader in this field.

INTERNATIONAL TRADE

The emotional debate on the banning of the ivory trade necessitates a review of the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

As its title indicates, the Convention is aimed at enhancing the survival of species through the control and co-ordination of trade in the species and their products. At present more than 100 countries have signed the Convention, South Africa being one of the first to do so.

In terms of the Convention species are listed in Appendices and a copy of the criteria for listing is attached.

Prior to the Conference of Parties in 1989 the elephant was listed in Appendix II which allowed the trade of raw ivory under a quota system. From 1986 to 1989 South Africa exported almost 10 000 raw and carved tusks from legally registerd stocks in private possession and from culling operations in the KNP. At this Conference of Parties however, it was decided to list the elephant in Appendix I and to impose a total ban on the trade in all products of the species. This was seen as the only way in which the uncontrolled slaughter of elephant in large areas of Africa could be presented. South Africa together with several other African countries and China registered a reservation as it did not accept this stringent measure. The reasons are set out above. A self-imposed moratorium was, however, decided on and presently no consignments of ivory are exported.

The present legal situation as regards to the export of ivory and elephant products is as follows:

- legally obtained hunting trophies may be exported providing that the country of export has obtained a quota for the year and that the importing country issues a CITES import permit prior to the granting of an export permit. South Africa has been granted an export quota for 18 animals;

- technically speaking, worked ivory can be exported if these objects are not for primarily commercial purposes i.e. for resale purposes. There is, however, the proviso that an import permit must first be obtained from the authorities in the country of import (see above);

- ivory acquired legally before the provisions of the present Convention applied to that specimen;

- specimens bred in captivity for commercial purposes; and

- certain household possessions;

- non-commercial loan, exchange and donation between scientists and registered scientific institutions.

Having formally lodged a reservation in respect of the elephant, South Africa is not bound by the Convention for this species. This means that it can trade in these products and live specimens at will. In the spirit of the Convention, however, it has been decided to impose a moratorium and an all out attempt will be made at the next Conference of Parties in 1992 to have its elephant population put on Appendix 11. This would enable the Republic to once again trade in terms of the Convention.

REFERENCES

MacGregor, J. 1989. The paradoxes of wildlife conservation in Africa, Africa. *Insight* 19(4): 201-211

Walsh, J. 1991. Loving the Jumbo to death. *Time*, March 1991, pp 68-69

ARTICLE II

FUNDAMENTAL PRINCIPLES

1. Appendix I shall include all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances.

2. Appendix II shall include:

   a) All species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival; and

   b) other species which must be subject to regulation in order that trade in specimens of certain species referred to in sub-paragraph a) of this paragraph may be brought under effective control.

3. Appendix III shall include all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the co-operation of other parties in the control of trade

4. The Parties shall not allow trade in specimens of species included in Appendixes I, II and III except in accordance with the provisions of the present Convention.

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

AN EVALUATION OF CULLING TECHNIQUES FOR FREE-RANGING AFRICAN ELEPHANT *(Loxodonta africana)*

V de Vos[a] and J Hattingh[b]

INTRODUCTION

When the Sabie Game Reserve, which later became the Kruger National Park (KNP) was proclaimed in 1898, elephants *(Loxodonta africana)* had been virtually eliminated by hunters (Stevenson-Hamilton 1911, 1937, 1957). In 1905 the first warden of the Reserve located about 10 elephant in the inhospitable country between the Letaba and Olifants Rivers. By 1912 it had reached 125. Over the next 50 years the elephant population increased steadily, benefiting from complete protection and an influx from beyond the borders of the KNP (Pienaar 1983). In the early 1960's, a period which coincided with an extended and severe drought, the first signs of over-utilization of the vegetation by elephants in the KNP were witnessed (Pienaar 1983). This gave rise to the decision in 1965 to control elephant numbers in the KNP and is based on the belief that elephants are but one of the many components of the KNP ecosytem which should be preserved and that elephants should not be allowed uninhibited increase beyond the limits where it may adversely affect other components of the ecosystem, especially during drought periods. The ceiling was subsequently set at 7 500 and the control programme commenced in 1967 (Pienaar 1983; De Vos *et al.* 1983).

Other areas in Africa where elephant were protected and allowed uninhibited increase have also gone through this scenario and have tackled the problem of overpopulation in different ways.

There are basically three options open at this stage:

1. To adopt a *laissez faire* policy; to let elephant numbers grow and let nature "control" through starvation or disease. This policy may cause dramatic fluctuations and effect other species and has led most conservation bodies to decide against this option.
2. To apply birth control measures by vasectomization of adult bulls or by drug therapy (chemical contraception). This is however still in the experimental phase, the technique as yet is difficult to apply especially to large populations and the ecological impact unknown.
3. To control numbers by taking out excess animals. This can be done either by capture and translocation of elephant and/or by culling/slaughtering procedures.

Most large conservation areas have opted for the latter choice. Due to logistic and adaptation problems associated with the translocation of large elephants, together with a very restricted market for elephants, the catching procedure has its limitations as a control procedure. This report will deal with the next and final option: slaughtering as a means of controlling elephant numbers. Two basic slaughtering procedures for elephant have been identified, namely the use of high powered rifles only, and the use of succinyl-dicholine-chloride (scoline, SDC) in conjunction with high powered rifles.

[a] Department of Research, National Parks Board, Private Bag X402, Skukuza, 1350, Rep. of South Africa

[b] Department of General Physiology, University of Witwatersrand, Johannesburg, Rep. of South Africa

CONSIDERATIONS

In choosing a method there are a number of considerations. When choosing the most suitable method of slaughter for elephant, there are a number of factors which should be considered. First and overriding all other considerations, and to meet ethical and statutory requirements, the process must be humane. Other important considerations should include ecological impact, veterinary and public health aspects and practical and economic issues.

Ethical and aesthetical values

It is considered unethical to let carcasses rot in the field, whilst protein deficiency is a grave issue amongst Africa's fast expanding human populations. It is therefore believed that the method of culling should provide for the possibility of recovering the carcasses for the use of consumption by man.

A humane slaughtering procedure demands a stunning method which should allow for quick unconsciousness or insensibility and the phase of unconsciousness should last until exsanguination results in a sufficient degree of cerebral hypoxia in order to cause permanent insensibility or death (Blackmore 1983). Pain or distress is however a perception - it has no definitive physical dimension, and it is probably the most modified of any sensory system of the body (Kitchell & Johnson 1985). In animals, especially wild animals, it is difficult to assess distress or unconsciousness. It is therefore currently believed that stimuli can be considered noxious or aversive to animals if they produce pain or distress in humans, tissue damage, and escape behaviour in the animal (Lineberry 1981). A certain degree of extrapolation and anthropomorphism is therefore allowed in the judgement of potentially noxious procedures in animals. Care should however be taken that emotions do not overcloud judgement. It should be kept in mind that there is no necessary connection between intelligence and the capacity to suffer (Singer 1976). Some animals however have an advantage over others when it comes to arousing human sympathy. Helpless baby seals with large brown eyes and rounded faces have a great advantage over adult rats with yellow teeth and long scaly tails (Dawkins 1980).

Elephants also tend to arouse public sympathy and emotions. The fact remains that once the decision to cull or slaughter has been taken, the same principles should apply to all animals.

Ecological considerations

The procedure should conform to the specific ecological management objectives for that specific region. If the objective is to control numbers but at the same time to keep the populations as natural as possible in terms of population structure, then the method should provide for "random sampling". Disturbance to the herds should also be minimal. Masses of rotting carcasses in the field create abnormal ecological conditions for scavengers and predators and could facilitate disease outbreaks such as anthrax (De Vos 1990).

Veterinary and public health considerations

The aim is that the products of control should be safe for human use and consumption and should not constitute a veterinary hazard in terms of disease transmission.

Practical and economic considerations

In the best interest of nature conservation administration it should be an economically viable proposition and not a financial drain.

CULLING PROCEDURE

1. Shooting with high-powered rifles

The use of high-powered rifles from the ground is the preferred method of slaughtering elephant for culling or cropping procedures by most nature conservation agencies in southern, eastern and central Africa. It has been described by Woodhead (1969) for Kenya, Hanks (1979) for the Luangwa Valley, Laws *et al.* (1975) for North Bunyoro, Uganda, Haigh *et al.* (1979) for Rwanda and Martin *et al.* (1989) for Zimbabwe.

Laws *et al.* (1975), Hanks (1979) and Martin *et al.* (1989) represent organizations that favour an elephant culling technique which consists of locating the herds mostly and preferably from the air, and then approaching them on foot by a team of two to four hunters. One hunter, the leader, does the shooting and the others act as gun-bearers or to support the leader in emergencies. Heavy calibre rifles (0,375, 0,404, 0,416, 0,470, 0,570) are mostly used. In order to avoid bias the first family unit encountered in the chosen area is taken. When encountered, these elephant usually take up defensive action by going into a closely knit bunch with the lead cow on the perimeter facing the hunter. The hunter first shoots the lead cow which has a further bunching effect on the remaining members of the group and greatly facilitates shooting. Whenever possible, all elephants are brain shot, but if they turn and run, a heart shot is attempted. Times of 45 to 90 seconds to drop family units of 12 to 15 animals are quoted. If necessary, the *coup de grace* is delivered by another member of the hunting team. A lighter calibre rifle has been used successfully for this purpose. In some areas another member of the hunting team carries a heavy spear to bleed the elephants as soon as possible after death. Hundreds of elephant have been dropped in this way - very few escaped.

Woodhead (1969) and Haigh *et al.* (1979) described a variation on this theme by using a helicopter to cut out and herd a group of elephant at a walking pace to a predetermined culling site where hunters have been positioned. They maintian that due to the herding and spotting capabilities of the helicopter there are no wounded or strays.

The KNP has introduced yet a further variation. Herding and shooting is done with a high-powered rifle (0,375 calibre) from a helicopter. A lower calibre (0,308) semi automatic rifle was found ideal for herd animals. The technique is basically the same as described for the scoline method *(vide infra)* but with the difference that scoline darting is left out and only shooting is done. Times of 20 to 60 seconds have been recorded for killing entire groups of up to 19 animals. It was found that a good marksman achieved an average of about 90 % success rate on first shot. Carcase distribution very rarely exceeded an area of more than 50 m diameter. In some cases carcases were piled up on each other and had to be pulled away afterwards. In disposing of single elephants it was also possible to put an animal down at virtually an exact spot.

2. Scoline method

The scoline method of culling elephant was developed and used in the KNP (De Vos *et al.* 1983). It is based on the use of scoline as an immobilizing agent by exerting a paralytic action through a persistent depolarisation of the motor endplates of skeletal muscles and then brain-shooting the immobilized elephant.

It starts with a reconnaissance flight which is carried out with a five-seater "Bell Jet Ranger" helicopter. If necessary, the herd is driven gently in the direction of a suitable site for darting. This spot is almost always away from the tourist road system, but conveniently near a service or firebreak road accessible to the vehicles used by the ground crew. The helicopter then returns to base to collect the projectile syringes and to place the ground crew within a convenient distance of the selected spot.

For the next stage of the operation the helicopter team is made up of a pilot, a marksman and an observer who also acts as a counter-weight. The helicopter is flown with its right rear door removed, with the marksman sitting behind the pilot in the open doorway and loosely fastened to the helicopter by a standard seat belt and a specially made "monkey chain". This position provides the marksman with some manoeuvrability and ability to lean out of the open doorway with his foot on the helicopter skid without danger of falling out. Darting and shooting is performed in that position.

The helicopter first selects a family group or separates the area where darting will be performed. The animals are only "pushed" initially when the group is cut to ensure general movement towards the spot where the actual darting is to be performed. Once this is achieved, the helicopter falls back to a discreet distance from where guiding is performed without creating undue disturbance.

At darting spot, usually a clearing in the vegetation, the darting and shooting phase commences. The helicopter swoops in above the group and two darts are fired in quick succession. The helicopter then veers off sharply in a circling or interception flight pattern in order to keep the herd in a tight group within the clearing. As soon as possible after an elephant is down, it is brain-shot from the helicopter with a high-powered rifle (0,375 calibre). In practice this is done within a few seconds to 15 minutes. In some cases the animals are only shot when the ground crew moves in, which necessarily means a time-lag in exess of 10 minutes.

As soon as the last animal has dropped, the ground crew is called in. The man in charge of the ground crew moves in first, examines all elephants and brain-shoots at close quarters those that still show signs of life.

DISCUSSION AND RECOMMENDATIONS

1. Shooting method

By taking out entire family groups, sample bias is minimized, leaving the population structure essentially as it was before. With brain-shooting, the edible parts of carcases are not violated. Body-shooting is done rarely and in those cases only affected parts of the carcass have to be condemned for the purpose of human consumption.

In order to evaluate stress and distress associated with the various culling methods, comparative physiological values were obtained from elephant subjected to the different culling procedures (Hattingh *et al.* 1984a). Baseline values were derived from undisturbed and unsuspecting animals that were brain-shot (Table 1). Elevated ACTH and cortisol levels were taken as indicative of stress

Table 1. ACTH and cortisol values of blood from culled elephant (adapted from Hattingh *et al.* 1984a)

GROUPS		ACTH pg/mℓ	Cortisol nmol/ℓ
Undisturbed, shot, sampled	mean	17,3	111,38
	SD	1,4	24,75
Herded, shot, sampled	mean	16,3	132,28
	SD	2,6	26,95
Undisturbed, SDC, sampled	mean	13,3	125,40
	SD	3,2	104,50
Herded, SDC, sampled	mean	23,2	858,00
	SD	5,1	283,25
Herded, SDC, shot, sampled	mean	29,4	687,50
	SD	5,4	269,50
Herded, SDC, delayed sampling	mean	39,3	501,88
	SD	6,4	144,93

as is generally accepted and well documented (Selye 1976; Levine 1985; Thurley & McNatty 1973; Van Heerden & Bertschinger 1982; Mitchell 1982). As indicated in Table 1, the lowest values were obtained for the baseline group with only slightly elevated cortisol figures for the herding and brain-shot group (from the helicopter). Cortisol values increased from 111,38 to 132,28 in these two groups, with wide standard deviations. ACTH values were slightly lower in the herding and brain shot group. On the basis of this evidence it must be concluded that herding and shooting presents very little stress to elephants, but with the proviso that herding is done discreetly and slowly and shooting is performed swiftly and with minimal wounding. The same principles probably apply to the shooting method from the ground. Times quoted for the shooting phase are extremely short (45-90 sec). Reports also indicate that it is extremely effective, with wounded elephant getting away an exception. It is felt, however, that the helicopter method gives the added insurance that no wounded animal can get away and it is considered safer to the shooting team. The helicopter method is also faster and provides the necessary flexibility to work on short notice in virtually any terrain. The only argument that was brought in against the involvement of a helicopter, is that herding by helicopter causes unnecessary distress to the animals (Martin *et al.* 1989). Considering the above physiological evidence, this argument is not valid. Of all the shooting methods, the helicopter shooting procedure is therefore the one of choice.

The above arguments are all based on the fact that experienced and capable hunting teams were used in all cases. Inadequate marksmanship and poor hunting ability can result in unnecessary wounding and prolonging of the contact phase, in which case the above arguments are not valid. It is imperative that the hunter should not only be an exceptionally good marksman, but should also have a good working knowledge of the behaviour of elephant under the specific circumstances and a good knowledge of the topographical anatomy of the vital centres of elephant, such as the brain, spinal column and heart. Scientists in the KNP are currently working on a computerized simulation model for the hunting of elephant, which should provide the necessary teaching aid for prospective elephant hunters (unpublished information).

2. Scoline method

By using an essentially random sampling method, thereby maintaining the population structure as it was, this method conforms to ecological considerations. The aim is also to provide a safe product for human consumption. SDC breaks down to succinic acid and choline, which are normal metabolites of the body (Hall 1971); the meat is therefore acceptable to public health authorities in South Africa. From a practical and safety point of view, this method has a proven record. In the KNP to date about 15 000 elephant have been slaughtered in this way, and with no mishap.

The arguments against the use of SDC as a euthanasia agent or for cropping of animals have been summarized by Harthoorn (1976):

> "Animals under the effect of succinycholine and its congeners *remain fully sensitive to pain and effect of fear*. Death from succinylcholine overdosage is certain to be extremely distressing and even partial overdosage has been described as very frightening by human volunteers, the air hunger and inability to swallow or cough causing mucus to collect in the throat, inducing a feeling of asphyxia. The approach by man must be highly alarming to the paralysed animal, and no unduly painful procedures should be contemplated on an animal restrained in this way. Euthanasia or cropping of animals with the use of this compound cannot be condoned, unless there is a reasonably high certainty of being able to carry out effective and painless destruction by other means immediately the animal is incapacitated".

This viewpoint has been corroborated by Button *et al.* (1981) who measured catecholamine release and ECG and EEG waveforms in SDC-treated domestic bovine calves. These findings indicate that any animal asphyxiated by SDC almost certainly suffers extreme psychic stress between the time of onset of apnoea and hypoxic cerebral depression.

In physiological studies performed on culled elephant in the KNP, Hattingh *et al.* (1984a) concluded that the changes in the levels of certain blood components can be attributed to stress induced by SDC culling procedures and that decreasing oxygen saturation will cause severe discomfort and stress and that "elephant exposed to SDC should be killed by a shot in the brain as soon as possible after darting".

Looking at some of the results of these experiments as depicted by Table 1 it seems:

1. that the greater the activity induced by herding, the greater the resultant stress.
2. that SDC without herding produces minimal stress.
3. that stress increases with time in SDC culled animals.
4. that the highest levels of stress are obtained in a combination of herded, SDC treated animals, such as the normal SDC culling procedures as used in the KNP.

It was further found (Hattingh *et al.* 1984b) that in elephant darted with toxic levels of SDC, blood PO_2 decreased an average of 0,4 kPa/min (3,1 mm Hg/min) and did not change suddenly from a normoxic to hypoxic state. Studies by Christensen & Krogh (1936), Davis *et al.* (1938), Opitz (1950) and Rebuck *et al.* (1976) indicate that loss of consciousness occurs in man when average PO_2 tensions are between 28 and 32 mm Hg. Hattingh *et al.* (1986) found figures of 25 mm Hg for unconsciousness and 23 mm Hg for brain death in rabbits. In man, distress is however already felt at PO_2 tension levels of 60 mm Hg and under. These values seem to be constant in species and the assumption is made that elephant most probably will lose consciousness at PO_2 tension levels of about 30 mmHg and will also feel distress at PO_2 tension levels of 60 mm Hg PO_2 and under.

In the KNP, PO_2 tension levels of about 70 mm Hg were recorded for elephant immediately after going down from the effect of SDC (unpublished data). It therefore gives the operator a margin of not more than 10 mm Hg, (which is equivalent to three minutes after the elephant has dropped,) to deliver the *coup de grace* or do effective stunning before distress from asphyxiation can be expected. These figures are however very variable and narrower margins are found. It has also been the experience in the KNP that this 3 min cut-off point is not always attainable, especially where young elephants are caught at the same time. If animals cannot be brain-shot immediately after collapse, the SDC method of culling as described therefore does not conform to humanitarian principles. As previously explained this can not be attained in practice.

As pointed out by Harthoorn (1976), animals under the effect of SDC are paralysed and may not show any visible reaction to outside stimuli, yet remain fully sensitive to pain and distress. The risk is therefore great that in the hands of an ignorant or unscrupulous operator the SDC method can be grossly abused.

CONCLUSIONS AND RECOMMENDATIONS

Physiological and clinical evidence point to the fact that the SDC technique of culling elephant, with or without brain-shooting afterwards, does not conform to currently accepted humane standards. There are feasible alterations and SDC is therefore considered unacceptible for the culling of elephant. Shooting from the ground is considered humane, but requires very specialized field personnel and the technique does not have the necessary flexibility to adapt to various circumstances which is required of culling. The technique of shooting from a helicopter, as developed in the KNP, conforms to humane, ecological, meat hygiene, safety and practical considerations and is therefore recommended for the culling of elephant.

REFERENCES

Blackmore, D.K. 1983. Practical problems associated with the slaughter of stock. *In:* **Eikelenboom** (ed) *Stunning of animals for slaughter*. The Hague: Martinus Nyhoff Publishers

Button, C., Bertschinger, H.J. & Mulders, M.S.G. 1981. Haemodynamic and neurological responses of ventilated and apnoeic calves to succinyldicholine. *Journal of the South African Veterinary Association* 52: 283-288

Christensen, E.H. & Krogh, A. 1936. Fliegenuntersuchungen: die Wirkung niedriger O_2-Spannung auf Hohenflieger. *Scandinavian Archive of Physiology* 123: 51-52
Davis, P.A., Davis. H. & Thompson, J.W. 1938. Progressive changes in the human electroencphalogram under low oxygen tension. *Journal of Physiology* 123: 51-52
Dawkins, M.S. 1980. *Animal suffering*. London: Chapman and Hall
De Vos, V. 1990. The ecology of anthrax in the Kruger National Park. *Salsbury Medical Bulletin* 68: 19-23
Haigh, J.C., Parker, I.S.C. & Parkinson, D.A. 1979. An elephant extermination. *Environmental Conservation* 6: 305-310
Hall, L.W. 1971. *Wright's veterinary anaesthesia and analgesia*. London: Baillière Tindal
Hanks, J. 1979. *A struggle for survival. The elephant problem.* Cape Town: C Struik Publishers
Harthoorn, A.M. 1976. *The chemical capture of animals*. London: Baillière Tindal
Hattingh, J., Cornelius, S.T., Ganhao, M.F. & Fonseca, F. 1986. Arterial blood gas composition, consciousness and death in rabbits. *Journal of the South African Veterinary Association* 57: 13-16
Hattingh, J., Wright, P.G., De Vos, V., McNairn, I.S., Ganhao, M.F., Silove, M., Wolvuren, Cornelius, S.T. 1984a. Blood composition in culled elephants and buffaloes. *Journal of the South African Veterinary Association* 55: 157-164
Hattingh, J., Wright, P.G., De Vos, V., Levine, L., Ganhao, M., McNairn, I.S., Russell, A., Knox, C., Cornelius, S.T. & Bar-Noy, J. 1984b. Effects of etorphine and succinyldicholine on blood composition in elephant and huffalo. *South African Journal of Zoology* 19: 286-290
Kitchell, R.L. & Johnson, R. 1985. Assessment of pain in animals. *In:* **Moberg, G.P.** (ed) *Animal stress.* Bethesda, Maryland: American Physiological Society
Laws, R.M., Parker, I.S.C. & Johnstone, R.C.B. 1975. *Elephants and their habitats. The ecology of elephants in North Bunyoro, Uganda.* London: Oxford University Press
Levine, S. 1985 A definition of stress? *In:* **Moberg, G.P.** (ed) *Animal stress*. Bethesda, Maryland: American Physiological Society
Lineberry, C.G. 1981. Laboratory animals in pain research. *In:* **Gay, W.I.** (ed.) *Methods of animal experimentation.* New York: Academic Press. pp 237-311
Martin, R.B., Craig, G.C. & Booth, V.R. 1989. *Elephant management in Zimbabwe.* A review compiled by the Department of National Parks and Wildlife Management, Harare, Zimbabwe. pp 119
Mitchell, G. 1982. Stress in pigs. *Advanced Food Research* 28: 167-230
Opitz, E. 1950. General physiology of oxygen deficiency. *In: German Aviation Medicine, World War II. Vol. 1.* Washington, DC: Government Printing Office
Pienaar, U. de V. 1983. Management by intervention: The pragmatic/economic option. *In:* **Owen-Smith, R.N.** (ed) *Management of large mammals in African conservation areas.* Pretoria: HAUM.
Rebuck, A.S., Davis, S., Longmine, D., Upthal, A.R.M. & Powles, A.C.P. 1976. Arterial oxygenation and carbon dioxide tensions in the production of hypoxic electroencephalographic changes in man. *Clinical Science and Molecular Medicine* 50: 301-305
Selye, H. 1976. *The stress of life*. New York: McGraw-Hill
Singer, P. 1976. *Animal liberation*. London: Jonathan Cape
Stevenson-Hamilton, J. 1911. The relationship between game and tsetse flies. *Bulletin of Entomological Research* 2: 113
Thurley, D.C. & McNatty, K.P. 1973. Factors affecting peripheral cortisol levels in unrestricted ewes. *Acta Endocrinologica* 74: 331-337
Van Heerden, J. & Bertschinger, H.J. 1982. Serum cortisol concentrations in captive tamed and untamed black-backed jackals *(Canis mesomelas)* and translocated dogs. *Journal of the South African Veterinary Association* 4: 235-237
Westhues, M. & Fritsch, R. 1965. *Animal anaesthesia*. Edinburgh: Oliver and Boyd
Woodhead, D.J. 1969. The sue of helicopters in wildlife mangement. *East African Agricultural and Forestry Journal* 34 (special issue): 105-107

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

ELECTRIC FENCES FOR ELEPHANT MANAGEMENT

Evan Robson[a]

Over the years, many game farmers and conservationists have tried electric fencing, as a means of wildlife control with varying degrees of success. Some swear by it, others swear at it. It should be appreciated that great strides have been made in the development of modern energisers. The very earliest electric fence worked on the principle of continuous current flow. This type was very ineffective as they could be shorted out very easily, and under ideal conditions could also prove very dangerous.

The second electric fence to appear on the market was what we called the "Tick Tock" Energiser. These old "Tick Tock" mechanically-operated units were of a much higher voltage but still had high impedence, in other words could still be easily shorted out. Much of the early experimentation with electrified game fencing was done with this generation of energisers. Due to the heavy competition from vegetation, in most cases the results obtained were unsatisfactory.

The modern energiser, as we now know it, makes use of the concept of high power and low impedence. With the invention of silicon controlled resistors, thyristors and the development of the control circuitry, the modern day energiser has the ability to discharge very high energy pulses safely into a fence line, thus enabling it to overcome competition from vegetation.

Energisers today have become a viable tool under practical fencing conditions, and if used correctly can slash fencing costs and control game more effectively than conventional, physical barrier fencing.

World-wide good results have been achieved by means of electric fencing. In Malaysia, the federal land development authority sanctioned the erection of many hundreds of kilometers of electrified fencing to protect valuable rubber and oil palm plantations. In these high-rainfall areas two live wires, one 1,8 m and one 0,9 m from ground level proved 100 % effective in controlling elephant denudation of the plantations.

In the USA and Canada, electric fences are used successfully to control coyote predation of sheep, to keep deer out of agricultural crops and bears out of apiaries. In Australia, electric fences are used to keep kangaroo, wild pig, dingos, wombats, wild dogs, emus and rabbits from crops and livestock.

In Africa itself, numerous countries have and are conducting experiments with electric fencing. In Kenya, Namibia and Botswana, electric fencing has been used successfully. More recently Zimbabwe, Malawi, Togo and Botswana are making use of our local expertise.

In South Africa many experiments have been done, in particular with the big game spcies such as elephant, rhinoceros, hippopotamus, buffalo and lion. In fact I would go so far as to say we in South Africa are probably the world leaders in the control of wildlife with the use of electric fences. We have the advantage not only of having an abundance of wildlife, but also a great variety of climatic conditions in which to erect electric fences. From the moist and humid east coast through the dry and arid west coast electric fences have been erected to suit the local conditions. Most of the earlier experiments done with elephants in particular were done in the Eastern and North-Eastern Transvaal. Until recently elephants were limited to these areas only in South Africa, except of course for the Addo Elephant National Park.

---

[a] 31 Swanepoel Street, Warmbaths, 0480, Rep. of South Africa

When elephants were first re-located to Swaziland and Gazankulu, electric fencing was used to keep them in. First their training camp alongside their bomas were electrified to teach them about electric fencing. The outer camps were then electrified to contain them once they were let out of the boma areas. To this day those elephants have a high respect for electric fences.

The Kruger National Park has also experimented with electric fences for amongst other things, elephant control. Electric fencing has therefore proved itself to be both an effective and economical tool for the control of wildlife. Admittedly, under pressure or under extreme conditions, an animal may break through any fence. Elephant have even escaped through the Armstrong fence around the Addo Elephant National Park.

ECONOMICS

The increased interest amongst game farmers and conservationists in keeping the larger species such as elephant, rhinoceros, lion etc. necessitates a barrier less sturdy and expensive than the Armstrong fence, but still effective enough. A strong, conventional type game-proof fence, supported by well maintained electric wires is all that is necessary. The latter costing between one fifth and one sixth of the cost of the Armstrong fence (*ca.* R80 000-00 per km)

WHAT FENCE DO WE NEED TO CONTROL ELEPHANT?

a) Conventional game-proof fence

The fence should be 2,4 m high and have between 19 and 20 strands of high strain steel wire with a minimum diameter of 2,24 mm. Straining posts spaced between 120 and 200 m apart should have an outside diameter of at least 114 mm and a wall thickness of at least 3,5 mm, standards 10 m apart and droppers 2 m apart.

b) Electrification

i) *High power*
The energisers used may be either mains-powered or battery-powered. As most game ranches do not have access to mains power, battery models are more often used. The more powerful battery models tend to discharge their batteries rather rapidly, so solar panels are used to maintain the batteries. Where mains power is available, mains powered energisers should be used as they are more powerful and economical, and there is a cost saving in that no solar panels or batteries are required. Care must be taken when selecting an energiser, for not only are there big differences in power output between different makes of energisers, but also between models of the same make. It is useless selecting a small strip grazing model, which is suitable for tame domestic livestock, against elephant and other wild animals. In many cases all this will do is annoy the animals with disastrous results to these fences and in some cases, surrounding population. My personal recommendation when working with elephant etc., is always use the strongest energiser available, no matter how short or long the fence may be. Remember that the harder you shock the animal concerned the first time, the quicker the animal will learn to respect the fence.

ii) *Fence design (Electrification)*
We have found that add-on or piggy-back live wires to an existing game fence are the easiest and most effective means of controlling big game. Most game farmers wanting to establish elephant on their farms normally have an existing game fence already erected. The conventional game fence not only acts as a physical and visible barrier but also as an earth grid for the electric add-on wires. (The better the earthing, the more effective the electric wire will be).

iii) *Positioning of live wires:*
It is most important to have the live wires at the correct heights above ground level. The average rule of thumb is to have the live wire at nose height for the particular animal

concerned. Unfortunately wild animals don't always abide by our rules. We have fence-crawlers such as warthog, porcupine, lion and sable to mention a few. For the fence-crawlers a live wire 25-30 cm from ground level is required. Then we have fence-creepers such as impala, buffalo, etc. A live wire between 75-80 cm above ground level will suffice. For the fence-jumpers such as kudu, eland and waterbuck, a live wire *ca.* 1,8 m above ground level is required. We also get fence-climbers such as baboons and monkeys. They can be stopped with electric wires, but they are a problem on their own not to be discussed today. Then we have the fence-pushers which include elephant, rhinoceros and hippopotamus. As most game farms have a large variety of game normally requiring the 3 live wires already mentioned, the control of the fence-pushers is virtually covered. The bottom two live wires will control rhinoceros and hippopotamus and to a lesser extent elephant. An elephant's nose height is sometimes difficult to judge as it may vary.

We have had good results controlling elephant with just the three live wires mentioned. But, when starting off with young elephant (2-4 years old) an extra live wire is needed at *ca.* 1200 mm above ground level. This wire has been most effective in the training of young elephant to respect qame fences.

MATERIALS FOR LIVE WIRES

To penny-pinch when it comes to the purchasing of good quality materials such as insulators, offset brackets or other accessories is false economy. Remember, only the best materials will make the best fences.

a) Offset brackets

Use offset brackets made from special spring steel that have been hot-dipped galvanised. The manufacturers have done their homework in choosing the correct spring steel to use. Do not use steel wire or "bloudraad" as I have seen in the field. Use a long offset bracket for the top live wire and short offset brackets for the rest.

b) Insulation

Again, use well-made insulators and not bits of plastics, pipe etc. When an electric fence is erected, it should be put up to last and to give as little problems as possible. Porcelain insulators have been outpriced by the fireproof glass fibre insulators today. Fireproof insulators are recommended on long game fences, since besides being fireproof, they are stronger and will last a lot longer. If plastic insulators must be used, then use plastic bobbin insulators where there is no fire hazard. Don't use plastic strain insulators at all on long fences. They can split under the immence strain exerted on them.

c) Metal components

Don't use any metal components that are not hot-dipped galvanised. Electro-chemical corrosion is a real problem to successful electric fencing and occurs when two dissimilar metals are joined together and then have a high current passing through them. The corrosion occurring at the joint will adversely effect conductivity. Line clamps and wire tensioners should therefore be hot dipped galvanised. Do not use copper wire with high strain steel wire. This will cause electrolysis at the joints resulting in corrosion.

d) Energisers

I have already mentioned high power. One more thing, though: Do not try and break long distance records with your energisers. It's much more effective running an energiser on a shorter distance and getting 7000 to 8000 volts on the fence than running a long distance and getting 3000 - 4000 volts. The whole idea is high power to stop the expensive animal on the inside getting out.

e) Visibility

Even when correctly designed and built, an electric fence will not prevent large animals from going through if they cannot see it. We have found that by attaching old cans with a little molasses or sugar water inside to the fence, it not only improves visability but also gives a pleasant odour to the fence. The animal will normally sniff at the can on the wire and "POW". A shock on the nose or tip of the trunk is certainly more effective than a shock on the body. Bits of plastic, strips of aluminium or tin foil also improve visibility but are not as effective as the tins with a sweet smell inside.

SOME PRACTICAL HINTS

a) Time and space

Wild animals need time and space to discover that the perimeters are hostile. Obviously, therefore, the longer the electric fence operates, the better the results will be.

b) Read the manufacturer's instructions

A common problem, when all else fails, consult the manufactures instruction manual. Many hours of wasted time and effort can be eliminated by first reading the instruction manual.

c) Do NOT take short cuts

d) Earthing

The better the earthing, the more effective the electric fence. Consult your manual for the best earthing methods.

e) Maintenance

It should be emphasized that the regular inspection and continuous and meticulous maintenance of the fence is of cardinal importance. A clean fence is visible, effective and easy to maintain.

f) Advice

Get the correct advice before purchasing and erecting your electric fence. It is amazing how many farmers have purchased the wrong materials for the job, and quite obviously have given electric fencing a bad name.

CONCLUSION

Electric fencing is a viable, economical and effective tool for the control of all types of game. It is essential that if the benefits of this type of fencing are to be enjoyed, care must be taken in designing the right fence for the game being controlled and that high powered, low impedence energisers be used. Attention must also be paid to earthing, insulation and obtaining the best quality materials for the job.

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

CONSTRUCTION OF ELEPHANT BOMAS

R R Henwood[a]

My decision to build an elaborate and permanent holding boma was based on several factors:

1. The necessity to hold elephants for approximately one month in captivity to allow them time to become a cohesive herd since they had been taken from various herds during the culling operation.
2. To allow elephants time to settle down and become acclimatized to their new surroundings to overcome the rigours of capture and transport.
3. A holding boma which is long lasting and suitable for many different types of animals such as elephant, white and black rhino and all types of large antelope.
4. The fourth and probably the most important factor was the time of year that the elephants become available from the Kruger National Park which is usually towards the end of May or early June.

I felt that it was necessary to hold the elephants for at least one month, but it would mean that their release would then be in early July which would be completely the wrong time of the year to expect young elephants to fend for themselves, and even if we shortened their length of stay in the boma by a week or two, it would still mean that they would be faced with the winter season immediately after release. The alternative was to lengthen their stay in captivity and prepare them for release in early spring, a stay of about three months if we were to give them their best possible chance of survival.

Knowing how destructive and strong elephants are, I decided not to skimp on construction, but to rather build a good, strong stockade which would give us peace of mind knowing that they could not escape or hurt themselves attempting to escape.

If they were going to stay in captivity for three months, then we may as well put the time to good use and attempt to school them into respecting a fence with electrification. I thus built a fenced enclosure behind the stockade similar to our perimeter fence, but a lot stronger. This was to act as an exercise paddock, but even more so, to familiarize the elephant with electric fencing as many of them had probably never seen a fence before being captured.

The pole stockade where the animals spent the first two weeks of their stay after transport was built with wooden poles with no wire and no electrification. The reason for this was that I did not want the animals to be bumped or pushed into the electric wire, as this would definitely have a detrimental effect on them settling down. They would be doing most of their feeding in here and I wanted them to feel very relaxed and secure behind the poles and not be frightened. This is where most of the jostling would take place.

The exercise paddock was built within three strands of electrified wire with approximately 9000 volts running through it, backed with 5 strands of cable placed on weldmesh. My idea was that should they test the electrified wire and break it, there would still be no way that they could escape as the cable and weldmesh would be sufficient to stop them. There is a case in mind where two elephants were released into a wire enclosure which was electrified and it only held them for a short while before they broke out and escaped from their enclosure and from the farm. My feeling is that electrification on wire mesh fence is not enough initially - the animals must learn to respect and

[a] Touchstone Game Ranch, P O Box 57, Marken, 0605, Rep. of South Africa

recognize it. This has to be slowly taught to them over several weeks and they must understand that if they break the electrification, they still cannot escape. Hopefully that once learnt, it will be remembered after release and for the rest of their lives.

SITE SELECTION

Site selection is very important and several points should be borne in mind when selecting a spot.

1. A well-drained area should be found preferably on gently sloping ground to avoid animals living in wet conditions, should inclement weather be experienced.
2. An area with large shade trees should be sought and if this proves difficult then artificial shade must be considered. It must be remembered that small trees with a trunk of less than about 300 mm will be broken or uprooted and any branches below three meters will be pulled down and broken within a week or two. It may also be necessary to protect the trunks of large trees in the enclosure, by wrapping wire mesh around several times, as the young elephants will often strip the bark.
3. It should be easily accessible to vehicles and especially the large transporter that will initially bring the animals in.
4. Positioned well away from houses, compounds and the perimeter fence, as there is a good possibility that if left unmolested and quiet at the time of release, they will make the boma the center of their home range. If positioned near habitation or a busy road etc., they will move after release and one can only hope that it will be in the right direction.
5. A continuously good water supply is needed as it is surprising how much water is required for drinking purposes and wallowing, especially in the dry winter months of the year.

BUILDING THE STOCKADE

Each pen is 24 metres square with an off-loading ramp positioned between the two, allowing off-loaded animals entry into either one or the other simply by moving the gate one way or the other. The off-loading ramp should be approximately 2,5 m wide x 1,2 m high and extending 6 m or two spans from the main stockade structure. The reason for the off-loading ramp extending away from the stockade, is that the animals are at ground level before entering the enclosure. An old wooden railway sleeper was cemented into position at the lip of the off-loading ramp to avoid crumbling of the edges and to give the trucks a good straight edge to reverse up to.

The walls of the stockade were erected as follows: We were able to acquire 125 mm x 2,750 m scrap steel piping which we cemented 750 mm into the ground and 3 m apart. These were then connected with cross-pieces top and bottom with 125 mm x 3,1 m tannalised gum poles and attached to the steel poles with 12 mm reinforcing rod bent over both inside and out.

The upright poles (100 mm x 2 m) were then attached to the cross-pieces using the same method of attachment, being sure to keep the poles 75 mm off the ground as an added precaution against white ants. The gaps between the poles are also approximately 100 mm and it is obviously necessary to cut down on the number of poles used but more importantly I have found that animals that cannot see out, tend to become more agitated and do not quieten down at all.

Steel gates were constructed by welding a channel iron frame together, 3 m wide x 2 m high and then 75 mm steel piping was welded into the frame vertically, leaving gaps of approximately 75 mm between the pipes. Steel wheels 150 mm in diameter were machined with a concave "V" and fitted onto each gate. A 6 m length of 50 mm angle iron was cemented, in an inverted position, into the ground to form a rail for the gate to run on. The reason for the 6 m length is to accommodate the 3 m gate in the open and closed positions.

Should it be necessary to build artificial shade areas in the stockade, they should be well out of reach of any elephant. Remember that an elephant can reach up to almost twice his body height.

Each pen has its own water-trough placed along one of the sides and is 750 mm wide x 2 m long and 400 mm deep (300 mm below ground). Half of the water-trough is outside the pole stockade to allow for easy cleaning and to also house the ball-valve system.

EXERCISE PADDOCK

The exercise paddock was 150 m x 100 m in size and was fenced as follows:

The same steel poles as were used on the stockade were used, but placed 5 m apart and cemented 750 mm into the ground. Five cables were threaded through holes in the poles at ground level, 600 mm, 1200 mm, 1800 mm, and at 2 m. The cable thickness was 18 mm and was selected only because we had it available. Onto the cable was placed 50 mm x 100 mm weldmesh tied every metre to each cable with baling wire. Three strands of electrified wire was now put onto the fence at 600 mm, 1100 mm, 1600 mm using the long offsets, and all were live wires, whereas the fence was all negative and gave me excellent earthing between ground and live wire.

SHOPPING LIST

Stockade

620 of 100 mm x 2,0 m Tannalised poles
104 of 125 mm x 3,1 m Tannalised poles
54 of 125 mm x 3,75 m scrap steel piping
600 m x 12 mm reinforcing rod
50 m of 100 mm x 50 mm channel iron
200 m of 75 mm steel piping
30 m of 50 mm angle iron
10 machined steel wheels for gates
2 of 25 mm ball valves and plastic piping

Off-loading ramp

44 of 100 mm x 2,0 m Tannalised poles
8 of 125 mm x 3,1 m Tannalised poles
4 of 125 mm x 3,75 m scrap steel piping
2 of 125 mm x 4,0 m scrap steel piping
45 m x 12 mm reinforcing rod
1 long wooden railway sleeper

Excercise paddock

88 of 125 mm x 3,75 m scrap steel piping
430 metres 100 mm x 50 mm weldmesh
2175 metres 18 mm steel cable
8 metres 100 mm x 50 mm channel iron
40 metres 75 mm steel piping
6 metres of 50 mm angle iron
2 machined steel wheels for gates
400 m baling wire
1300 m 2,24 mm steel wire (for electrification)
430 long offsets (for electrification)
1 Heavy duty 12 v battery (for electrification)
Solar panels or Escom power supply

Cement, artificial shade area and labour have not been included.

CONCLUSION

Building a holding enclosure such as the one I have described here can be a costly and time-consuming operation, but what the recipient of the elephant must take into consideration, is that should the animals escape, he would automatically be liable for any damage to property or equipment and this together with the high cost of re-capture plus the added risk of animal losses should be sufficient motivation to spend the extra money and build a good, strong and reliable boma.

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

EXPERIENCES WITH THE SHORT-TERM MANAGEMENT AND CARE OF NEWLY-CAPTURED JUVENILE AFRICAN ELEPHANTS *(Loxodonta africana)* IN THE KRUGER NATIONAL PARK

R G Bengis, D F Keet, J Raath and V de Vos[a]

Since 1978 a total of 761 wild-caught juvenile African elephants have been handled at the elephant-holding facility at Skukuza in the Kruger National Park (KNP). This paper describes the management and husbandry of, as well as clinical conditions observed in, these animals during their one to four month stay at this facility.

INTRODUCTION

Elephant-population control has been practised in the KNP since 1967. The outside demand for translocation of elephants to new areas, as well as their favourable infectious disease status, prompted the National Parks Board to institute a "Live take off" of that part of the elephant annual culling quota, which could be physically handled and confined. Initially veterinary zoosanitary precautions required that elephants be quarantined for a minimum of 30 days with two negative serological tests for foot and mouth disease (FMD). Following research done by Howell *et al.* (1973) and Bengis *et al.* (1984), it was shown that although African elephants were susceptible by artificial (needle) infection to the SAT type FMD viruses, they were highly refractory to massive natural challenge. This resulted in the quarantine and serological test requirements for local (Southern Africa) movement to be lifted. With supply facilitated, demand for juvenile elephants increased and the market has to date not become saturated. This situation resulted in the annual capture and confinement of scores of juvenile elephant at the Skukuza holding facilities, giving rise to the management, husbandry and clinical experience reported in this paper.

BASIC BOMA CONSTRUCTION

Basic boma construction has been covered in another presentation at this symposium, but a few important points should be emphasised.

1. The boma should consist of two linked areas with a controllable connecting opening to facilitate the daily cleaning of the boma, as well as providing safe handling of individual clinical cases. Elephants are highly intelligent and rapidly learn the cleaning and feeding routines which should be kept constant.
2. Adequate shade must be provided. Elephants tolerate cold better than heat because of their low surface area to body mass ratio.
3. More than one feeding and watering point should be provided per enclosure to reduce competition at these points.
4. Each boma should be supplied with a large mound of red soil. Elephants practise geophagia and red soils are iron-rich. Iron-deficiency anaemia has been described in elephants denied access to soil (Schmidt 1978). The soil mixed with water also provides good skin care and protection to elephants.
5. Access to hay should be through slatted openings to reduce wastage.

[a] National Parks Board, Private Bag X402, Skukuza, 1350, Rep. of South Africa

6. All bomas should be connected via a linking chute and the gates accessing this chute should be double-hinged and of greater width than the chute so that the animals can be channeled in either direction.

7. The bomas should be constructed with regard to the ground slope in such a manner that their drainage does not overflow from one compartment into an adjoining compartment.

8. All channeling gates should be fitted with rapid securing and releasing locking mechanisms.

9. The loading and off-loading ramp and chute should have a curved configuration and be fitted with strategically placed sliding gates to control the movement of the animals.

BASIC MANAGEMENTAL HINTS

a) Animals of similar ages and sizes should be accommodated together. This helps alleviate bullying and domination of smaller animals by large aggressive individuals.

b) Where possible never keep elephant in solitary confinement. They are social herd animals and being alone is extremely stressful.

c) From a managemental point of view we found that six elephants was the optimum number to be housed in a 30 m x 20 m boma.

d) One hay rack per three elephants appears to be optimum, but with more sought-after foods, such as pelleted concentrates, one must have one trough for every two elephants.

e) Citrus fruits, marulas *(Sclerocarya caffra)* and even sugar cane can be used to lure elephants into and out of most areas of the complex. Before attempting to load elephants for removal from the complex, they should be accustomed to moving out of the boma, into the loading chute and back. This is accomplished by opening the gate connecting their boma and loading chute for several days prior to loading and tempting them to enter and explore the chute. This is facilitated using fruit placed in the chute. Within a few days the elephants will be found to be moving freely and unstressed from their boma into the loading chute.

f) Adequate water must be available, not only for drinking purposes, but for elephants' characteristic behavioural and thermoregulatory water-using activities. Strategically placed showers may be erected in each boma for wetting-down purposes.

g) Hardwood rubbing posts are greatly appreciated by elephants and assist in preventing the accumulation of excess layers of dead skin.

NUTRITION

a) Nutrition of weaned juvenile elephants

In the natural state, elephants eat approximately 6 kg of plant material per 100 kg body weight per day. The average wild elephant must spend 18 hours per day feeding. Elephants in captivity are generally fed on a diet with less roughage and of higher nutritional value, and therefore this figure can possibly be reduced to 4 kg of feed per 100 kg body weight per day. Elephants have a relatively short digestive tract and a fast ingesta transit time. This results in a relatively low digestive efficiency, reported by Benedict & Lee (1938) to be in the region of 44% - compared with 60% efficiency in domestic herbivores. The natural feed of elephants is high in roughage and fibre (30%) and low in protein (7-10%) and one should strive to approximate these levels in captive feeding.

We have over the past decade had great success feeding our captive elephants on the following diet:

Lucern (Alfalfa) and tef hay *(Eragrostis tef)* mixture *ad lib* in slatted hay racks.

Once a day freshly cut branches of predominantly *Grewia* spp (Raisin bush) are offered. These are highly palatable and sought after, and both the leaves and bark are eaten with relish.

Specially-formulated elephant cubes (Epol Animal Foods) are also given at a rate of approximately 1 kg per 450 kg body weight per day. These pellets are formulated to contain 12% protein, 2,9% fat, 53% carbohydate, 10,6% fibre, 3,6% ash and 2 g/kg vitamin C - giving a T D N of 67,9% and a Ca:P ratio of 2,5.

Finally citrus fruits, or the fruits of the marula tree (when available) are given daily as a treat. These are highly sought after and can later be used to lure elephants into and out of various situations, and are also occasionally used to assist in administering oral medication.

b) Elephant paediatric nutrition

The captive rearing of very young unweaned elephant calves should not be approached lightly. It is an extremely demanding and time-consuming exercise. The milk substitute requirements of baby elephants are extremely specialised and the question of the replacement of a mother figure to afford 24 hours per day devoted companionship must be addressed. Whole cows' milk is not well tolerated by young elephants. It would appear that the butter fat component is the cause of the maldigestion or malabsorption which results in scouring. Some authors blame this on the fatty acid composition of bovine butter fat (Peters *et al.* 1972) and others relate it to the size of the fat globules (Bellinge & Woodley 1964) and report that it is better tolerated if the milk is homogenised.

Human infant formulas such as "Enfamil" and "S-26" have been successfully used and as a basic rule, baby elephants require one litre of these formulas per 10 kg body weight per day. Thus a 100 kg elephant requries 10 ℓ and a 200 kg elephant 20 ℓ per day. Rice-based formulas (Schmidt 1978) and maize meal porridge mixed with dilute or skimmed cows' milk (Young & Oelofse 1969) have given variable results.

The volume capacity of a young elephant's stomach is relatively small (*ca.* 2 ℓ) and thus numerous small feeds are desirable. Overloading the stomach results in the rapid passage of uncurdled milk out of the stomach and through the small intestine, giving rise to bacterial overgrowth in the caecum and colon and causing entero-colitis manifested as diarrhoea. For the first six months of life, young elephants should be fed at regular intervals throughout the day and night, but after six months the night feeds can gradually be phased out. Elephants start experimenting with solids from about six months of age - and can be totally weaned by 15-18 months.

VIRAL DISEASES

Few viral diseases have been diagnosed in the elephants under our care. Cutaneous papillomatosis is a fairly common benign selflimiting disease seen in newly captured juvenile elephants. Characteristic warty lesions (1-3 cm in diameter) which occasionally become scarified and take on a reddish pink "button" appearance, are found predominantly on the trunk skin, cheeks, lips and neck. They may be single or numerous and have recently been found to be caused by a Herpes virus (Jacobson *et al.* 1986).

Herpes virus lung nodules are an occasional post mortem finding in elephants (McCully *et al.* 1971). This appears to be a subclinical or latent condition and it is not known whether the same herpes virus is responsible for this condition, as causes the cutaneous papillomatous nodules.

BACTERIAL DISEASES

Abscesses

The most common bacterial condition encountered over the years has been subcutaneous abscesses caused by *Corynebacterium pyogenes*. These abscesses usually develop at sites of penetrating injuries caused by thorns, capture darts and other sharp objects. Elephant skin is invariably covered with mud and dirt, and this ubiquitous, normally saprophytic organism is introduced by the penetrating sharp object into the subcutaneous layers. Owing to the thickness of the skin, abscesses may sometimes dissect laterally instead of coming to a head, and may thus go undetected for a long time, and attain large dimensions. Where the tissues underlying the abscess are hard and rigid eg. on the forehead, pressure necrosis of the overlying skin may occur as the abscess enlarges - resulting in sloughing of this skin, causing large defects which heal very slowly. In general, abscesses are treated by aggressive surgical drainage, flushing with 6% hydrogen peroxide followed by irrigation with copious amounts of water or dilute surgical soap solutions.

Abscess prevention with respect to dart wounds is attempted by instilling oily intramammary antibiotic solutions into the dart wounds, as well as the administration of long acting penicillin intramuscularly shortly after capture.

Salmonellosis

Since the inception of elephant capture and confinement in bomas in the KNP, a single outbreak of salmonellosis occurred in 1976 and this resulted in high morbidity and significant mortality. *Salmonella typhimurium* was isolated, but the source of infection was never identified. Vaccination of captured elephants against salmonellosis was then instituted and continued for several years. Exhaustive attempts were made to identify a carrier state for this disease in elephants, but all rectal swabs taken from captured and culled elephants cultured negative on selective media. Thus after several years, the prophylactic vaccination of captured elephant was discontinued and no further outbreaks have occurred. A single death of a captured African elephant from salmonellosis in Britain has also been reported. *Salmonella hadar* was cultured in this case.

Anthrax

Anthrax *(Bacillus anthracis)* is endemic in the far northern region of the KNP, but cyclic epidemics occur in other regions of the park from time to time. Anthrax has been confirmed in elephants that died during these epidemics but elephants do not appear to be very vulnerable to this fatal disease in the KNP. No cases have been recorded to date in our captive elephants.

VERMINOSIS

During the first few years of elephant capture, intermittent morbidity and mortality was experienced as a result of heavy burdens of bile duct hookworms *(Grammocephalus calthratus)*. The original oral anthelmintic preparations used were not effective against this parasite, but injectable levamisole is effective.

During 1982/83, three elephants died due to exsanguination from bleeding gastric ulcers. These ulcers were found to be caused by heavy burdens of the spirurid, *Parabronema rhodesiense*, in the gastric mucosa. It would appear that stress contributed to the enlargement of the ulcers initially produced by this parasite. This parasite appeared to be resistent to the levamisole group of anthelmintics and has subsequently been found to be susceptible to the ivermectins which are now given routinely at capture.

NON-INFECTIOUS DISEASES

The following non-infectious clinical conditions were encountered in captive juvenile African elephants:

Congenital conditions

1. Neural tube defects:
   Two cases of encephalomeningiocoele were encountered

One case of spina bifida was identified

2. A case of unilateral anophthalmos was identified

3. A case of cleft palate was identified

Traumatic corneal lesions

On three occasions penetrating wounds of the cornea were encountered which probably occurred just prior to or during capture. Excellent results were obtained using intra-conjunctival antibiotic injections and suturing the eyelids together. This alternative was used after unsuccessful attempts at conventional conjunctival (nictitans) flap surgery. It was found that the sutures tore out of the nictitating membrane within a day or two and hence we reverted to through-and-through sutures to appose upper and lower eyelids. When possible an antibiotic/Vitamin A eye ointment was applied regularly into a small opening left in the lateral canthus of the eyelids. Of the three cases, two healed completely with only slight residual scarring of the cornea. The third case was complicated by the development of a partial anterior senechia, but a fair percentage of vision was salvaged.

Colic

The symptoms of colic in elephants are similar to those in horses and include restlessness, getting up and lying down, abnormal postures, biting the trunk tip, tenesmus and groaning. Only two cases of colic were recognised:

1. A spasmodic hypermotility colic resulting from the ingestion of mouldy lucerne. The successful treatment consisted of immobilisation, intravenous injection of spasmolytic drugs and the administration of liquid paraffin by stomach tube.

2. Severe constipation with tenesmus. This was successfully treated by immobilisation plus copious enemas using surfactant agents diluted in water. This animal's concentrated pellet and fruit intake was increased over the following few days in an attempt to prevent hard faecal boluses from developing in the descending colon.

Choke

A single case of choke was encountered after swallowing of a whole orange. Symptoms were restlessness, plus much fruitless time spent at the drinking trough, because each attempt to drink was followed by the ingested water gushing back out through the mouth. The animal became progressively dehydrated and an attempt to dislodge the foreign body using smooth muscle relaxants, lubricants and a probang resulted in a ruptured oesophagus and the elephant was destroyed. On post-mortem, the oesophagus was found to be locally devitalised as a result of pressure necrosis. Subsequently it was decided, because of the greedy competition amongst elephants when feeding oranges, to halve or quarter these fruits before feeding.

Skin conditions

1. An egg-sized tumour was removed from the external ear canal of an elephant. Histologically it was reported to be an oedematous fibrosarcoma with relatively anaplastic characteristics.

2. Acanthotic dyskeratosis - was diagnosed histologically from an elephant with thickened inflexible skin that had numerous cracks and fissures.

3. Focal raised circumscribed lesions (1-5 cm in diameter) were seen on the ears of one young elephant. These lesions later became necrotic and ulcerated. Biopsies revealed dermal capillary thrombosis resulting in infarction. Perivascular lymphocytic cuffing was also present. A viral aetiology was suspected (Pox? Herpes?) but no inclusion bodies were seen.

4. A dermoid cyst has been described in an 8-year-old African elephant.

5. Fibropapillomatous polyps of the rectal mucocutaneous junction and the vulvo-vestibule have also been described in captured African elephant.

6. Partial infarction of the pinna of the ear was seen in one captive elephant. This case appeared to be traumatic in origin and sloughing of the dried out infarcted area occurred after seven days. Iatrogenic necrosis of the ear of an elephant has been described by Schmidt (1978) following the intravascular injection of an irritant drug.

7. Lacerations - especially of the trunk are common and following debridement, mattress suturing using thick non-absorbable sutures is usually successful.

Metabolic diseases

Hypoglycaemia is relatively common in debilitated or emaciated elephants and usually occurs during the increased metabolic demand of cold autumn and winter nights. These animals are usually found in the early morning in a comatose condition, hypothermic and flaccid. These elephants should be treated with energy-rich oral alimentation, 3-4 ℓ of 5 % dextrose subcutaneously followed by five to 10% dextrose plus megadoses of Vitamin B complex intravenously. The results are usually spectacular with the animal regaining consciousness and getting up within minutes, necessitating the removal of the intravenous line. It must be stressed that this is only a symptomatic treatment, since the cause of the debility has not been addressed. Occasionally such hypoglycaemic elephants develop encephalopathy characterised by numerous neurological defects after euglycaemia has been achieved. These include ataxia, circling, nystagmus, anisocoria and dysmetria. These cases have a poor prognosis. It must be emphasised that attention should be paid to supplying warmth to debilitated and hypoglycaemic elephants as part of prevention and treatment.

Hypertrophic osteodystrophy with valgus deformities of the tibiotarsal joint have been reported in elephants with high protein and calcium intake. We have seen this condition in captive elephants near Windhoek fed exclusively on lucerne and bone meal.

Tusk conditions

Three different clinical conditions of the tusks have been identified in our captive elephants:

a) Fairly commonly, a purulent infection of the tusk sulcus has been seen. This appears to be caused by traumatic impact of the tusks as the elephants push against solid objects in their confined area. The sensitive tissues lining the sulcus become damaged and the resultant bruising and haemorrhage becomes secondarily infected. Spontaneous healing occurs when the animals settle down and also following release into the veld.

b) "Blind" tusks which fail to erupt through the skin and form a subcutaneous swelling are occasionally seen. The condition is probably also traumatic in origin, the trauma occurring at an early developmental stage of these modified incisors.

c) Tusk pulpitis with a discharging fistulous tract opening at the tip has been seen in two captured elephants at Skukuza. A similar condition and its treatment has been reported (Wyatt 1986) as well as a death resulting from probable toxaemia as a result of chronic pulpitis (McGavin *et al.* 1983).

CASTRATION OF YOUNG BULL ELEPHANTS

Many zoological gardens prefer to obtain female elephants for their exhibits, because male animals, on reaching puberty may become fractious and unmanageable, especially during "musth" periods. We therefore decided to attempt castration in two juvenile bulls. A single incision was made in the right paralumbar fossa between the last rib and tuber coxa (which are very close together). Both intra abdominal testes could be located by palpation through this incision, and bilateral orchidectomy was performed blindly, yet successfully using a chain ecrasseur. The skin was closed with stainless steel sutures, and healing took 3 weeks, before the sutures could be removed. According to Sikes (1971) no extension of epididymal tissue is presented beyond the body of the testis, and the first part of the vas deferens has a non-secretory Wolffian duct-like structure making the problem of "cutting proud" unlikely. These two castrated bulls were sold to an American Safari Park, but no feedback was ever obtained.

REFERENCES

Bellinge, W.H.S. & Woodley, F.W. 1964.Some notes on the rearing of young African elephants. *East African Wildlife Journal* 2: 71-74

Benedict, F.G. & Lee, R. Further observations on the physiology of the elephant. 1938. *Journal of Mammalogy* 19: 175

Bengis, R.G., Hedger, R.S., de Vos, V. & Hurter, L.R. 1984. The role of the African elephant *(Loxodonta africana)* in the epidemiology of foot and mouth disease in the Kruger National Park. *Proceedings of the XIIIth World Congress on Diseases of Cattle, Durban, South Africa,* 1: 39-44

Howell, P.G., Young, E. & Hedger, R.S. 1973. Foot-and-mouth disease in African elephants. *Onderstepoort Journal of Veterinary Research* 40: 41-52

Jacobson, E.R., Sunberg, J.P., Gaskin, J.M., Kollias, G.V. & O'Banion, M.K. 1986. Cutaneous papillomas associated with a herpesvirus-like infection in a herd of captive African elephants. *Journal of the American Veterinary Medical Association* 189: 1075-1086

McCully, R.M., Basson, P.A., Pienaar, J.G., Erasmus, J. & Young, E. 1971. Herpes nodules in the lung of the African elephant. *Onderstepoort Journal of Veterinary Research* 38: 225-236

McGavin, M.D., Walker, R.D., Schroeder, E.C. Patton, C.S. & McCracken, M.D. 1983. Death of an African elephant from probable toxemia attributed to cgronic pulpitis. *Journal of the American Veterinary Medical Association* 183: 1269-1283

Peters, J.M., Maier, R., Hawthorne, B.E. & Storvik, C.A. 1972. Composition and nutrient content of elephant *Elephas maximus* milk. *Journal of Mammalogy* 53: 717

Schmidt, M. 1978. *In:* ***Fowler, M.E.*** *(ed.) Zoo and Wild Animal Medicine*. Chapter 27 (pp 709-723)

Sikes, S.K. 1971. *The Natural History of The African Elephant*. New York: American Elsevier Co.

Wyatt, J.D. 1986. Medical treatment of of tusk pulpitis in an African elephant. *Journal of the American Veterinary Medical Association* 189: 1193

Young, E. & Oelofse, J. 1969. Management and nutrition of 20 newly-captured young African elephants, *Loxodonta africana*, in the Kruger National Park. *International Zoo Yearbook* 9: 179-184

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

THE AFRICAN ELEPHANT *(Loxodonta africana)* AS A GAME-RANCH ANIMAL

J G du Toit[a]

Game-farming has increased tremendously in South Africa in recent years and demands are made by this industry that cannot yet be met. This paper is aimed at extracting current available knowledge of the natural systems and applying it to the artificial game-ranch concept.

REASONS WHY FARMERS WANT TO KEEP ELEPHANT

1. Sentimental reasons

Game-ranch owners are often conservation conscious and therefore they create their own game reserve where the "big five" must feature.

2. Tourism

South Africans have urbanized in recent years and a great need has developed to "break away" to a natural environment eg hiking trails. Elephants enchant tourists and display the untouched Africa.

3. Hunting

This is a long-term investment and the ranch-owner must have a large enough area to establish a viable herd. An elephant bull, aged between 5-10 years, can be introduced, but will only have a significant trophy after 25 years.

4. Ecological reasons

Elephants push over trees and keep an equilibrium between grass and trees. Hanks (1979) mentioned that they push over trees maintaining the energy and mineral cycles; their pathways reduce the spread of veld fires; the opening of new water points during dry periods produces water for other animals; they form pan systems by rolling in small mud pools after rains and the dispersal of seeds (eg *Acacia albida* seedlings) takes place as the seeds germinate in elephant dung.

ELEPHANT PROBLEMS ON GAME RANCHES

1. Escape from ranches

Elephants in large game reserves may break out from time to time. This is the biggest problem where game reserves border on densely populated areas and conflict can lead to injuries and manslaughter. De Villiers (1980) found that crossing of the fence in the Etosha National Park took place during the dry season when herds expanded their grazing areas. He stated that in 89,4% of cases they were animals with shoulder heights of more than 2,8 m. According to Croze (in Hanks 1979) bulls between 25 and 50 years of age competed to mate with females in oestrus. These age intervals represent animals with shoulder heights of 2,8 to 3,4 m. Farmers of the Otjivasandu area believe that bulls break through to the farms first, to "inspect" the area and are followed afterwards by breeding herds.

[a] P O Box 29421, Sunnyside, 0132, Rep. of South Africa

The above-mentioned data reflect the importance of good water distribution and the availability of food. The age structure of bulls in herds plays an important part in preventing breaking out of reserves or game ranches.

2. Interactions with people

The introduction of elephants on game ranches requires a period of boma training. During this time they are hand-fed and lose their fear of human beings. When young bulls reach puberty at the age of 10 years, they become aggressive and will attack people with fatal results.

3. Destruction of facilities

Elephants will damage permanent installations like water points, telephone lines, buildings, etc., and therefore the protection of equipment is of primary importance.

4. Damage to trees

Elephants tend to debark trees like the baobab *(Adansonia digitata)* and *Acacia* spp throughout the African continent. McCullagh (1973) found that elephants in Uganda select baobab and *Terminalia* trees. The woody pulp and bark of these species contain a higher concentration of linoleic acid than non-selected species. He suggested a deficiency of essential fatty acids, as a reason for their "destructive" behaviour. Special plant communities, eg. the *Moringa ovalifolia* "sprokieswoud" in the Etosha National Park, may need special protection against this destructive behaviour from a conservation point of view.

5. Competition for food and water resources

The most important habitat requirements of elephants are clean water, enough food (browse and grass) and shade (Smithers 1983). They will tolerate most animals near water holes, with the exception of rhinoceroses and hippopotami. In Botswana they killed sable near water holes with little water. The biggest conflict at water holes on game ranches may possibly occur between elephants and rhinoceroses.

Elephants will utilize a wide spectrum of plant species as found by many researchers. In Uganda, Dougall & Sheldrick (1964) mentioned 64 plant species; Pienaar, Van Wyk and Fairall (1966) listed more than 100 species in the Kruger National Park; and Viljoen (1988) found that 33 plant species in Kaokoland formed the main component of their diet. Elephants will browse more during the warm dry season and therefore compete with browsers like giraffe, kudu and black rhinoceros on game ranches. This effect is shown by Jarman (1971) in the Zambezi Valley. The overlap in diet between elephant and buffalo decreased from 22,6 % in the wet season to only 1,1 % in the dry season, when elephant started to browse. This is an important factor to bear in mind where black rhinoceros and elephant occur on the same game ranch. As a guideline elephants must not be more than 15 % of the total biomass of the herbivore component on a game ranch. The densities of elephants for different game reserves in Africa are illustrated in table 1.

POSSIBLE MORTALITIES OF ELEPHANTS ON GAME RANCHES

Hanks (1979) grouped the factors for mortalities in elephants under the following headings: predators (excluding man), diseases and parasites, accidents, drought, starvation, stress, hunting and poaching, old age and fighting. Mortality rates for calves will depend on their age and the area. In Kabalega (Murchison Falls) Park, mortalities for elephant calves under three years of age varied from 20 % in 1945 to 38 % in 1965. The main factors were heat (not enough shade), stress and poor nutrition. In Manyara, where conditions are favourable, the mortality for first-year calves is 10 % and thereafter the same as for adults, 3-4 % (Moss 1975).

Table 1: Selected elephant densities for different parks grouped in rainfall categories (Viljoen 1988)

RAINFALL LOCATION	SIZE (km^2)	ELEPHANT NUMBERS	DENSITY (elephant/km^2)	DENSITY (ha/elephant)
200-400 mm per annum				
Tuli, Botswana	1 250	600	0,48	208
400-600 mm per annum				
Etosha National Park	22 270	1 114	0,05	2 000
Hwange National Park	14 450	21 278	1,46	68
Okavango, Botswana	16 000	3 040	0,19	526
Kruger National Park	19 485	7 404	0,38	263
600-800 mm per annum				
Zambezi Valley, Zimbabwe	11 617	12 711	1,09	92
Chobe National Park	12 000	6 000	0,50	200
Addo Elephant Nat. Park	77	92	1,19	84
800-1000 mm per annum				
Luangwa Valley, Zambia	40 000	86 400	2,16	46
1400-1800 mm per annum				
Garamba National Park	4 480	22 669	5,06	20

According to Hanks (1979) drought could be one of the most important factors controlling elephant populations in Africa. Drought and starvation go hand in hand, because drought restricts plant growth that leads to starvation.

1. Diseases

Pienaar (1961) mentioned that anthrax can be spread by herd animals like elephant, buffalo and warthog that are fond of wallowing. These animals can carry infected mud from one water hole to another. Elephants can die of anthrax, although they are not that vulnerable and mortalities made out 0,28 % during the above mentioned outbreak. Ebedes (1977) found that 25 (1,6 %) elephants died of anthrax out of a total of 1 526 animals in the Etosha National Park over a 10-year period.

The above-mentioned data show that anthrax mortalities should play a minor role on game ranches, although is is recommended to vaccinate these animals during outbreaks.

Trypanosomes were repeatedly demonstrated in the blood of African elephants, but little information is available on the pathogenicity (Salzert 1982). Where elephants are introduced in tsetse-infested areas from non-infested areas, mortalities can be expected.

2. Poisoning

Davidson (1967) mentioned elephants that left the Wankie National Park and drank the contents of dipping tanks on bordering cattle ranches. These elephants died of the toxic effects of the dip. This is an important factor where elephants are introduced on ranches in arid areas bordering cattle farms.

3. Predation

Where young elephants are introduced in areas where lions occur, predation can be an important factor. An elephant calf which was separated from its mother was killed by lions in Lake Manyara National Park (Schaller 1972). Pitman (as quoted by Hanks 1979), reported that young elephants are not infrequently killed by lions in Uganda.

4. Natural causes

Young elephants may get stuck in mud at drinking places. Young elephants without a "leader" cow are very nervous and in the case of veld fires, will stampede and burn themselves. This is an important factor where burning programmes are implemented on game farms.

ADVANTAGES OF ELEPHANTS ON GAME RANCHES

1. Ecological

The most important advantage is the animal's influence on the ecology of the environment. Viljoen (1988) mentioned the following effects of elephants on the Northern Namib Desert. During droughts, the desert fauna depends on water holes dug and maintained by elephants. The browsing of trees keeps the browse-level within the reach of smaller browsers. There is an increase in the dispersal and germination rate of *Acacia* seeds passed through the elephant's gastro-intestinal tract.

The opening of pathways to feeding and drinking areas for other animals occurs. Seeds in elephant dung are an important food source for game birds during droughts. Elephants take a mud bath daily, which is important to control body temperature and protect them against biting insects. Mud wallows start at old termitaria, where animals will eat soil and create a hollow where rainwater accumulates. Smaller animals like warthog will roll in these hollows followed by bigger animals such as buffalo and elephant. During the early rainy season animals move away from permanent water points and utilize these pans, which will relieve the grazing pressure.

The elephants' influence is mainly on trees and bushes and not grass. They push over and break parts of trees and ring-bark trees that will lose their fire resistance and are therefore destroyed by grass fires. This feeding behaviour leads to the so-called "elephant problem" (Eltringham 1979). Elephants encourage the spread of veld fires by opening up thickets and allowing grassland to encroach.

Elephant form an integral part of the ecological system on a game ranch and can be an important tool in the hands of the ranch manager to prevent bush encroachment.

2. Conservation

The elephant numbers in Africa declined because of pressure on their habitat and poaching for ivory. In South Africa, the largest population occurs in the Kruger National Park, with smaller groups in medium-sized reserves. The elephant population in South Africa can therefore drop drastically when disease, drought or poaching occur in the Kruger Park. Large game ranches can play an important role to conserve elephant populations.

3. Tourism

The elephant will play an important role as a tourist attraction on photographic safaris that take place on private game ranches. As a hunted species on a game ranch, it will play no role at all on a short-term basis.

DISADVANTAGES OF ELEPHANTS ON GAME RANCHES

1. Manslaughter by elephants

In India 100 to 150 people die annually as victims to elephant attacks. This figure is low, when compared to 15 000 deaths due to rabies in the same country. The patterns in manslaughter by elephants in India are given by Sukumar (1989) in Table 2. The most significant factor is that in 82% of the cases male elephants are involved. The introduction of male elephants on game ranches is a critical problem that the ranch manager must consider, especially on ranches bordering cultivated areas or where hiking takes place.

The reasons for aggression may be a rise in testosterone levels when the animals are in musth, injuries like a broken tooth and areas where poaching takes place (Sukumar 1989). A large number of killings (45%) occurs within settlements, when people try to prevent the elephant from feeding on cultivated crops.

Table 2: Patterns in manslaughter by elephants

	NUMBER	PERCENTAGE
People killed		
Men	102	77,3
Women	23	17,4
Children	7	5,3
Total	**132**	
Place of encounter		
Forest	68	55,3
Cultivation	55	44,7
Total	**123**	
Elephant responsible		
Male	51	82,2
Female	6	9,7
Herds	5	8,0
Total	**62**	

2. "Destruction" of habitat

Hanks (1979) stated that mopane *(Colophospermum mopane)* trees in the Luangwa Valley, Zambia, were felled at a mean rate of 138 trees/km^2/year, or 4% of the standing crop of trees each year. Anderson & Walker (1974) reported that elephants preferred to browse on the regrowth of previously damaged mopane in Zimbabwe. Their study showed that 63% of the total tree population in the three main vegetation types had been killed or converted to shrubs over the past seven years. Under natural conditions the "destruction" of trees plays an integral part of an ecological process. Elephants, by opening up thickets, allow grassland to encroach and encourage the spread of fire (Eltringham 1979). The game ranch manager must decide on a maximum number of animals for the ranch, based on the carrying capacity and interactions with other species and try to maintain a balance between grassland and woodland habitat. An overpopulation of elephants on a game ranch may turn it into a "desert", especially in drier bushveld areas.

3. Damage of structures/installations

Elephants are well-known for their vandalistic behaviour regarding telephone poles, water installations, hunting camps and cultivated crops. Electric fences can help to protect camps and trenches around windmills and rocks around telephone poles may keep the elephant at bay.

RECOMMENDATIONS FOR THE INTRODUCTION OF ELEPHANTS ON GAME RANCHES

1. Age of the animal

The matriarchal social structure of the elephant is important when introducing young elephants on large game ranches, especially where predators are present. A typical family unit of elephants usually consists of an old female (the matriarch) and two or three females (the matriarch's daughters) and several calves of varying ages and sizes belonging to any of the females. Female calves remain with the family unit, but male calves leave the unit when they reach puberty. They will stay solitary or join other males to form a bachelor group (Eltringham 1979). The function of the matriarch is to protect the family against danger, eg. calves attacked by predators. She leads the family to suitable feeding areas and water holes in a passive way, in that other elephants will follow the matriarch's lead.

Elephant calves used for introduction are usually the product of a culling programme. The introduction of adult wild elephants to create a family unit is practically impossible. Where possible a tame adult female from a zoo or circus can be used to stimulate the creation of a stable family unit. The females must be larger than the males to prevent "bullying" during the boma period. Where predators are present, calves of at least 1,7 m shoulder height should be introduced.

2. Sex ratios

The herd structure for elephants in the Kruger National Park during the 1990 census was: breeding herds 83,5 % and male herds 16,5 % of the total population of 7 278 elephants (Viljoen[b] 1991, pers. comm.)

Laws, Parker and Johnstone (1975) found the mean group sizes for elephant bulls in Tanzania 3,08 and Kenya 2,42 and the mean family group size was 11,6. The family units comprised 85% of the population; that is nearly the same as for the Kruger Park population.

The ratio of bull herds to family herds is 1:5,7 (15 % : 85 %). Family herds consist of males and females and a recommended sex ratio for the introduction of elephants on game ranches is an adult male for each breeding herd comprising six to ten animals.

3. Minimum viable population size

Factors that will influence the introduction group size of elephant on game ranches will be genetic, social, size of the area and economic. Franklin (quoted by Sukumar 1989), stated that intensive inbreeding leads to a loss of fitness through lowered fertility, higher juvenile mortality, depressed growth, etc. Based on the information of the breeding of domestic animals, a minimum of 50 breeding individuals are suggested to keep inbreeding depression below 1% per generation. Sex ratio plays an important role in genetic drift, the more unequal the sex ratio, the higher the rate of genetic drift. An effective population size based on the sex ratio of adult animals is shown in the following equation:

$$Ne = \frac{4\,NmNf}{Nm + Nf}$$

Ne = Effective population size
Nm = Number of breeding males
Nf = Number of breeding females

The ideal sex ratio of 3 males to 5 females for a minimum effective population size gives 19 breeding males to 31 breeding females. When these values are tested, it gives an effective

---

[b]Private Bag X402, Skukuza, 1350, Rep. of South Africa.

breeding population size of 47 which shows that the sex ratio will not influence the genetic drift and inbreeding drastically. A total population size of 125-150 animals is required to provide 50 breeding animals.

Very few game ranches will be able to carry 120 elephants. The only way game ranchers, that are concerned about inbreeding can combat the problem, is to remove fences with neighbours and to create a large enough area, or to replace young bulls on a regular basis with animals of unrelated populations. The elephant population in the Addo Elephant National Park increased from 11 elephants in 1931 to 160 in 1990. The possible reason for no ill-effects of inbreeding in this population could be the long generation breeding interval in elephants.

The minimum group size regarding the social structure can be based on the average herd sizes of bull herd (3,08) and family groups (11,6) as discussed earlier. The introduction of adult family groups is recommended. Where calves are introduced, an adult female is necessary to stimulate the formation of the matriarchal system.

4. Minimum viable area

What will the minimum viable area be for the conservation of the elephant? According to Table 1 the rainfall, size of the area and whether or not the property is fenced will play an important role in the density of elephants/km^2. Lowveld farms can be compared to the Kruger National Park's density of 0,38 elephant/km^2 (1 elephant/263 ha). As a guideline, the extrapolation of the density with the minimum introduction herd size of eight animals, the following calculation can be made:
Minimum Lowveld farm size = 263ha/elephant x 8 elephants = 2 104 ha

If one assumes that the minimum introduction herd size is 30-50% of the carrying capacity for elephants, then lowveld farms less than 4 000 ha will be unsuitable for the introduction of elephant.

The game ranch manager must remember that it is "dangerous" to work on fixed carrying capacities and that an approach of adaptive management must be followed. As stated earlier it is important that the elephant will not comprise more than 15 % of the total biomass of herbivores on the game ranch.

5. Time of the year

According to Field (1971), elephants in Rwenzori National Park showed a marked increase in browsing when the monthly rainfall dropped below 50mm, although it remained a minority activity which did not exceed even 45 % under the driest conditions. This is an important factor to remember, where elephants are to be released to the Sour Bushveld. The optimum time of the year for the introduction of young elephant on game ranches in Southern Africa is from end of March to end of May, when there is still enough browse present.

RECOMMENDATIONS TO KEEP ELEPHANTS FENCED ON GAME RANCHES AND LIMIT THE CHANCES OF MANSLAUGHTER

1. Teach animals to respect electric fences

The first contact of the young elephant with a fence is at the capture site. The elephant is an intelligent animal and it is important to teach it at the capture site to respect an electric fence. At the introduction site, it is important to build a pre-release pen adjacent to the boma of about a hectare and the same structure as the bordering fence to teach the young elephants to respect fences on the ranch.

Sukumar (1989) stressed the fact that an electric fence is not a physical barrier, but merely a psychological bluff. He knew of an old Indian bull elephant from Kemasul, Malaysia, that consistently broke through an electric fence by rearing up on its hind legs, placing its front foot on the upper wire that snapped and then crossing over. The footsole is a bad conductor of electricity and therefore did not shock the old bull.

Viv Bristow[c] (1991, pers. commm.), has a tame elephant bull that will use its trunk to feel close to the electric wire and test if the electricity is on. It uses its tusk to twist the wire and walk through the fence if the electricity is on, or walks straight through it if the electricity is off.

Elephants that learn to cross an electric fence must be removed from the ranch or shot to prevent a "problem animal" in future.

2. Good water and food supply

Sufficient waterholes, well distributed throughout the game ranch and earth dams for mud baths, are essential to prevent the animals from leaving the area. Salt is an important ingredient in the diet of an elephant and salt licks can be placed near the water holes.

Maize or sunflowers can be cultivated during the dry season to provide a good quality food for elephant on the ranch.

3. Selection of the type of elephant

Animals have their own personalities that one can already discover when they are still very young. Where tourism is encouraged on a game ranch, it is important to select elephant calves with a docile temperament.

4. Boma training

Hand-feeding of young animals must be discouraged to prevent them losing their fear of humans. The aim must be to "boma-train" the elephant and not "boma-tame" them. An elephant that loses its fear for human beings is a "problem animal".

5. Castration of aggressive male animals

According to Leshner (in Sukumar 1989) a rise in the level of male sex hormone, testosterone, is accompanied by increased aggressiveness in many vertebrate animals. The level of testosterone in blood plasma increases from 0,2-1,4 ng/mℓ during the full musth phase in captive Asian bull elephants. This may be an explanation why elephant bulls in musth are more aggressive. Flanagan & Flanagan (1983) found an increase in docility six months after the successful castration of an aggressive young elephant bull.

6. Proposals for the protection of tourists/local people

- Warning signs on the boundary fence to warn people of elephants on the game ranch
- Insurance "protection" when claims for injuries are made by tourists against game ranch owner.
- Hiking trails on foot must be accompanied by a ranger with a rifle
- Camping sites must be protected

CONCLUSION

The game ranch manager must evaluate the advantages against the disadvantages when he decides to introduce elephants on game ranches. Because the elephant plays an important role in the ecology, the introduction of animals is recommended on large game ranches. The conflict between

---

[c] P O Box 733, Harare, Zimbabwe

elephants and humans will be a problem in future on small game ranches and the introduction on such areas must be well considered.

REFERENCES

Anderson, G.D. & Walker, B.H. 1974. Vegetation composition and elephant damage in Sengwa Wildlife Research Area, Rhodesia. *Journal of the South African Wildlife Management Association* 4: 1-4

Davidson, T. 1967. *Wankie, the story of a great game reserve*. Cape Town: Books of Africa

De Villiers, P.A. 1980. Die verspreiding en beweging van olifante in Etosha - finale verslag. Departement van Landbou en Natuurbewaring, Suidwes-Afrika.

Dougall, H.W. & Sheldrick, D.L.W. 1964. The chemical composition of a day's diet of an elephant. *East African Wildlife Journal* 2: 51-59

Ebedes, H. 1977. Anthrax epizootics in Etosha National Park. *Madoqua* 10(2): 98-118

Eltringham, S.K. 1979. *The ecology and conservation of large African mammals*. The Macmillan Press Ltd

Field, C.R. 1971. Elephant ecology in the Queen Elizabeth National Park Uganda. *East African Wildlife Journal* 9: 99-123

Flanagan, H.O. & Flanagan, F.O. 1983. Castration of African elephant *Loxodonta africana*. *Zimbabwe Veterinary Journal* 13 (3/4): 50-51

Hanks, J. 1979. *A struggle for survival - the elephant problem*. Cape Town: C Struik Publishers.

Jarman, P.J. 1971. Diets of large mammals in the woodlands around Lake Kariba, Rhodesia. *Oecologia (Berlin)* 8: 157-178

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: Claredon Press.

McCullagh, K.G. 1973. Are African elephants deficient in essential fatty acids? *Nature, London* 242: 267-268

Moss, C. 1975. *Portraits in the wild. Animal behaviour in East Africa*. London: Hamish Hamilton.

Pienaar, U. de V. 1961. A second outbreak of anthrax amonst game animals in the Kruger National Park, 5th June to 11th October 1960. *Koedoe* 4: 4-17

Pienaar, U. de V., van Wyk, P. & Fairall, N. 1966. An aerial census of elephant and buffalo in the Kruger National Park and the implications thereof on intended management schemes. *Koedoe* 9: 40-107

Salzert. 1982. Elephants. *In:* **Klös, H.G. & Lang, E.M.** (eds.) *Handbook of Zoo Medicine*. New York: Van Nostrand Reinhold Company

Schaller, G.B. 1972. *The Serengeti lion - a study of predator-prey relations*. Chicago: University of Chicago Press

Smithers, R.H.N. 1983. *Die Soogdiere van die Suider-Afrikaanse Substreek*. Pretoria: Universiteit van Pretoria

Sukumar, R. 1989. *The Asian elephant. Ecology and management*. Cambridge: Cambridge University Press

Viljoen, P.J. 1988. The ecology of the desert-dwelling elephants *Loxodonta africana* (Blumenbach, 1797) of Western Damaraland and Kaokoland. DSc (Wildlife Management) thesis. University of Pretoria

0*Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991*

THE HUNTING POTENTIAL OF ELEPHANTS[a]

Nico van Rooyen[b c]

Few hunting experiences world-wide equal the thrill of elephant hunting in Africa. From the earliest days, the lure of hunting these forest giants for the commercial value of their ivory attracted hunters from the four corners of the earth. They criss-crossed the continent in their quest. For many hunters this became their way of life and large parts of Africa were explored by these travellers.

The modern hunter's pursuit of elephants has a totally different dimension. At least 90 % of present-day hunters have a nostalgic yearning, maybe even an obsession, to follow the spoor of these African giants. This obsession mounts progressively as the hunter succeeeds in bagging other members of the "Big Five".

Elephants were traditionally hunted in the extensive African wilderness. The charm of being in the great outdoors was enhanced by the challenge of the hunt. What is more challenging to the hunter than starting out at first light, following the spoor of a herd of bull elephants for 30 km and many hours, and then, totally spent, sitting on a log with the sweat on your back burnt to saltpetre by the scorching African sun and having to decide whether to give up the chase? Will I make it? Will there be enough time to reach camp before nightfall? The elephant hunter must be prepared to return to camp many a time, footsore, to lick his wounds and to set out again the next day. Success will come at last.

If you happen to be following the spoor of a great tusker well-known to the locals and described to you in great detail, the adrenalin will be flowing strongly in your veins and you will not feel the pain of walking for days and not finding your quarry. It is then that you build a campfire wherever nightfall overtakes you, make yourself as comfortable as possible for a long night before taking up the spoor again at daybreak.

If, at the close of the next day, you hear branches snapping ahead of you, you realise that you have met the challenge that elephant hunting poses; that is what elephant hunting is all about. Shooting the animal is a virtual anti-climax. Being free in the veld, the slogging for days and weeks in the inhospitable African wilderness, the excitement of testing your skills in sneaking into a herd of elephants in order to get the big bull in the sights of your rifle, these are the things that make elephant hunting an unforgettable experience.

In South Africa alone there are 6 000 registered sport-hunters, members of the 13 amateur hunters' associations affiliated to the Confederation of Hunters' Associations of South Africa (CHASA). If one considers that 90 % of these are potential elephant hunters, plus the thousands of hunters from abroad, it should be clear that demand far outstrips supply. Free-market forces have therefore escalated the price of elephant hunting and placed it beyond the reach of most hunters. Even though most hunters realise that hunting an elephant will forever be a dream, a substantial number world-wide have the financial means of making the dream come true.

---

a Translated from the original Afrikaans by B L Penzhorn

b Nico van Rooyen Taxidermy, P O Box 911-217, Rosslyn, 0200, Rep. of South Africa

c Deceased

When considering the prices paid for trophy elephants as well as for hunting safaris with elephants on the bag list, one realises that it has become a highly profitable resource for the handful of African countries still able to market their surplus elephants in this way.

It is ironical that South Africa, maintaining probably the best elephant management programme on the continent, has only recently entered this market, making available a small number of surplus bulls annually on private reserves and on one of the national states bordering the Kruger National Park.

To the best of my knowledge, no elephants were hunted on private reserves in 1990. The four bulls being offered on two reserves this year will net the owners R45 000 per elephant. Safari outfitters combine this with a 14-day safari, escalating the price to the region of R100 000. Ten elephants were hunted in Gazankulu in 1990, which brought in R26 500 per elephant. The meat was utilised by the local population.

Elephant hunting is possible in a handful of countries only: South Africa, Namibia, Zimbabwe, Tanzania and Ethiopia. Zimbabwe is maintaining a sound management and utilisation programme for its wildlife, and elephant hunting is a lucrative source of foreign exchange and a vital source of revenue for the treasury. Many entrepreneurs make a living from elephant hunting and also create many employment possibilities in a country with escalating unemployment. In Zimbabwe elephant hunts are offered on communal land, on land controlled by National Parks & Wildlife and a small number on private property. A total of 71 bulls were hunted on communal land in 1990. Hunting of these problem animals was handled by safari outfitters and in all cases was combined with 21-day safaris. Elephants were offered for US$7 500, and with the daily safari fee included each animal was worth at least R40 000. The local population benefits from this utilisation of elephants. Traditionally, elephants threatened the very existence of the local population by destroying crops and property. Now the locals are benefitting by receiving a proportion of the hunting fee, as well as by the jobs created by the safari companies.

Elephant hunting on land controlled by National Parks & Wildlife in Zimbabwe falls into three categories:

a. Packages rented to safari outfitters as concession areas.

b. Surplus elephants and other hunting packages auctioned annually to prospective hunters world-wide.

c. Surplus elephants made available exclusively to members of local hunters' associations.

In the rented concession areas, elephants were recently sold for about R7 500 to safari outfitters who then sold them to hunters for US$7 500, plus a daily fee for a 21-day safari. The price set by the government will be revised this year, and safari outfitters will probably have to pay about R12 000 next year.

I attended the 1991 auction in Harare last month. Fourteen elephant bulls were offered in two hunting areas in the Zambezi Valley. Prices varied between R22 000 and R34 000 with an average of R27 944 per animal. Before buying an elephant, hunters had to purchase a 14-day safari for R18 850 which did not include outfitting.

Elephant bulls are offered to members of the Zimbabwe Hunters' Association at R7 500 per animal. These animals are in areas where culling takes place. Cows are offered to local hunters at R2 000. In 1990 about 200 elephants were hunted in Zimbabwe, 100 being in areas directly controlled by National Parks & Wildlife.

This management programme, with minor adjustments, has been in operation for a number of years in Zimbabwe. Their elephant population is healthy and by allowing the surplus to be hunted, a valuable renewable resource has generated funds for conservation of their natural heritage. If the potential utilisation of elephants by hunting is considered against the background of our difficult economic times, it is inconceivable that some bodies are not utilising this source optimally.

The legal aspects of elephant management were covered in another paper. As we are all aware, utilisation of the African elephant is strictly controlled by CITES. South Africa ratified this Convention on 13 October 1975, thereby unequivocally committing itself to the directives and regulations of CITES. As the African elephant was upgraded to Appendix 1 two years ago, the CITES regulations have a profound effect on the trade in elephant products and on elephant hunting. This entails that South Africa has to obtain a CITES quota for the export of legally-hunted elephant products. In addition, the importing country has to issue an import permit before South Africa may issue an export permit. Although these provisions hamper hunting of elephants, we are optimistic that it will be possible, in the near future, to export legally-hunted elephant products, as is the case with leopards, from South Africa to most other countries. Fortunately, CITES is not unwilling to make concessions for legally-hunted animals on Appendix 1, provided that it was done as part of a proper management programme.

Our commitment to CITES has to be borne in mind when hunting, the most profitable use of the resource, is considered. It may become easier in future, or on the contrary, may be utterly destroyed if sportsmen are denied permission to take their trophies home. This will impact extremely negatively on the price of elephant hunting.

If surplus elephants were to become available for hunting on private property in future, a few pitfalls will have to be avoided. It is well known that the potential demand for a product decreases if the price increases. Although there is a strong demand for elephant hunting at present, there is a maximum price which most hunters are prepared to pay. Exorbitant prices may put even this exclusive hunt beyond the reach of virtually all hunters. Consumer resistance may develop, which will make the marketing of elephant hunting increasingly difficult. Please note that hunters are willing to pay a premium for the total adventure. It was with this in mind that I described an elephant hunt in the African wilderness in my introduction. In addition to the unique African experience, various other interesting species are included in the hunting package. The safari is therefore not restricted to hunting of an elephant. The private land-owner will have to determine the exact requirements of the hunter. He should not be blinded by gaining the maximum financial benefit for himself, but should fulfil all the requirements of an ethical hunt when presenting his product. He should realise that hunting as a resource sets certain demands which cannot be jettisoned in favour of his financial gain. In addition to the written rules, hunting is regulated by many unwritten ones.

The hunter's general experience is that most private land-owners labour under a huge misconception regarding the needs of the hunter. One should note that the majority of hunters maintain high ethical values and wish to pursue their sport accordingly.

A major problem concerning organised hunting in the South African context is that many game ranchers are under the impression that hunters are willing to hunt under any conceivably condition, at the whim of the rancher, and in addition are willing to pay exorbitant prices for the privilege. A true hunting experience with accepted ethical standards has to be provided at all times. Land-owners should refrain from abusing nature and violating sport-hunting for personal financial gain.

It is difficult to accommodate large and dangerous mammals on private land, precisely those animals reaching the best prices on the hunting market. This encourages ruthless people to set up such animals in the most artificial and unethical way and to offer them to sports hunters.

I shudder to think that commercialisation on small tracts of land may force elephants in South Africa onto the same sorry road as the king of beasts. The "canned lion" concept in South Africa is rejected with contempt by the hunters of the world. The idea of shooting hand-reared, semi-tame lions kept in small camps and fed daily is repugnant to most hunters. This makes a mockery of the highest challenge and ideal of many a hunter: to hunt a lion in Africa, and not merely to shoot it. The organised hunting fraternity in South Africa resents this abuse and has objected vehemently to the authorities ever since the practice appeared on the scene about 10 years ago. With deep regret I have to report that at least two provincial authorities have given in to "big money" and are seeking arguments in favour of this reprehensible practice. In the interests of earning foreign exchange a blind eye is turned to this abuse of our wildlife and some authorities suddenly find nothing wrong with disposing of surplus lions from lion parks and zoos in this way.

In my opinion, therefore, elephants should not be kept on small game ranches, but only on large private conservation areas where the true African wilderness can be experienced and the elephants will have a significant hunting potential. If there is closer liaison with the market, it will be realised that most hunters do not seek supermarket-type hunting, but a true challenge, as described.

The wildlife industry does not have to develop the hunting potential of elephants - it is an existing market. Mutual dialogue only is required to transform it into a fantastic hunting resource.

DIE JAGPOTENSIAAL VAN OLIFANTE

Nico van Rooyen

Daar is min jagervarings in die wêreld wat vir die jagter soveel bekoring inhou as olifantjag in Afrika. Die drang om hierdie bosreuse van Afrika te jag ter wille van die handelswaarde van hul ivoor het sedert die vroegste tyd jagters van verskillende uithoeke van die wêreld hierheen gelok en hulle die lengte en breedte van die kontinent laat deurkruis. Dit het vir vele selfs 'n leefwyse geword en op die wyse is baie dele van hierdie kontinent deur die blanke beskawing ontdek.

Die jag van olifante deur die hedendaagse jagter het egter 'n heel ander dimensie. Dit is met nostalgie dat ten minste 90% van alle jagters vandag die ingewortelde obsessie het om op een of ander tyd op die spore van die bosreuse van Afrika te loop. Hierdie obsessie versterk gewoonlik namate die jagter die ander lede van die "groot-vyf" reeds gejag het.

Olifantjag in Afrika het tradisioneel nog altyd in die uitgestrekte Afrika-wildernis plaasgevind. Hierdie bekoring om in die vrye natuur te wees word dan versterk deur die uitdaging wat die jag bied. Wat is meer uitdagend vir die jagter as om van vroegdag af die spore van 'n trop olifantbulle te volg en dan 30 km verder en baie ure later uitgemergel op 'n boomstomp te gaan sit terwyl die felle Afrika-son die sweet op jou rug reeds in salpeter verander het en dan met die besluit te worstel of moet ek verder? Laat my kragte dit toe? Sal daar genoeg tyd wees om vanaand nog weer terug te keer kamp toe? So moet jy as olifantjagter bereid wees om talle male seervoet terug te keer kamp toe, jou wonde te lek en môre weer te probeer. Uiteindelik sal jy suksesvol wees.

As jy natuurlik die spoor volg van daardie groot ivoordraer wat die plaaslike bevolking ken en haarfyn aan jou beskryf, dan pomp die adrenalien natuurlik dik in jou are en voel jy nie daardie seer van dae se stap en tevergeefse soeke nie. Dit is dan dat jy wanneer die aand aanbreek, net daar in die veld op die spoor jou vuurtjie maak en net so met klere en al jou so gerieflik moontlik inrig en 'n lang nag deurbring om môre weer voort te gaan.

As jy dan aan die einde van die volgende dag die takke voor jou hoor breek dan besef jy dat jy met sukses die uitdagings wat olifantjag jou bied kon trotseer, want dit is waaroor olifantjag gaan. Die uiteindelike skiet van die dier is eintlik 'n anti-klimaks. Dit is die vry wees in die natuur, dis die swaarkry van dae en weke se swoeg en sweet in die ongenaakbaarheid van die Afrika veld, dis die opwinding om soms vir ure lank strategië te beproef om jou pad in 'n trop in te manipuleer ten einde die groot bul te bereik wat 'n olifantjag vir die jagter 'n onvergeetlike ervaring maak.

In Suid-Afrika alleen is daar oor die 6000 geregistreerde jagters binne die georganiseerde jagsport (m.a.w. lede van die 13 amateur jagtersverenigings wat verteenwoordiging op die konfederasie van jagtersverenigings van Suid-Arika - CHASA - geniet). As ons dus 90% van hierdie jagters neem by wie daar 'n behoefte bestaan om olifante te jag plus die duisende in die buiteland, dan is dit voor-die-hand-liggend dat die aanvraag vandag die aanbod vêr oorskry. Deur markkragte soos bepaal deur vraag en aanbod is die logiese situasie dan vandag ook dat olifantjag geweldig duur is en vêr buite die bereik van die meeste jagters geraak het. Hoewel meeste jagters aanvaar het dat om eendag 'n olifant te kan jag slegs 'n droom by hulle sal bly, is daar tog nog 'n aansienlike hoeveelheid jagters in die wêreld vir wie die droom finansieel binne bereik is.

As ons kyk na pryse wat olifante sowel as safaris waarby olifante ingesluit is, op die jagmark haal, dan besef mens dat dit vandag 'n baie winsgewende benuttingsbron geword het vir die paar lande in Afrika wat nog in staat is om 'n surplus olifante op die wyse te kan bemark.

Dit is ironies dat Suid-Afrika, wat seker een van die beste olifantbestuursprogramme op die kontinent handhaaf, eers redelik onlangs tot hierdie mark toegetree het deur jaarliks 'n baie klein aantal surplus bulle vir jag beskikbaar te stel. Hierdie surplus olifante word beskikbaar gestel op privaat reservate en een van die nasionale state aangrensend aan die Nasionale Krugerwildtuin.

Volgens inligting tot my beskikking was daar gedurende 1990 geen olifante op privaat reservate gejag nie. Die 4 bulle wat vanjaar op twee reservate aangebied word bring vir die eienaars R45 000 per olifant in. Die safari-ondernemers kombineer dit met 'n 14 dae safari wat 'n totale inkomste van so 'n olifantsafari opstoot na ongeveer R100 000.00. In Gazankulu was daar gedurende 1990 10 olifante gejag waarvoor hulle saam met hul 14 dae safari fooi R26 500 per olifant ontvang het. Die vleis is deur die plaaslike bevolking benut.

Dit is vir die jagter vandag natuurlik nog net moontlik om olifante in 'n klein aantal lande soos Suid-Afrika, Namibië, Zimbabwe, Tanzanië en Ethiopië te jag. As mens kyk na Zimbabwe wat daarin slaag om selfs na onafhanklikheid nog 'n goeie bestuurs- en benuttingsprogram vir sy wild te handhaaf, dan is dit duidelik dat die jag van olifante daar natuurlik 'n baie belangrike bron van valuta beteken sowel as 'n onmisbare bron van inkomste vir die staatskas. Daar is dan ook verder talle ondernemers wat 'n groot deel van hul bestaan aan olifantjag te danke het en op dié wyse 'n aansienlike hoeveelheid werksgeleenthede skep in 'n land waar werkloosheid daagliks toeneem. In Zimbabwe word olifante vir doeleindes van jag aangebied in hulle trustgebiede (sg. "communal land"), in gebiede onder beheer van hulle nasionale parke en 'n klein aantal op privaat grond. In die trustgebiede was daar gedurende 1990 'n totaal van 71 bulle gejag. Die jag van hierdie probleem-olifante was hanteer deur safari-ondernemers wat in alle gevalle dit met 21 dae safaris gekombineer het. Hulle het hierdie olifante aangebied teen R20 000 (US $7500) plus hul dagfooi wat elke olifantsafari dus ten minste R40 000 werd gemaak het. Die benuttingsprogram van hierdie olifante is interessant in die sin dat dit tot voordeel van die plaaslike bevolking aangebied word. Hierdie olifante wat tradisioneel hul voortbestaan bedreig het deurdat dit hul gesaaides verniel het en hul eiendom beskadig het, het nou vir hulle voordelig begin word deurdat hulle 'n inkomste verkry uit die jag daarvan. Boonop verskaf die safari maatskappye werk aan talle van die plaaslike inwoners.

Die jag van olifante binne die gebiede onder beheer van hulle nasionale parke kan in drie kategorieë ingedeel word: a) Pakette wat as konsessiegebiede aan safari-ondernemers verhuur word; b) Surplus olifante wat jaarliks per publieke veiling saam met ander jagpakette aan enige voornemende jagter vanuit enige deel van die wêreld verkoop word; en c) Surplus olifante binne die gebiede onder beheer van hulle nasionale parke wat eksklusief aan hulle plaaslike jagtersvereniging beskikbaar gestel word.

Sover dit die gebiede betref waarvan safari ondernemers konsessieregte huur, is olifante onlangs teen ongeveer R7 500 verkoop. Die safari ondernemers verkoop die olifante weer op 21 dae safaris aan jagters teen US$7500 (R20 250) plus sy dagfooi. Die prys wat die regering vir olifante in die gebiede vra gaan vanjaar hersien word wat sal meebring dat die prys aan safari ondernemers volgende jaar ongeveer R12 000 sal beloop.

Ek het self die 1991 veiling in Harare, wat verlede maand plaasgevind het, bygewoon. Daar is altesame 14 olifantbulle in twee jaggebiede in die Zambesivallei aangebied. Pryse vir die 14 bulle het gewissel vanaf R22 000 tot R34 000 wat 'n gemiddeld van R27 944 per olifantbul was. Voordat mens 'n olifant kon koop moes jy eers 'n basiese jag bekom het wat gemiddeld R18 850 vir 14 dae safari's beloop het. Op hierdie jagte moet mens natuurlik jouself toerus.

Olifantbulle word aan lede van die Zimbabwe Jagtersvereniging aangebied teen R7 500 per olifant. Aangesien dat die olifante wat in hierdie gebiede aangebied word deel vorm van hul uitdunningsprogram, bied hulle natuurlik ook olifantkoeie aan hul plaaslike jagters teen R2 000 per koei. In totaal was daar gedurende 1990 ongeveer 200 olifante in Zimbabwe gejag waarvan 100 in gebiede direk onder beheer van hulle nasionale parke.

Hierdie bestuursprogram word met klein variasies, vir jare reeds met groot sukses in Zimbabwe toegepas. Hulle olifantbevolking is steeds gesond terwyl hulle deur die surplus te laat jag, 'n hernubare bron in kosbare waarde omskep het en daardeur fondse bewerkstellig het vir die bewaring van hulle natuurerfenis. As mens dus hierdie benuttingspotensiaal van olifante d.m.v. jag in aanmerking neem, dan is dit ondenkbaar dat daar vandag, te midde van moeilike ekonomiese tye wat ons beleef, instansies is wat nie hierdie potensiële bron ten volle benut nie.

Die wetlike aspekte rakende olifantbestuur is reeds behandel. Soos ons nou bewus is, word die benutting van die Afrika-olifant baie streng beheer deur CITES (Konvensie op Internasionale Handel in Bedreigde Spesies). Deur die bekragtiging van hierdie internasionale ooreenkoms op 13 Oktober 1975 het Suid-Afrika hom onomwonde verbind tot alle voorskrifte en bepalings van CITES. Hierdie bepalings het natuurlik 'n baie sterk invloed op die handel in olifantprodukte maar ook op die jag van olifante in Suid-Afrika, vernaamlik nadat die spesie ongeveer twee jaar gelede opgegradeer is na Bylae 1 status. Dit bring mee dat Suid-Afrika 'n kwota by CITES moet verkry vir die uitvoer van wettig gejagde olifantprodukte. Bo en behalwe hierdie kwota moet die land waarheen dit uitgevoer word eers 'n invoerpermit uitreik alvorens Suid-Afrika 'n uitvoerpermit mag uitreik. Hoewel hierdie bepalings 'n beperkende uitwerking op selfs die wettige jag van olifante het, is ons vol moed dat wettig gejagte olifantprodukte binnekort, net soos luiperds, vanuit Suid-Afrika na meeste lande uitgevoer sal kan word. Dit is egter verblydend dat CITES nie ongeneë is om toegewings te maak t.o.v. wettig gejagte diere onder Bylae 1 nie, mits dit deel vorm van 'n behoorlike bestuursprogram. Ons verbintenis tot die CITES ooreenkoms bly egter 'n aspek waarmee ernstig rekening gehou moet word wanneer daar oorweging geskenk word aan hierdie mees winsgewende metode van benutting van hierdie bron, nl. jag. Dit kan in die toekoms makliker word, maar dit kan hierdie moontlikheid ook geheel en al vernietig deurdat dit vir sportmanne onmoontlik kan maak om hul trofeë met hulle saam te kan neem, in welke geval dit die prys van die jag van olifante baie negatief kan beïnvloed.

Indien dit sou gebeur dat surplus olifante eendag op privaat grond vir doeleindes van jag aangebied kan word is daar egter 'n paar slaggate waarvoor opgelet sal moet word: Dit is 'n bekende feit dat volgens normale markkragte die potensiële mark vir 'n produk verklein namate die prys styg. Hoewel olifante groot in aanvraag is moet onthou word dat daar 'n perk is wat meeste jagters bereid sal wees om daarvoor te betaal. Buitensporige hoë pryse kan meebring dat dit net eenvoudig te duur word vir jagters om selfs aan hierdie eksklusiewe vorm van jag deel te hê. 'n Verbruikersweerstand kan ontwikkel en dit kan daartoe lei dat dit al hoe moeiliker word om olifantjag suksesvol te bemark. Daar moet noukeurig gelet word op die feit dat jagters 'n hoë premie vir die totale avontuur betaal. Ek het doelbewus vir u aan die begin van my referaat 'n kort beeld van olifantjag in die wilde Afrika geskets. Behalwe die werklike Afrika-ervaring wat daarmee gepaard gaan, moet onthou word dat daar gewoonlik ook 'n aantal ander interessante spesies by so 'n pakket ingesluit word. Dit is m.a.w. dus nie 'n safari waarop slegs 'n olifant gejag word nie. Die privaat grondeienaar sal moet aanleer wat die behoefte van die jagter presies is sodat wanneer hy van hierdie benuttingsbron gebruik maak, hy hom nie net blind staar teen die grootste finansiële voordeel vir homself in die transaksie nie, maar sodat hy ook aan al die eise wat etiese jag daar stel kan voldoen tydens die aanbieding van sy produk. Hy moet dus daarop let dat die jagsport as 'n benuttingsbron sekere eise stel wat nie oorboord gegooi kan word bloot ter wille van die finansiële voordeel wat vir hom as die aanbieder daaruit verkry kan word nie. Behalwe die geskrewe reëls is daar ook nog talle ongeskrewe reëls waardeur die jagsport ge-orden word.

Die jagter se ondervinding is dat daar 'n geweldige wanopvatting by meeste privaat grondeienaars bestaan sover dit die behoefte van 'n jagter aanbetref. Daar moet gelet word daarop dat meeste jagters hoë etiese norme nastreef en hulle wil dus hul sport dienooreenkomstig be-oefen. 'n Groot probleem waarmee die georganiseerde jagsport vandag in die Suid-Afrikaanse konteks te kampe het is die feit dat baie wildboere onder die indruk verkeer dat jagters bereid is om, op sy voorskrif, onder enige denkbare omstandighede wild te jag en boonop bereid is om enige denkbare prys vir so 'n voorreg te betaal. Daar moet ten alle tye die ware jagervaring onder die aanvaarde etiese norme aan die sportman gebied word. Grondeienaars moet hulle daarvan weerhou om ter wille van selfsugtige finansiële gewin op gewetenlose wyse die natuur te misbruik en sodoende die jagsport te verkrag.

Groter en gevaarliker soogdiere word moeiliker om op privaat grond te akkommodeer. Dit is juis hierdie diere wat dan ook die beste pryse in die jagmark haal. Dit moedig mense aan om dikwels op gewetenlose wyse van die diere op die mees kunsmatige en onetiese wyse vir doeleindes van jag op te stel en aan sportmanne aan te bied.

Ek sidder as ek dink dat die olifant in Suid-Afrika dieselfde verdoemende pad weens kommersialisering op klein stukkies grond sal moet loop as die trotse leeu. Ja, die sogenaamde "canned lion" konsep in Suid-Afrika word vandag soos 'n pes deur die jagtersgemeenskap van die wêreld minag. Die massa verwerp die idee om half-mak, hans-grootgemaakte leeus, wat daagliks gevoer word, in klein kampies te skiet. Verder maak hierdie abortiewe jagpraktyk hier plaaslik 'n bespotting van wat eens vir die jagter as hoogste uitdaging en ideaal beskou was, nl. om 'n leeu in Afrika te kan jag Iw. nie net skiet nie. Die ge-organiseerde amateur jagsport in Suid-Afrika is gegrief deur hierdie misbruik en ons het reeds vir die afgelope 10 jaar (sedert die gebruik sy kop hier uitgesteek het) ons afkeur daarteen, in onomwonde taal teenoor owerhede uitgespreek. Dis vir my tragies om te rapporteer dat ten minste twee provinsiale owerhede reeds voor die geldmag geswig het en allerlei redes probeer vind om hierdie laakbare praktyk goed te praat. Ter wille van toerisme en die verdiening van valuta word die oë nou in die geval gesluit vir die misbruik van ons natuur. Dis nou kwansuis vir sommige owerhede geheel en al aanvaarbaar dat die jagsport verkrag word ter wille van die benutting van oortollige leeus uit leeuparke en dieretuine.

Ek is dus van mening dat as olifante nie op klein wildplasies aangehou word nie, maar wel op groot privaat bewaringsgebiede, die werklike Afrika atmosfeer geskep kan word, waar dit op sinvolle wyse jagpotensiaal sal hê. As daar nouer met die mark geskakel word sal die aanbieder ook leer dat meeste jagters nie 'n supermark-styl jag verlang nie, maar soos vir u beskryf, die ware ervaring en uitdaging.

Dit is dus nie vir die wildbedryf nodig om die jagpotensiaal van olifante te ontwikkel nie, want dit is 'n mark wat reeds bestaan. Dit kan dus slegs benut en uitgebou word en met wedersydse gesprekvoering tot 'n fantastiese jagpotensiaal ontwikkel word.

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

CAN THE AFRICAN ELEPHANT EARN ITS KEEP?

Randall Jay Moore[a]

The numbers of African elephant on the African continent have been halving each decade since the end of the Second World War, and in the past few years this rate has also increased dramatically in certain African states.

Attempts at halting the slaughter are not new. Over the past 20 years countries like Kenya have stopped hunting and trading in ivory. The international community has been monitoring the trade over the past 15 years and an attempt to control the trade has been in existence since 1986. All efforts have failed in most of Africa.

The singular outpouring of concern over this species is quite remarkable, and one might well ask what is it about the elephant that takes us from one extreme to another. The choice we have faced in past similar situations has often been between absolute domestication or absolute eradication. As human uses of resources has intensified, wildlife has been forced to either "earn its keep" as with the domestication of the Asian elephant, or disappear altogether.

How can the African elephant "earn its keep" and sustain its population carrying capacity at manageable levels in the thirty African states it now resides? One way would be through direct use value. The direct use value is derived from economic use of the resource and its services, such as for ivory and tourism.

The importance of elephants and their value in tourism in certain African countries may be considerably more than any other use value in terms of foreign exchange earnings. In a recent report entitled *The viewing value of elephants*, Brown and Henry have attempted to estimate part of the non-consumed value of elephants. Kenya is visited by about 250 000 to 300 000 tourists each year who spend approximately US$200 milion. To estimate from this expenditure the actual viewing value of elephants, Brown applied travel costs (ie US$1400) and contigent valuation techniques.

The results of the two techniques are quite comparable, and suggest the value of viewing elephants in Kenya to be about US$25 million per year. This may be as much as ten times the value of its poached ivory exports. This example suggests that there is a powerful case for keeping elephants alive for their non-consumptive value rather than harvesting them for their ivory. However, I personally believe a sound elephant management and utilization plan must accommodate both.

The history of wildlife conservation efforts in Africa has been dominated by a universal approach of divorcing local communities from any control or rights of exploitation of their wildlife. Wildlife utilization except for limited safari hunting has been discouraged, and any safari and hunting revenues have gone to the state, and not to the local communities whose game has been exploited.

It is possible to design an elephant management programme that obtains maximum revenue from both consumptive and non-consumptive uses. In Botswana, for example, an analysis of the economic benefits for management of the elephant population compared the benefits from game viewing only to those involving viewing combined with some sustainable consumptive uses. The introduction of consumptive uses reduced the benefits from game-viewing tourism by 10% but resulted in additional benefits from elephant by-products. These additional benefits almost doubled the economic value of the elephant!

---

[a]Randall Moore Production, PO Box 781571, Sandton, 2146, Rep. of South Africa

These significant revenues that can be earned from consumptive and non-consumptive uses of the African elephant populations would allow some of this income to be returned to the local communities which would hopefully result in the communities engagement in elephant conservation principles.

DOMESTICATION OF THE AFRICAN ELEPHANT:
Does it have a history and a role to play in modern times?

In a remote corner of NE Zaire lies Garamba National Park. At one of the park headquarters, Gangala na Bodio, live four domesticated adult African forest elephants. These elephants are the last remnants of a domesticated herd which 40 years ago numbered over 100. All had been trained to respond to human commands by Belgian colonists with the help of local Zairois and a few visiting Ceylonese mahouts. The success of the Gangala na Bodio Elephant Training School dispelled the notion that African elephants could not be domesticated. However, because of the training centre's remoteness, and the wealth of published information about the school's achievements being published in French/Belgian scientific journals, few in the outside world were to learn of its success. So the myth, "The African elephant is not trainable", continued up into the present.

By 1927 the Gangala na Bodio Elephant Training School had some 50 trained elephants and this number grew in time to well over 100 elephants. The elephants were used for a variety of agricultural tasks such as clearing and plowing huge tracts of untamed wilderness and transforming it into extremely valuable plantations. Not only did the elephants clear and plow but they transported the crops from the field into packing sheds and then transported the products overland hundreds of kilometers to the nearest railhead or river port. The elephants proved invaluable in this remote corner of Africa thousands of miles from the sea, where a road system was almost non-existent and limited river transport hopelessly unreliable. With the elephant there were no problems with shortages of fuel or spare parts and as time went by they even provided their own replacements at the school.

For the next 25 years the domestication centre flourished but it began to decline in the uncertainty of the years preceding independence of the Belgian Congo in 1960. By then there were only 15 elephants remaining. Serious internal political problems existed and the trainers had to flee into the bush with their charges as the Garamba was overrun by Simba rebels.

In the following years the elephant numbers continued to decline to the present number of four adults. Now, however, further proposals for the rehabilitation of the training centre are being considered along with the renewed capture and domestication of local elephants for tourism.

I have recently been allowed by the Botswana Government to import my 10 African elephants from the Republic of South Africa to the Okavango Delta for the purpose of conducting elephant-back safaris. In 1990 we conducted 10 weeks of elephant-back safaris and the pilot project was so successful that the Department of Wildlife granted us permission to continue our work for the next two years. There are many advantages of game-viewing from atop the back of an African elephant as opposed to the rumble-seat of a four-wheel drive vehicle. The elephants are less disruptive on the local vegetation and they make very little noise. Elephants fill up their fuel tanks at the nearest waterhole and take no part in using up our precious fossil fuels. At a viewing height of about 13 feet nothing escapes your view, it is simply the ultimate in game-viewing.

The Botswana Government has recently asked me to investigate the possibilities of starting an elephant training centre in their country as a possitive spin-off for the juvenile elephants that would be captured in future proposed culling operations. The proposed elephant training school would serve as an institution for education, training, and tourism. Each year a number of juvenile elephants brought into the school would receive a minimum of one year training before being exported to zoological institutions throughout the world on a long-term lease basis. The elephants would eventually be returned to Botswana as trained adults to be used in tourism, pilot agricultural projects, and some would serve as the nucleus for rebuilding herds for re-introduction projects throughout Africa.

After a very recent visit to the Far East where I visited many elephant training centres and tourist-related operations I came away convinced the Asians were and have been for a very long time onto something good. I fully believe all 30 African countries that currently hold the wild elephant populations of Africa should seriously consider domestication of a small part of its elephant population and perhaps in the future a limited commercial use of *Loxodonta africana* may help ensure its surivival into the 21st century.

REFERENCES

1. **Barbier, E.B., Burgess, J.C., Seanson, T.M. & Pearce, D.W.** 1990. *Elephant economics and ivory.* Earth Scan Publishers, London.
2. **Watson, R.** 1990. King Leopold's Elephants. *New Scientist*
3. **Moore, R.J.** 1983. *Revitalization Proposal for the Gangala na Bodio Elephant Training School.* Presented to IZCN

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

DISEASES OF ELEPHANTS

L Colly[a]

INTRODUCTION

This paper will be a review of available references to disease in both African and Indian elephants, together with conditions encountered in the breeding family of African elephant at the Johannesburg Zoological Gardens. Emphasis will be placed on the African species and, in particular, to wild populations. This latter area is noteworthy in that very little has been published; most records being on captive and working populations of both species.

In the Republic of South Africa only two reports on conditions occuring in elephant have been published. Young & Oelofse (1969) reported on conditions encountered with the confinement of young elephant to bomas, and Basson *et al.* (1971) reported on pathological conditions seen at post-mortem examination of culled elephant.

Many illnesses in elephant parallel those of horses and cattle, yet, because of their anatomy and physiology, some medical conditions are specific.

INFECTIOUS DISEASES

Bacterial

Anthrax

This highly fatal disease has occurred in captive populations following contamination of feed and water (Jordan 1964). In Asia, because of the epidemic nature of outbreaks, working elephant are regularly vaccinated. Where endemic anthrax occurs, as in the Kruger National Park, sporadic deaths follow on flare-up and spread of the disease.

Salmonellosis

This has been widely reported as occurring in captivity (Janssen *et al.* 1984; Chooi & Zahari 1988) but it is essentially a disease of capture and captivity stress. Typically it presents as fever, anorexia, lethargy and a foul-smelling diarrhoea. At autopsy the gut lining is diphtheritic, with generalized congestion and there are petechial haemorrhages of the heart.

Diarrhoea in newly-captured young animals should always be carefully monitored as this infection can often be fatal.

Tuberculosis

Elephant are susceptible to both human and bovine tuberculosis but it is usually diagnosed at post-mortem examination following chronic wasting disease. Tuberculin testing can be undertaken but interpretation is as yet uncertain due to false negatives and positives.

[a] Zoological Gardens, Parkview, Johannesburg, 2193, Rep. of South Africa

Clostridial diseases

Tetanus and enterotoxaemia have been reported.

Colibacillosis

Lack of colostrum at birth as well as unsanitary conditions can predispose to this infection.

Pasteurellosis

This is rare in elephant but takes a peracute form with death within some twelve hours - the symptoms are very similar to anthrax.

Viral

Various viral infections have been reported such as rabies, foot-and-mouth disease, elephant-pox, and a coryza-like syndrome. Standard supportive therapy, where appropriate, would be undertaken in attempted treatment.

Foot-and-mouth disease

This is of particular significance in southern Africa because of the economic implications of an outbreak. Fortunately, although the elephant can contract the disease and shed virus, there is no evidence that the species can transmit the disease.

Elephant pox

This occurs as a typical pox-like disease with vesicles, erosions and ulceration of the mucous membranes, hoof-sloughing and lameness and can last up to six weeks. As this is a zoonosis, attending personnel must be careful to avoid infection.

Herpesvirus

This has been described in free-living elephant - occurring in one form as lymphoid nodules in the lungs and in another as cutaneous papillomas presenting as raised nodular fibrous growths, especially on the trunk.

Encephalomyocarditis virus (ECMV)

ECMV has been reported to have caused acute death in several groups of captive elephants in the USA and in Australia. Other than symptoms of anorexia, listlessness and dyspnoea in the live animal, an acute myocarditis is seen at post-mortem with confirmation by viral isolation and serum neutralization. Of particular interest is that the ECMV virus is widely distributed in the smaller wild mammals and although the manner of transmission to elephant is uncertain, it would appear to require ingestion of the virus probably through food contamination, perhaps with a small body accidentally ingested during, particularly, a rodent plague. Several outbreaks of this disease have occurred in pigs in Natal (pigs appear to be a very susceptible species) and the virus is widely distributed in rodents in the Republic.

It could be very interesting to see the results of a sero-survey for the presence of ECMV in wild elephant and porcine populations. ECMV is also a potential zoonosis but human infection is mild or inapparent.

African horsesickness

Positive titres have been reported from the coastal region of East Africa where elephant, and not zebra, have been present during an outbreak in equines. However the significance of this finding is not described.

Mycoses

Fungal infections have rarely been reported.

Mycoplasma

This is being fairly widely reported as occurring in captive elephant populations as rheumatoid arthritis, with a chronic and progressive arthritis. It tends to fluctuate, migrates from joint to joint with a seasonal and early morning lameness. Diagnosis is by means of serum testing for rheumatoid factor. Treatment using anti-mycoplasma and anti-inflammatory drugs relieves and controls the condition.

In the African elephant family at the Johannesburg Zoo we have encountered what could be this condition although we have not been able to confirm the continued presence of the rheumatoid factor - despite an earlier low positive titre in the breeding cow. This fluctuating lameness has only occurred in our cow and two of her calves and can present in a matter of hours. It shows mainly in the forequarters with a severe stiffness of the leg. Progression is slow and painful with the legs swung out laterally before moving them forward. In most cases one large dose of an anti-inflammatory drug (Dexa-tomanol, Byk Gulden), is sufficient to bring on remission within 24 hours. It can however last 3-4 days despite additional treatment.

NON-INFECTIOUS DISEASE

Skin diseases

Many conditions such as sunburn, dermatitis, trauma, ulceration, neoplasia and rashes have been reported and have been treated with established treatments.

Abscesses

Due to the thick and tough skin, abscessation can cause a problem as it tends to spread subcutaneously and not point to the exterior. This requires surgical intervention and thorough after-treatment, a conservative approach often not being successful. Darting can lead to abscessation and antibiotic cover is recommended as a routine. In a recent darting accident where the dart dropped very low and struck the lower leg of our elephant cow, a very large abscess developed. Despite initial lancing, flushing and long-acting antibiotic cover, success was not achieved until sensitivity testing on the organism isolated *(Staphylococcous aureus)* was carried out. It then required four daily immobilizations with the appropriate antibiotics both intra-muscular and intra-venous before success was achieved. Cost and ease of administration must be taken into account - the former being R800 per day.

In East Africa the occurrence of jaw abscesses (up to 10% of the population) has been linked to stress in animals confined to certain parks.

Subcutaneous dependant oedema

Oedema associated with general debility, liver fluke, anaemia and hypoproteinaemia has been described. A more specific ventral oedema (often manifesting overnight) is not uncommon and is thought to be the result of great anxiety and stress (it is similar to angioneurosis of humans). One of the problems associated with this oedema is that during healing the fluids gravitate to the prepuce and clitoral area and can lead to pressure necrosis and sloughing. Both a cow and a heifer at the Johannesburg Zoo have developed this condition. It appears to be associated with pregnancy and first appears about five months before parturition shortly after significant mammary development. The oedema, after several weeks, gradually gravitates posteriorly and then down to the vulval region with exposure of the mucous membrane. In the case of the heifer, trauma has occurred and healing is therefore slow with a degree of fibrosis probably present.

Diseases of the feet

In captivity, foot problems are common especially when elephants are kept for long periods in wet and dirty conditions indoors on concrete. It then becomes essential to train the animals to allow easy examination and minor treatment such as nail trimming, sole paring, cracked heels and overgrowth of cuticle. Provided there is good husbandry and access to hard ground, these problems should rarely occur.

Diseases of the musculoskeletal system

Fractures and dislocations:
Elephants do not easily move on three legs and consequently any fracture is serious and has a poor prognosis. In captive situations where facilities for slinging exist it is possible for healing to take place. In young animals bone-plating is feasible but only where facilities are available. Dislocations have a better chance at healing as they are often partial. With immobilization and a power winch, reduction can be attempted.

Degenerative joint disease

This occurs in captive populations and is ascribed to their husbandry and environmental conditions eg. damp, concrete, chaining, lack of exercise. As referred to earlier, mycoplasmal arthritis is of concern in the pathogenesis of degerative joint disease.

Trunk injuries

This vital part of the elephant's anatomy, essential to his existence, is subject to various traumas eg. crushing, laceration, nerve damage. A deep incised wound on the upper trunk will not only bleed severely but can also lead to shock and death.

Diseases of the digestive system

Teeth

Molars - the unusual progressive replacement of the molars can be interfered with by malocclusion and would require chiselling off of the offending tooth crown - the rest of the tooth would undergo resorption and be replaced by the normal progression.

Tusks - are subject in captivity to severe wear and tear through rubbing and fracturing. The danger lies in exposure of the root canal, with subsequent infection, nerve damage, sinusitis and even loss of the tusk. Tusk extraction is described by Biggs *et al.* (1988). It requires considerable physical effort, a variety of strong tools and time.

Colic

This is usually caused by a change in diet or over feeding on rich food. Some signs are abdominal distention, discomfort, abnormal posture, groaning and a lack of defaecation. Colic in a young elephant and its treatment has recently been described by Du Toit (1991). Our bull elephant has twice suffered acute colic - the most serious incident after gaining access to and eating a 50 kg bag of whole mealies. Being whole they fermented slowly otherwise he may literally have burst! His flanks were grossly distended and the pain was so severe that he went down on his knees into a dog-sitting position to relieve the pressure - all accompanied by groaning. Fortunately, as we prepared to render assistance he started to pass faeces and semi-digested mealies until his large night room was literally awash.

Liver disease

This has mostly resulted from internal parasites such as liver fluke, bile duct hookworm *(Grammocephalus)* and hydatid cysts.

Diseases of the respiratory system

These include pneumonia, bronchitis and pharyngitis.

Diseases of the uro-genital system

Dependent oedema has been described earlier. Other conditions such as metritis and painful urination have been described. Due to the anatomy of the female, treatment of post partum metritis is extremely difficult.

Chronic renal failure has been reported in young elephant (Morris *et al.* 1987) leading to stunting, unthriftiness, depression and anorexia with polydipsia and polyuria.

Diseases of the circulatory system

Medial sclerosis and atheroma

These interesting conditions have been extensively described by Sikes (1968). In East Africa they have been directly associated with habitat degeneration in two lowland national parks compared with montane national parks where the conditions do not occur. Atheroma is a fatty deposit within the inner layer of arterial walls; medial sclerosis results from abnormal deposition of calcium salts in the tunica media of the large arteries. Both these conditions lead to partial or complete occlusion causing heart failure, lameness, stroke, trunk paralysis and drooping of ears. It occurs in younger elephants.

Stressors leading to the onset of this condition include prolonged exposure to sunlight through destruction of shade trees, overpopulation and a restricted diet following habitat degeneration.

Frustration occurs through loss of the migratory habit, boredom and lack of exercise. It must be of interest to conduct a comparative survey amongst various populations in southern Africa to determine if similar stressors are present and leading to an increased incidence of these conditions.

"Sudden death" and "Broken heart"

Both have been reported following respectively on great fear occasioned for instance by severe thunderstorms and the loss of a companion.

Diseases of the nervous system

Heatstroke

This can follow on excessive exposure to high ambient temperatures and the sun. It has been seen particularly in Asian elephant and is usually fatal. Symptoms include dullness, depression, hyperventilation and sudden collapse. It is generally considered that the elephant withstands cold better than heat.

Diseases of special sense organs

Eyes are subject to injury, conjunctivitis, keratitis and cataracts.

Ears can easily be traumatized but of importance is care in using ear veins for administering intravenous injections where irritant solutions could end up perivascularly. It can lead to extensive sloughing of portions of or even the whole ear.

PARASITIC DISEASES

Protozoa

Babesia and other protozoa have been reported but only *Trypanosoma* occuring in Asian elephant are considered serious.

Trematodes

Fluke infestation can lead to liver disease.

Nematodes

Various species have been recorded and are successfully treated w;th anthelmintics.

Arthropod infestations

Lice, ticks, mites and flies can cause irritation and inflammation.

CONCLUSION

It appears there is scope for increasing knowledge of conditions occuring in the live southern African population of elephant. It is hoped this will be forthcoming through surveys and field investigations.

ACKNOWLEDGEMENTS

I wish to thank the Director, Johannesburg Zoological Gardens and the Medical Officer of Health, Johannesburg for permission to present this paper.

REFERENCES

Basson, P.A., McCully, R.M., Kruger, S.P., Van Niekerk, J.W., Young, E., De Vos, V., Keep, M.E. & Ebedes, H. 1971. Disease conditions of game in Southern Africa: recent miscellaneous findings. *Veterinary Medical Review* 2/3: 313-340

Briggs, M., Schmidt, M., Black, D., Roach, R., Opdahl, J., Stark, G., Owens, D. & Driver, M. 1988. Extraction of an infected tusk in an adult African elephant. *Journal of the American Veterinary Medical Association* 192: 1455-1456

Chooi, K.F. & Zahari, Z.Z. 1988. Salmonellosis in a captive Asian elephant. *Journal of Zoo Animal Medicine* 19: 48-50

Du Toit, J.G. 1991. Behandeling van obstruksiekoliek in die Afrika-olifant *(Loxodonta africana). South African Veterinary Medicine* 4(1): 3

Janssen, D.L., Karesh, W.B., Cosgrove, G.E. & Oosterhuis, J.E. 1984. Salmonellosis in a herd of captive elephants. *Journal of the American Veterinary Medical Association* 185: 1450-1451

Jordan, W. 1964. An outbreak of acute disease in Chester Zoo diagnosed as anthrax. *Veterinary Record* 76: 927-930

Morris, P.J., Held, J.P. & Jensen, J.M. 1987. Clinical pathologic features of chronic renal failure in an African elephant *(Loxodonta africana). Proceedings of the First International Conference on Zoological and Avian Medicine* 468-472

Schmidt, M. 1986. *In:* **Fowler. M.D** (ed.). *Zoo and wild animal medicine*, 2nd ed. W.B. Saunders Company, Philadelphia. pp 884-923

Sikes, S.K. 1968. Habitat stress and arterial disease in elephants. *Oryx* 9: 286-292

THE DIAGNOSIS OF DISEASES IN ELEPHANTS *(Loxodonta africana)*

D G A Meltzer[a]

Abstract: Haematology and blood chemistry from healthy free-ranging elephants *(Loxodonta africana)* killed by a brain shot or darting with succinyldicholine is reviewed. These values have been shown not to differ significantly from those in immobilized animals and thus may be useful in making a diagnosis of disease in a species that is difficult to evaluate clinically.

INTRODUCTION

Specific infectious and parasitic diseases in African elephants *(Loxodonta africana)* are dealt with elsewhere. As in any animal a diagnosis of disease in elephant will be based on the history, a clinical examination and the examination of specimens collected. Difficulties in handling; the need to immobilize the animal; and a lack of understanding of the clinical signs seen make the clinician more dependent on laboratory analyses when attempting a diagnosis than he may be when dealing with domestic livestock.

This paper reviews haematological and blood chemistry data, a large proprotion of which has been collected from elephants culled both here and in other parts of Africa. Some of the work done can be classified as curiosity research in that it has not been performed with problem-related questions to be answered. Other studies[8 12 13] have indicated potential sources of variation in both haematology and blood chemistry which may be used as indicators of specific responses to the handling and management of elephants or elephant populations. Data presented has been limited to those substances which can be measured using relatively unsophisticated equipment.

CLINICAL PARAMETERS

Table 1: Clinical data obtained from immobilized animals

Rectal temperature	Heart rate	Respiration	Reference*
36,3 ± 0,6 increasing to 37,2 ± 0,6	62 ± 12 to 51 ± 10	8 ± 2 to 4 ± 1	Immobilized elephants M99 (n=12) [12]
36 (35-37)			Immobilized elephants M99/ACP (n=11) [19]

* superscript numbers refer to references at the end of the text

PO_2 levels decreased and PCO_2 increased, probably through the combined effects of abnormal posture and the immobilization drugs used[12].

[a] Price Forbes Chair in Wildlife Diseases, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort, 0110, Rep. of South Africa

Table 2: Reported haematological findings in African elephants

	Reviewed data[5]	Immobilized animals		Animals at rest[18]
		M99/Acetyl promazine[19]	Ketamine/ Xylazine[1]	
RBC 10^{12}/ℓ (2,3-3,1)	3,64 (2,9-5,0)	5,02 (4,2-6,6)	3,0 (2,1-4,3)	2,85
PCV ℓ/ℓ (0,30-0,36)	0,44 (0,38-0,49)	0,48 (0,44-0,51)	0,35 (0,27-0,47)	0,34
Hb (104-120)	143 (105-172)	144 (115-180)	118 (91-169)	113
MCV fℓ (109-128)	124 (97-141)	97 (71-121)	114,3 (106-122)	120
MCH pg	40,2 (28-50,7)	29 (23-36)		
MCHC g/dℓ	33,4 (30-35,6)	30 (26-37)	34,7 (31-39)	
ESR mm/h	34,6 (21-61,5)	29 (19-41)		
WCC 10^{9}/ℓ (6,2-7,8)	10,2 (9,0-11,0)	10,4 (6,8-14,3)	13,6 (7,2-22,4)	6,83
Lymphocyte %	54,6 (31-76)	58,2 (44-69)	43,8	
Neutrophil %	32,2 (21-50)	37,9 (27-45)	21,9	
Eosinophil %	1,7 (0-2,5)	2,4 (0-6)	0,4	
Monocyte %	5 (0,1-13,5)	1,5 (0-4)	12,1	
Bilobed Monocyte %			21,1	
Basophil %	0,03 (0-0,1)	0	0,75	
Platelets % 10^{9}/ℓ	400 (294-455)			

This data should be interpreted in the light of the reported changes that have been shown to take place as a result of the immobilization technique adopted and the responses of individual animals to this and other stressors[8,10,12]. A further source of error appears to have been the classification of the bilobed leucocytes unique in elephants[1]. Cytochemical staining of esterases in leucocytes[15] has shown that these cells are of the monocytic series. They have apparently been classified as lymphocytes by some authors[1].

Blood collection is performed routinely from the ear vein. An alternative site, the vena caudalis centralis, dorsally in the tail, has been described in the Indian elephant *(Elephas maximus)*[17]. The arches of the caudal vertebrae are not closed dorsally from the ninth or tenth caudal vertebra onward. The central caudal vein forms with the fusion of two veins in the region of the seventh to eleventh vertebra and runs dorsally down the tail from there. The site for venipuncture is the dorsal midline of the tail in the region of the fourteenth caudal vertebra. This can be located by palpating the transverse processes of the tenth caudal vertebra where the caudal skin fold ends on the ventral aspect of the tail. From this point downward the transverse processes, mammillary processes and vertebral arches are palpable. An 18-gauge needle is inserted through the skin and underlying fascia and advanced ventro-cranially on the midline. The vein is entered at a depth of 8 mm including the thickness of the skin of 5 mm.

BLOOD CHEMISTRY

Several authors have measured various plasma constituents and enzymes in brain-shot animals or animals culled with succinyldicholine (scoline, SDC). No significant differences were found when the chemistry of blood collected from elephants immediately after death when brain-shot or after immobilization with SDC or M99[12 13].

Table 3. **Plasma concentrations of glucose, lactate, and cortisol measured in elephants that were either shot or immobilized.**

Glucose mmol/ℓ	Lactate mmol/ℓ	Cortisol nmol/ℓ	
4,16 - 7,97	1,3 - 9,4	111,4 - 858	Shot or culled with scoline[13]
4,9 ± 0,5	1,3 ± 0,5	106 ± 43	Immobilized (M99)[12]
	8,4 ± 3,0		Herded prior to immobilization with M99[12]
4,9 ± 0,8	0,8 ± 2,3	146 ± 49,3	Immobilized (Scoline)[12]
5,19 ± 0,63			Immobilized (M99/ACP)[1]

Data ranges from Hattingh *et al.*[13] represent values measured in animals from different treatment groups. These groups consisted of animals culled by a brain shot or SDC, at rest or after herding. Significant increases in plasma concentrations of the above substances were shown to occur in herded animals. A significant rise in plasma cortisol in immobilized elephants was found 17 min after darting[12]. Initial high plasma lactate levels fell in serial samples collected at intervals after immobilization with SDC or M99 and showed a significant correlation to time.

PLASMA LIPIDS

Reports indicate that a high incidence of arterial disease seen in free-ranging elephants can be related to stress and the deterioration of habitat[7 8]. Elephants confined in nature reserves consisting mainly of grassland suffered from arteriosclerosis while their forest-dwelling counterparts were relatively free of disease[8]. Analyses of the diets showed that forest vegetation provided greater quantities of polyunsaturated fatty acid than the grasslands. Fifty-one percent of a population of 144 female elephants shot in the Luangwa Valley were found to have arteriosclerotic lesions[8]. These lesions were classified as light, medium or heavy and found to be more severe in animals of 30-50 y. A smaller number of male elephants, the majority of which were <40 y, were also examined. Lesions were found in only 11 % of these animals. The majority of lesions were seen as intima or media plaques in the aorta from 6 cm cranial to the mesenteric arteries to the iliac bifurcation. Serum total cholesterol and free cholesterol levels in diseased animals did not differ from those of healthy animals.

Hattingh *et al.*[13] showed that plasma lipid levels increased significantly in animals that were herded prior to being shot or immobilized with SDC.

Table 4: Reported plasma lipid concentrations in elephant

Total lipid g/ℓ	2,17 ± 0,21	Shot (n=5) [7]
	(2,34-3,89)	Shot or darted with scoline (n=47) [13]
	2,35 ± 0,31	Immobilized with M99 (n=9) [12]
	4,23 ± 0,55	Immobilized with scoline (n=4) [12]
Total Cholesterol	2,89	Shot (n=91) [8]
	2,29	Shot (n=5) [7]
	(1,46-1,67)	Shot (n=84) [4]
	4,59 ±0,23	Immobilized with Ket/Xyl (n=23) [1]
Free Cholesterol	0,75	Shot (n=91) [8]
	0,5 ± 0,05	Shot (n=5) [7]

PLASMA PROTEINS AND NITROGEN-CONTAINING SUBSTANCES

Total plasma proteins, blood urea nitrogen, creatinine and uric acid were measured in 141 culled elephants[3] (Table 5). Significant seasonal variations in plasma BUN and creatinine concentrations were reported. Plasma BUN concentrations in samples collected during the wet season were significantly higher than those measured in dry season samples. Plasma creatinine concentrations on the other hand were significantly lower in the wet season. Total plasma protein concentrations in elephants culled in the Kruger National Park[12 13] did not differ from those reported elsewhere[4].

ELECTROLYTES

Plasma potassium was shown to increase in herded elephants that were culled in the Kruger National Park[13]. This data is presented in some detail to enable an understanding of the changes that may occur. The remaining electrolytes appear not to be affected by exercise or the stress of capture.

Serum enzyme concentrations are commonly used in clinical veterinary medicine as parameters of organ function or organ pathology. Data on serum enzymes determined in elephants are summarized in Table 7.

Studies of the tissue distribution of these and other enzymes indicate that AST and ALT levels are highest in the muscles of elephants. ALT levels in the liver are relatively low and this enzyme cannot be used to indicate acute liver disease in these animals[14]. Although the numbers of animals used in this study were small this approach to evaluating various plasma enzymes and parameters of specific organ pathology is promising.

Table 5: **Concentrations of total plasma protein, blood urea nitrogen, creatinine and urates in elephants**

Total plasma proteins g/ℓ	BUN mmol/ℓ	Creatinine µmol/ℓ	Urate mmol/ℓ	
87,2 (68 -107)	4,23 ± 1,07	131 ± 0,27	0,05	Shot (n=141) [6]
	6,67 ± 1,45			Immobilized M99/ACP (n=7) [19]
	1,98 ± 0,53	97,2 ± 17,7	0,02 ± 0,006	Immobilized Ketamine/ Xylazine (n=31) [1]
(99-117)				Shot or scoline dart (n=47) [13]

CONCLUSIONS

Haematology and blood chemistry are often misused when the correct method of blood collection and preservation are not followed; when cognisance of the effects of drugs, handling, excitement and others stressors on these parameters is not considered; and above all when forms requesting analyses are regarded as shopping lists and funds available are unlimited. A rational approach taking the history, circumstances and clinical findings into account is essential if laboratory results are to have any value. At this stage the above summarized data appear to be of limited value in the circumstances in which elephants find themselves today.

REFERENCES

1. **Allen, J.L., Jacobson, E.R., Harvey, J.W. & Boyce, W.** 1985. Hematological and serum chemical values for young African elephants *(Loxodonta africana)* with variations for sex and age. *Journal of Zoo Animal Medicine* 16: 98-101
2. **Brown, I.R.F. & White, P.T.** 1976. Serum enzyme activities in the African elephant *(Loxodonta africana). Experientia* 32: 980-981
3. **Brown, I.R.F. & White, P.T.** 1977. Serum calcium, magnesium, phosphorus and alkaline phosphatase in the African elephant, *Loxodonta africana. Comparative Biochemistry and Physiology* 56B: 159-162
4. **Brown, I.R.F. & White, P.T.** 1979. Serum electrolytes, lipids and cortisol in the African elephant, *Loxodonta africana. Comparative Biochemistry and Physiology* 62A: 889-901
5. **Brown, I.R.F. & White, P.T.** 1980. Elephant blood haematology and chemistry. *Comparative Biochemistry and Physiology* 65B: 1-12
6. **Brown, I.R.F., White, P.T. & Malpas, R.C.** 1978. Proteins and other nitrogenous constituents in the blood serum of the African elephant, *Loxodonta africana. Comparative Biochemistry and Physiology* 59A: 267-270
7. **Cmelik, S.H.W. & Ley, H.** 1977. A further contribution to the knowledge of the blood lipid fractions from the African elephant *Loxodonta africana. Comparative Biochemistry and Physiology* 58B: 205-209
8. **Dillman, J.S. & Carr, W.R.** 1970. Observations on arteriosclerosis, serum cholesterol and serum electrolytes in the wild African elephant *(Loxodonta africana). Journal of Comparative Pathology* 80: 81-87

9. **Ganhao, M.F., Hattingh, J., Braack, L.E.O., Raath, J.P. & Pitts, N.I.** 1989 Blood composition of wild animals during immobilization. *South African Journal of Science* 85: 281-282
10. **Hattingh, J. 1986**. Physiological measurement of stress. *South African Journal of Science* 82: 612-614
11. **Hattingh, J., Pitts, N.I., Ganhao, M.F., Moyes, D.G. & De Vos, V.** 1990. Blood constituent responses of animals culled with succinyldicholine and hexamethonium. *Journal of the South African Veterinary Association* 61: 117-118
12. **Hattingh, J., Wright, P.G., De Vos, V., Levine, L., Ganhao, M., McNairn, I.S., Russell, A., Knox, C., Cornelius, S.T. & Bar-Noy, J.** 1984a Effects of etorphine and succinyldicholine on blood composition in elephant and buffalo. *South African Journal of Zoology* 19: 287-290
13. **Hattingh, J., Wright, P.G., De Vos, V., McNairn, I.S., Ganhao, M.F., Silove, M., Wolverson, G. & Cornelius, S.T.** 1984b. Blood composition in culled elephants and buffaloes. *Journal of the South African Veterinary Association* 55: 157-180
14. **Keller, P., Ruedi, D. & Gutzwiller, A.** 1985. Tissue distribution of diagnostically useful enzymes in zoo animals: a comparative study. *Journal of Zoo Animal Medicine* 16: 28-45
15. **Osbaldiston, G.W., Sullivan, R.J. & Fox, A.** 1978. Cytochemical demonstration of esterases in peripheral blood leucocytes. *American Journal of Veterinary Research* 39: 683-685
16. **Skinner, R.K., Brown, I.R.F. & White, P.T.** 1976. Serum amylase in the African elephant, *(Loxodonta africana). Comparative Biochemistry and Physiology* 55B: 363-366
17. **Wissdorf, H. & Poulsen Nautrup, C.** 1989. Presentation of the vena caudalis centralis, a further important anatomical structure for venipuncture in Asian elephant situated dorsally in the tail. *Zentralblatt für Veterinärmedizin Reihe C* 18: 279-280
18. **Woodford, M.H.** 1979. Blood characteristics of the African elephant *(Loxodonta africana cyclotis). Journal of Wildlife Diseases* 15: 111-113
19. **Young, E. & Lombard, C.J.** 1967. Physiological values of the African elephant *(Loxodonta africana). The Veterinarian* 4: 169-172.

Table 6: **Plasma electrolyte concentrations in elephants reported as means in mmol.l, ± = standard deviation and data in parentheses represent ranges.**

Na^{+}	(123,5-129,3)	n=47 [13]
	125,2	Shot n=80 [8]
	135,4	Shot n=122 [4]
K^{+}	4,3 ± 0,5	Undisturbed, shot n=5 [13]
	5,4 ± 0,4	Herded, shot n=7 [13]
	4,3 ± 0,4	Undisturbed, SDC n=6 [13]
	5,4 ± 0,9	Herded, SDC n=17 [13]
	4,9 ± 0,4	Herded, shot, SDC n=5 [13]
	6,0 (5,3-6,4)	n=80 [8]
	6,42 ± 0,86	Wet season n=49 [4]
	6,08 ± 0,83	Dry season n=56 [4]
Ca^{++}	2,19	Shot n=80 [8]
	2,8 (2,35-3,28)	Shot n=102 [3]
	2,6 (2,28-3,0)	Immobilized Ketamine/ Xylazine n=31 [1]
Mg^{++}	1,51	Shot n=80 [8]
	1,81 (1,07-2,55)	Shot n=87 [3]
Fe^{+++}	12 (7,5-16,6)	Immobilized Ketamine/ Xylazine n=31 [1]
Cl^{-}	(84,6-90,6)	n=47 [13]
PO_3	2,78 (1,25-4,3)	Shot n=100 [9]

Table 7: Reported serum enzyme concentrations in elephants

ENZYME		
ALT U/ℓ	3,5 (0-10)	Shot (n=58) [2]
	3,1 ± 2,4	Immobilized Ketamine/ Xylazine (n=31) [1]
AST U/ℓ	19,7 (3-117)	Shot (n=64) [2]
	28,6 ± 8,1	Immobilized Ketamine/ Xylazine (n=31) [1]
α-HBD U/ℓ	131,5 (31-232)	Shot (n=65) [2]
CK U/ℓ	152,9 (0-324)	Shot (n=27) [2]
Alkaline Phosphatase IU/ℓ	210 ± 91	Immobilized Ketamine/ Xylazine (n=31) [1]
		Shot [3]
	273 ± 220	Age = 0-2 y (n=7)
	127 ± 77	Age = 3-5 y (n=7)
	110 ± 91	Age = 6-8 y (n=8)
	136 ± 59	Age = 9-11 y (n=5)
	85 ± 40	Age = 12-15 y (n=23)
	67 ± 40	Age = > 15 y (n=89)

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

APPLIED ASPECTS OF DIGESTIVE PHYSIOLOGY OF ELEPHANT

H H Meissner[a]

INTRODUCTION

An animal's choice of food is constrained by its metabolic requirement and by the functional anatomy and physiology of its digestive tract. By developing basic relationships between size and requirements or digestive capacity, one may be able to predict intake and digestive efficiency in the elephant. This may be necessary to supplement the rather scanty data in the literature.

RELATIONSHIP BETWEEN DIGESTIVE CAPACITY AND INTAKE WITH WEIGHT OF THE ANIMAL

The basal or maintenance requirements of a wide range of animals vary in relation to weight ($W^{0,75}$) (Kleiber 1961; Schmidt-Nielsen 1984). This means that the maintenance energy requirements of a 5000 kg elephant should be only 180 times those of a 5 kg dik-dik, and not a 1000 times as one might have imagined. The capacity of the digestive tract in contrast, being a volume factor, should increase in direct proportion to weight, provided that adaptive anatomical structures are for the moment not considered. It has been shown that the capacity of the fermentation chamber forms a similar fraction of weight in both foregut and hindgut fermenters, as also does the total digestive capacity of the gastro-intestinal tract. However, the weight of gut contents increases with weight raised to a power of somewhat above one, probably because of variable digestive anatomies. A mean value of W1,05 has been reported (Paraa 1978; Demment 1982). Nevertheless, this suggests that overall gut capacity, as well as the capacity of the fermentation chambers (whether reticulorumen or caecum plus colon), effectively increases in direct proporton to body size.

Furthermore, because the specific metabolic rate decreases with increasing weight but gut capacity remains a constant fraction of weight, larger ungulates should be able to tolerate a lower minimum dietary quality than smaller species (Bell 1971; Jarman 1974). Nutrient or energy concentration of the diet, therefore, is predicted to vary in relation to $W^{-0,3}$ ($W^{0,75}/W^{1,05}$). However, this assumes that: (1) the turnover rate of contents in the digestive tract remains constant, and (2) digestive efficiency is the same. This is not so, because higher quality feedstuffs or herbage ferments faster than more fibrous material, and hence passes through the digestive tract more rapidly. Also, digestive efficiency is influenced by passage rate. Material (usually fibre) that passes through the fermentation chamber faster is fermented less completely than material that is retained for longer. Results of Foose (1982) and others suggest that daily food intake declines with increasing weight in relation to about $W^{-0,2}$ (Owen-Smith 1988), which means that diet quality should vary as a function of $W^{-0,1}$ ($W^{0,75}/W^{1,05}/W^{-0,2}$). Thus, although larger ungulates should eat diets of lower nutritional quality than smaller species, the difference is less marked due to reasons (1) and (2) above.

The turnover rate of rumen contents decreases with increasing fibre content of the diet, i.e. rumen retention time becomes longer because food particles need to be reduced before they can pass out of the reticulorumen. This restriction does not apply to hindgut fermenters, which hence show a faster passage rate of material through the gut than ruminants. Thus a hindgut fermenter should be able to tolerate a diet of higher fibre content, and thus lower nutritional quality, than a ruminant of similar body size. But, because of the faster passage rate, hindgut fermenters would be less efficient in digesting fibre than ruminants. Yet, in compensation, the more rapid rate of food

[a] Department of Livestock Science, Faculty of Biological and Agricultural Sciences, University of Pretoria, Pretoria, 0002, Rep. of South Africa

passage would allow hindgut fermenters to eat more food per day than ruminants on fibrous diets, and consequently, should assimilate more nutrients per unit time than ruminants. Prediction equations adapted from Owen-Smith (1988), show that this is indeed the case (see Table 1).

From the foregoing it can be predicted that large herbivores will ingest a lower fraction of their weight per day than smaller ungulates. This can be the result either of a constraint on digestive throughput rates due to lower dietary quality, or of their lower metabolic requirements (or both), assuming similar dietary qualities. Thus, large herbivores such as elephants should be able to satisfy their food requirements within a shorter daily feeding time than smaller species provided plant structure does not restrict rate of intake. This is apparently not the case because foraging time over 24 h cycles show a significant tendency to increase with weight (Table 1), which means that large animals forage for longer periods per day than smaller species. It is concluded, therefore, that plant structure does impose a restriction on rate of intake and that elephants would forage for the greater part of the day.

In summary, these relationships predict that the elephant because of a very large body size will tolerate a low quality diet, will show ineffective fibre digestion because it is a hindgut fermenter with a relatively fast passage rate, will forage for a long time per day, and should exhibit a higher intake than anticipated from its size, because of the advantage of being a hindgut fermenter with a relatively fast passage rate. I will now review the literature to see to what extent results support these predictions.

Diet composition

Elephant may consume an impressive array of plant species (Hoppe 1984), although the bulk of the daily dry matter intake may come from a few selected species (De Villiers & Kok 1988). They may frequent vastly different habitats which will influence their choice of plant species, but will also select different habitats during different seasons. Under open grassland conditions, grass may form 60-95 % of the diet year-round. In wooded savannas, grass may occupy 40-70 % of the feeding time during the wet season, but only 2-40 % during the dry season months (Owen-Smith 1988). In the dry season elephants feed more on bark, woody stems and roots (Owen-Smith 1988; Meissner *et al.* 1990) which indicates that the quality of diet may drop considerably at times. Fruits and seed pods are actively sought out by savanna elephants when available (Buss 1961; Field 1971; Lewis 1986). When browsing during the wet season, elephants strip leaves and break off branchlets to consume the terminal twigs.

Elephants apparently spend most of the day eating, thus conforming to prediction (Table 1). According to several authors (Guy 1976; Laws 1970; Hoppe 1984), they spend at least 12 h and often more than 18 h per day feeding. The food undergoes little mastication but only an inefficient squeezing, which accounts for the observation that pieces of undigested material between 5 and 15 cm long can often be retrieved from the faeces. This suggests also that the elephant tolerates a quality of diet that may be extremely low at times and that digestion of fibrous material is poor.

Diet quality and digestive efficiency

There is a lack of knowledge on quality of diet during the different seasons. Van Hoven *et al.* (1981) measured the chemical composition of digesta as it progressed towards the rectum. The digesta consisted of highly lignified cell wall constituents and comparatively low protein content, which apparently is fermented inefficiently, as judged by low cellulolytic activity, even though fermenting organisms such as protozoa are found well into the small intestine (apart from the caecum and colon). Van Hoven *et al.* (1981) estimated that cellulose digestibility might have been only 10 %. Meissner *et al.* (1990) found cellulose digestibilities ranging between 9,6 and 28,4 % depending on season, with the lower values recorded in the dry season when the diet of the elephant consists of high proportions of bark and leafless twigs. Other cell wall constituents were digested to the extent of 12-28 % for neutral detergent fibre, 7-20 % for acid detergent fibre and 35-55 % for hemicellulose. The hemicellulose thus contributes the major share of volatile fatty acid formation, although starch (from roots of trees) and sugars (from fruits) may also be partially fermented (Van Hoven *et al.* 1981).

The protein content of the diet varied between 7 and 11 % (Table 2) in the study of Meissner *et al.* (1990) which corresponds with figures obtained from analysis of stomach contents by McCullogh (1969) and Van Hoven *et al.* (1981). The cellulose content of the elephant diet corresponds with that of other species (29-36 %), but because the cell wall tissues may be heavily lignified at times (13-17 % lignin), digestion is poor as discussed above. The hemicellulose content is comparatively low (13-14 %) which suggests that, even with a comparatively high digestibility coefficient, hemicellulose apparently does not constitute the major portion of the energy-supplying substances.

The poor digestion of cell wall constituents is confirmed by low dry matter digestibility results. Benedict (1936), as cited by Hoppe (1984), reported a digestibility coefficient of 44 % for Timothy grass hay by Indian elephants compared to 60 % for the same hay by cattle. Foose (1982) measured digestibilities of about 45 % in zoo elephants compared with between 49 and 65 % in several ruminant species, while Coe (1972) calculated a digestibility coefficient of 42 %. In the veld study of Meissner *et al.* (1990) measurement by lignin index showed values ranging between 30 % in the dry season and 45 % in the wet season (Table 2), and they concluded that 50 % dry matter digestibility is probably the upper limit of what can be obtained under veld conditions. This confirms the prediction on quality of diet and digestive efficiency.

Passage rate of digesta and food intake

Foose (1982) showed that hindgut fermenters have shorter mean retention times (i.e. faster passsage rates) than foregut fermenters of similar weight (Figure 1). Moreover, elephants exhibit retention times intermediate between those of equids and rhinos, i.e. shorter than would be expected from their size. Foose (1982) measured between 50 and 60 h but mean retention time in the elephant can be as low as 33 h (Warner 1981). These results suggest that intake in the elephant in general may be higher than anticipated from the weight-intake relationship shown in Table 1. The relationship on grass and legume hay predicts an intake of 1,0 % of weight for a 4 500 kg elephant, while the all-species equation predicts an intake of 1,2 % of weight.

In the literature food intake has been estimated either from the weight of stomach contents, assuming a mean turnover time of 12 h, or by extrapolation from feeding rate and daily feeding time. Both methods give similar results, indicating a mean daily food dry matter intake of about 1,0-1,2 % of weight per day for males and non-lactating females, and 1,2-1,5 % for lactating females (Owen-Smith 1988). In the study by Foose (1982) the zoo elephants, which apparently weighed 2 800-3 000 kg, ate about 35 kg per day, which also converts to 1,2 % of weight. In a recent study Meissner *et al.* (1990) reported a negative association between intake and digestibility (see Figure 2), suggesting that the intake of elephants increased significantly when the quality of food deteriorates towards winter. These calculations indicate that the dry matter intake of a 4 500 kg male elephant can vary between 1,0 and 1,5% of weight depending on quality of diet. Also, while the elephant apparently compensates for low energy availability by an increased intake, the effort is not completely effective and the elephant will loose body reserves during the winter or dry season when the digestibility is 25-35 %, but would maintain or gain condition during the rainy season up to late autumn when the diqestibility is 40-50 %.

The results do indicate a slightly higher mean intake than predicted. They also suggest that passage rate may increase in the dry season and that a 30 h mean retention time as reported by Warner (1981) is highly probable.

CONCLUSION

The evidence at present confirms most predictions of the size relationships. An additional advantage which partially accounts for the elephant being highly adaptable to many nutritional environments, is the advantage of being a hindgut fermenter. This allows the elephant a high intake even when presented with a very poor quality menu. Under such circumstances the rate of ingestion is increased, the soluble and more nutritious parts extracted in the stomach and small intestine, and the fibrous parts discarded rapidly through the faeces. Furthermore, by being adaptable, mixed savanna veld as occurs in the lowveld, is suitable for carrying relatively large numbers of elephant. While they prefer grass in the rainy season they do not over-exploit this natural source, because they harvest different materials in the dry season, eg twigs, roots and bark.

REFERENCES

Benedict, F.G. 1936. *The physiology of the elephant.* Carnegie Trust, Washington, DC

Bell, R.H.V. 1971. A grazing ecosystem in the Serengeti. *Scientific American* 225: 86-93

Buss, I.O. 1961. Some observations on food habits and behaviour of the African elephant. *Journal of Wildlife Management* 25: 131-148

Coe, M.J. 1972. Defaecation by African elephants. *East African Wildlife Journal* 10: 156-174

Demment, M.W. 1982. The scaling of ruminoreticulum size with body weight in East African ungulates. *African Journal of Ecology* 20: 43-48

De Villiers, P.A. & Kok, P.B. 1988. Eto-ekologiese aspekte van olifante in die Nasionale Etoshawildtuin. *Madoqua* 15: 319-338

Field, C.R. 1971. Elephant ecology in the Queen Elizabeth National Park, Uganda. *East African Wildlife Journal* 9: 99-123

Foose, T.L. 1982. *Tropic strategies of ruminant vs non-ruminant ungulates.* PhD thesis, University of Chicago.

Guy, P.R. 1976. The feeding behaviour of elephant in the Sengwa Area, Rhodesia. *South African Journal of Wildlife Research* 6: 55-64

Hoppe, P.P. 1984. Strategies of digestion in African herbivores. *In:* **Gilchrist, F.M.C. & Mackie, R.I.** (eds.) *Herbivore nutrition in the subtropics and tropics.* The Science Press: Craighall, Johannesburg

Jarman, P.J. 1974. The social organization of antelope in relation to their ecology. *Behaviour* 48: 215-267

Kleiber, M. 1961. *The fire of life.* John Wiley, New York

Laws, R.M. 1966. Age criteria for the African elephant, *Loxodonta africana. East African Wildlife Journal* 4: 1-37

Lewis, D.M. 1986. Disturbance effects on elephant feeding: evidence for compression in Luangwa Valley, Zambia. *African Journal of Ecology* 24: 227-241

McCullogh, K. 1969. The growth and nutrition of the African elephant. II The chemical nature of the diet. *East African Wildlife Journal* 7: 91-97

Meissner, H.H., Spreeth, E.B., De Villiers, P.A., Pietersen, E.W., Hugo, T.A. & Terblanche, B.F. 1990. Quality of food and voluntary intake by elephant as measured by lignin index. *South African Journal of Wildlife Research* 20: 104-110

Owen-Smith, N. 1988. *Megaherbivores: The influence of very large body size on ecology.* Cambridge University Press, Cambridge.

Paraa, R. 1988. Comparison of foregut and hindgut fermentation in herbivores. *In:* **Montgomery, G.G.** (ed.) *The ecology of arboreal folivores.* Smithsonian Institution Press, Washington DC. pp 205-229

Schmidt-Nielsen, K. 1984. *Scaling. Why is animal size so important?* Cambridge University Press, Cambridge.

Van Hoven, W., Prins, R.A. & Lankhorst, A. 1981. Fermentative digestion of the African elephant. *South African Journal of Wildlife Research* 11: 78-86

Warner, A.C.I. 1981. Rate of passage of digesta through the gut of mammals and birds. *Nutritional Abstracts Review.* B 51: 789-820

Table 1: Prediction equations which indicate the relationship with size of quality of diet, time required to forage and food intake as a percentage of weight of the animal (adapted from Owen-Smith 1988).

Group and description	Dependent variable	Prediction equation	Predicted value at 100kg	500kg	1000kg	4500kg
Quality of diet						
Ruminants	% crude protein in stomach contents	$21,6\ W^{-0,23}$	7,5	5,2	4,4	-
All species	% non-stem in digesta	$116\ W^{-0,118}$	67	56	51	41
Ruminants	fermentation rate of contents of rumen or caecum-colon (u mole gas/gDM/h)	$945\ W^{-0,22}$	343	241	207	-
Time required to forage						
Ruminants	foraging time	$27,9\ W^{0,08}$	40	46	48	-
Non-ruminants	(% of day)	$19,0\ W^{0,17}$	42	55	61	79
Food intake						
Foregut fermenters	DM intake per day					
grass hay*	(% of weight)	$2,35\ W^{-0,132}$	1,3	1,0	0,9	-
legume hay	(% of weight)	$2,87\ W^{-0,147}$	2,0	1,6	1,4	-
Hindgut fermenters						
grass hay*	(% of weight)	$6,95\ W^{-0,236}$	2,3	1,6	1,4	1,0
legume hay	(% of weight)	$13,8\ W^{-0,315}$	0,2	1,6	1,6	1,0
All species	(% of weight)	$6,0\ W^{-0,191}$	1,8	1,6	1,6	1,2

* poor quality

Table 2: Quality parameters in food and faeces of elephant and food DM digestibility as affected by season (from Meissner *et al.* 1990)

	April/May	July/August	December/March	MSD
Food, % in DM				
Crude protein	8,7^{ab}	6,7^{a}	10,7^{b}	2,1
Neutral detergent fibre	60^{a}	66^{b}	57^{a}	4,0
Acid detergent fibre	45^{a}	54^{b}	43^{a}	3,7
Hemicellulose	14	13	14	1,5
Cellulose	29^{a}	36^{b}	30^{a}	2,9
Lignin	14^{ab}	17^{b}	13^{a}	1,3
Faeces, % in DM				
Neutral detergent fibre	78	78	78	3,0
Acid detergent fibre	66	68	66	3,0
Hemicellulose	11^{b}	10^{a}	12^{b}	0,8
Cellulose	42^{ab}	43^{b}	40^{a}	2,0
Lignin	23	24	24	1,5
Food CM digestibility as estimated by:				
Lignin index, %	39^{a}	30^{a}	45^{c}	4,7

MSD = Mean Standard Deviation
a, b, c = Different superscripts in the same line differ at the 5 % level of probability

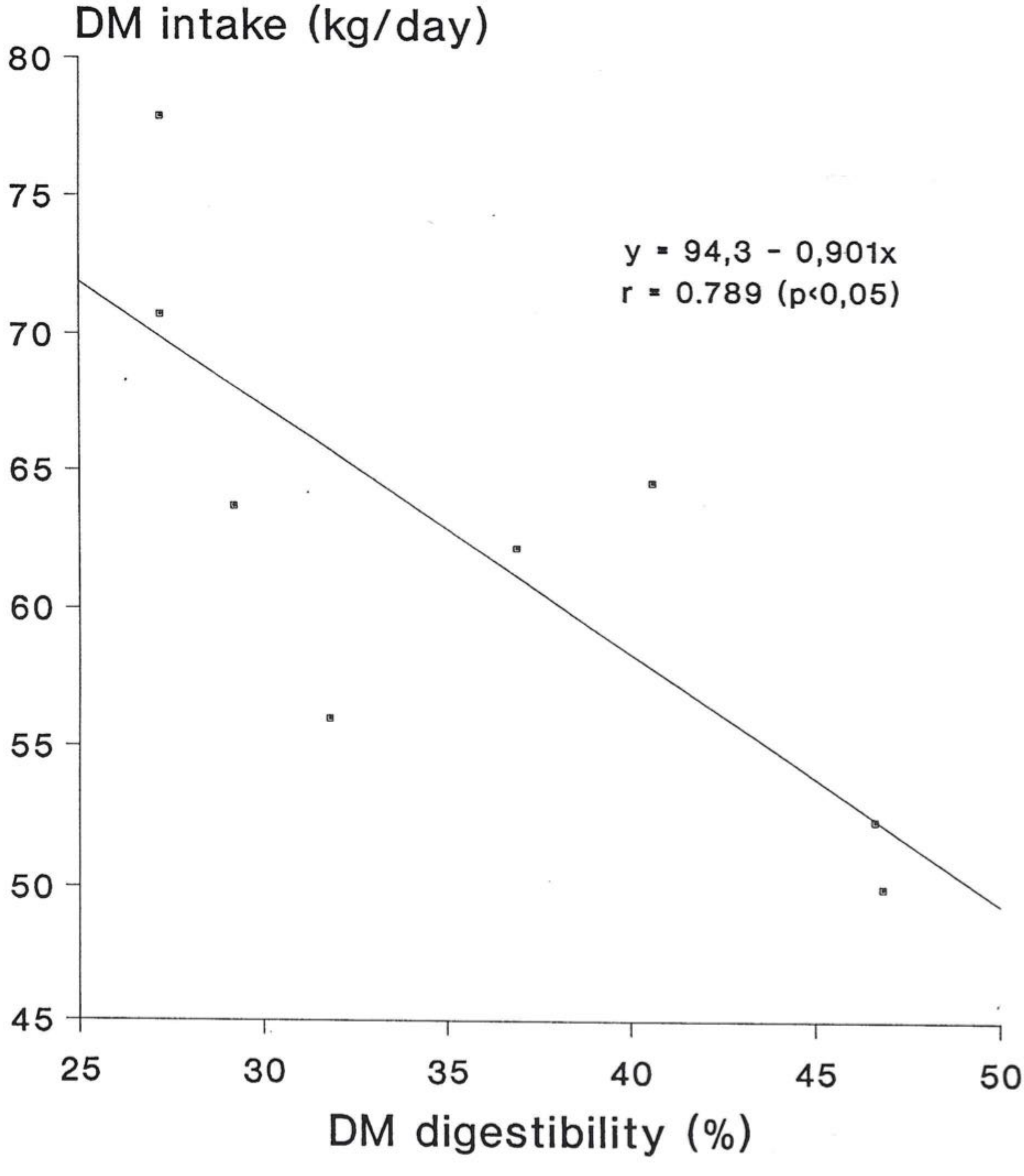


Fig. 1: Dry matter (DM) intake of elephant as affected by digestibility

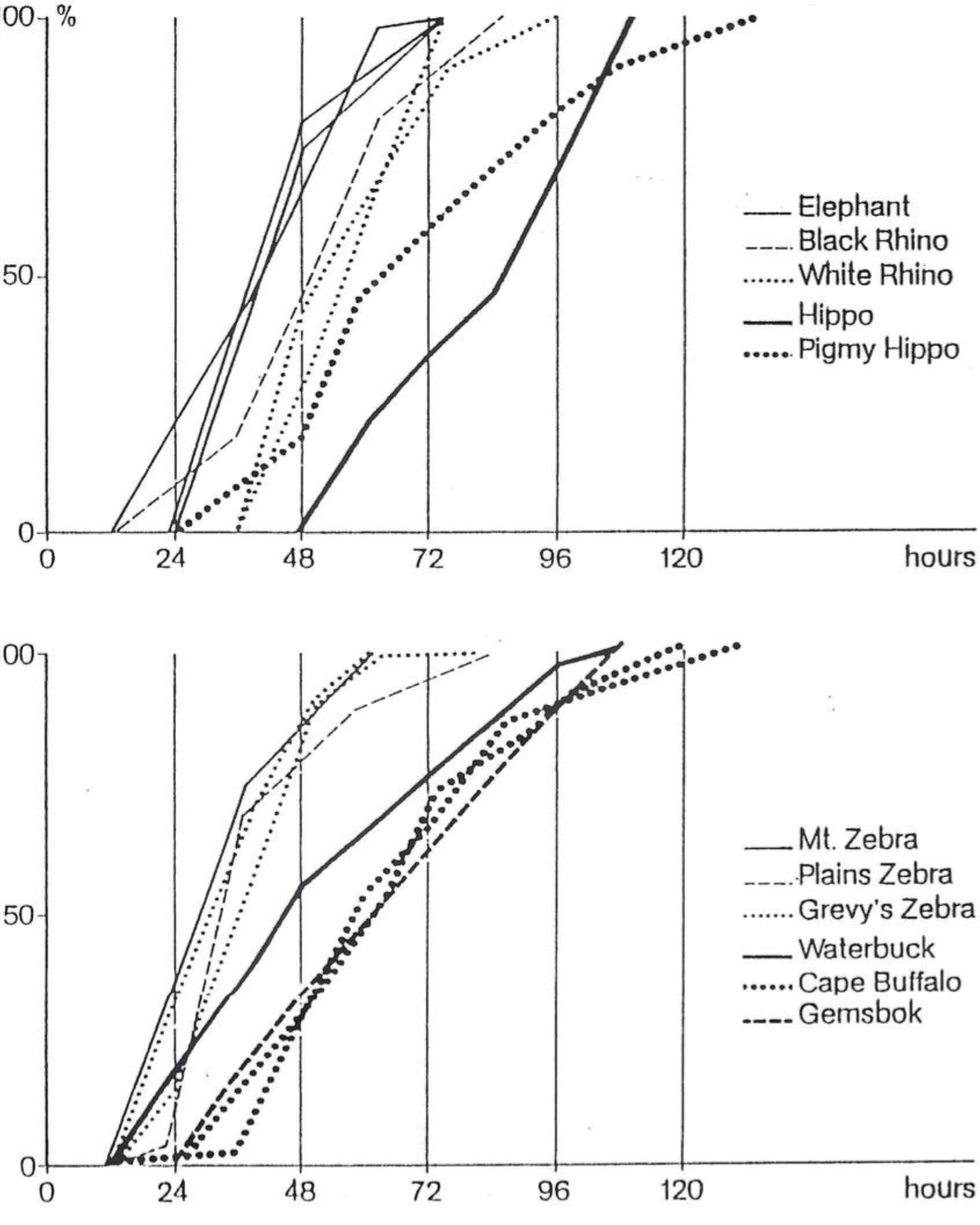


Fig. 2: ***Upper part:*** **cumulative faecal excretion of stained Timothy hay plotted against time for large hindgut-fermenters (elephant, rhinoceros) and non-ruminating foregut-fermenters (hippopotamus) compared with that of animals in the** ***lower part:*** **mountain zebra, plains zebra and Gevy's zebra and large roughage-eating ruminants (waterbuck, Cape buffalo, gemsbok). Retention time in hindgut-fermenters is shorter than in ruminating and non-ruminating foregut-fermenters. [Compiled from data in Foose (1982)]**

Proc. Symp. "The African Elephant as a Game Ranch Animal", Berg-en-dal, Kruger National Park, 29-30 April 1991

AUTOPSY PROCEDURE AND A REVIEW OF DISEASES OF THE AFRICAN ELEPHANT *Loxodonta africana* IN THE KRUGER NATIONAL PARK

D.F. KEET[1]

INTRODUCTION

In this discussion we will concentrate on the peculiarities of elephant anatomy. I will follow the standard autopsy sequence and try to adapt it to the animal's bulk and the complexity of its morphology. Abnormalities will be illustrated. These pathological conditions will also be those that we encounter in our local free-living elephant population.

INSTRUMENTS

The individual should never attempt an autopsy on his own and without robust equipment.

A team of at least two slaughterers is essential, as well as:

- Knives and steel
- Hooks
- Saw
- Chain saw
- Axe
- Shovel
- Block and tackle
- Wheelbarrow
- Adequate water
- Rope or chain.

METHOD

History

When approaching the dead animal, always note if the animal is in sternal or lateral recumbency. Often you will receive reports of "dead" elephants lying on their sides. At close range the autopsy candidate may wake up and turn on you. An elephant cannot tolerate sternal recumbency for more than 30 minutes without expiring. This is because of the unique respiratory structure and the tremendous abdominal mass. Vultures can also be very good indicators of the status of the animal.

Identify and sex the animal. It is important to photograph the carcass. The external sexing of calves can be difficult. Measure the distance between the umbilicus and the genital orifice. Females are more or less eight finger widths and males are four. Expose the penis or clitoris - males are a uniform blueish grey and females are pink.

At this stage an assessment of physical condition can also be done. It concerns mainly changes in the external shape of body regions.

---

[1] State Veterinarian, P.O. Box 12, Skukuza, 1350, Republic of South Africa

The depth of the lumbar depression and the protrusion of the adjoining dorso-lateral ridge of the wing of the ilium affords a good overall condition-criterion[1]. In young animals the appearance of distinct temporal dents and buccal depression give a further indication of poor physical condition.

Collect a faecal bolus from the rectum. The presence of large, undigested portions of wood, fibre, fruit and leaves indicates difficulty in mastication, usually due to abnormalities of the molars, old age or abnormal diet.

Elephants sometimes go down in awkward positions, which may give the impression that one of the limb bones is fractured. It is important to examine that leg, because a broken leg in such a large animal can be fatal because of the lack of mobility.

All the external openings must be examined - this includes the temporal gland in the temporal depression. Excessive secretion from this gland also indicates stress such as that resulting from pain or disease.

Examine the carcass for any penetration wounds - i.e. bullets and tusks.

Anthrax is the one infectious disease that accounts for a significant percentage of mortality in certain free-living populations. For this reason it is always extremely important to make a blood smear and examine it before the carcass is skinned and opened.

Skin the animal

In the healthy animal the skin is supple and readily moved to and fro by the underlying cutaneous muscle. It is thick and in certain areas characterised by the presence of hard excrescences or wart-like studs.

Dry skin is not necessarily a characteristic of old age, though in old animals the skin loses some of its elasticity.

In my opinion it is not always necessary to skin the whole animal because of its bulk.

It is sometimes difficult to detect subcutaneous abscesses because the thickness of the skin forces the abscess to dissect laterally between the skin and the muscle and this prevents it from erupting through the skin.

If there are perforating wounds visible it is also a good reason to skin the animal.

Cutaneous Papilomatosis

This is a fairly common benign self-limiting disease seen in captured juvenile elephants. Characteristic warty lesions are found predominantly on the trunk, skin, cheeks, lips and neck. It was recently found that this is caused by a Herpes virus.

External parasites

Very few external parasites are found on free-living elephants in the KNP.

The only tick commonly found so far is *Amblyomma tholloni*. They have never been noted south of the Olifants River in the north of the KNP. Recently a new species for the KNP, *Rhipicephalus maculatus*, was recovered from elephants in the south.

The elephant louse *Haematomyzus elephantis* occurs throughout the KNP. It is highly species-specific and is found in the skinfolds of the head and external ear canal.

A flea, *Echidnophaga larina*, is sometimes encountered on elephants but is more specific to warthogs.

Superficial lymphnodes

The parotid, mandibular and superficial cervical lymphnodes are all in more or less the same position as in other species. No popliteal lymphnodes could be found in any of the carcasses examined. Because of the thickness of the skin palpation is virtually impossible.

Reflect the upper fore and hind limb

This is not always possible in mature animals but it can be achieved with the help of a vehicle or block and tackle.

Muscles can also be trimmed away from the bone to make the limb lighter and remove it in the coxo-femoral joint.

Open the abdominal cavity

In the case of the elephant the incision should be a vertical one, from the tip of the last rib straight down over the bulge of the abdomen right down to the ground surface. The incision can then be extended mid-ventrally towards the sternum.

The triangular abdominal wall and skinflap can then be lifted and the organs be examined *in situ*.

The elephant has 20 or 21 pairs of ribs with very little space between the last rib and the ilium.

With the aid of a hook the abdominal organs can now be dissected loose and removed. The abdomen normally contains about 3 ℓ of straw-coloured ascitic fluid.

The stomach

It is about 100-140 cm long and about 40 cm in diameter.

The spleen lies as a long, parallel-sided strap across the left anterolateral aspect of the stomach. The cardio-oesophageal junction is clearly demarcated. The stomach then narrows towards the pyloris, lying to the right but no distinct pyloric valve can be found.

It is extremely important to study the contents of the stomach. This will reveal which plants have been ingested. In dry periods elephants ingest vast quantities of mud and contents are usually dry.

The appearance of the contents can also indicate a mastication problem.

Parabronema sp. causes ulcerations in captivity.

The oesophagus is very short.

Remainder of intestinal tract

The intestines may have a combined length of 18 m.

The duodenum forms a distinct U-shaped loop and receives the openings of the bile and pancreatic ducts.

A coiled jejuno-ileum succeeds the duodenum.

The pancreas is about 50 cm long and highly lobular. A single large duct is present, which in most cases has a common opening with the bile duct into the duodenum.

The caecum is very large, and sacculated.

The colon and rectum are large, suspended on a mesocolon, with a powerful sphincter which protrudes slightly on a raised projection or anal flap.

After the abdominal organs have been removed, the diaphragm must be dissected away from the thoracic wall.

The elephant's lungs are large and firmly adherent to the inside of the chest wall and the diaphragm. They are attached by tough white connective tissue. There is thus no pleural cavity. From this we can see that the best approach would be to proceed from the diaphragm and to dissect the lungs from the thoracic wall instead of removing the thoracic wall. In small elephants it is possible to remove the thoracic wall and apply blunt dissection to remove it from the lungs.

Respiratory movements of the lungs of the elephant are produced entirely by positive movement of the chest musculature. From this we can see that, as soon as an elephant lies down on his brisket, its respiratory movements become severely limited - and this is compounded by pressure of the abdominal organs on the diaphragm.

The heart rate regularly increases in recumbent elephants, due to reduced ventilation and a resultant hypoxia and/or hypercapnia. Baby and juvenile elephants can tolerate longer periods on their briskets.

The trachea is about 30 cm in length supported by very stout cartilaginous rings, incomplete dorsally.

Lymphoid nodules associated with the Cowdry Type A intranuclear inclusions in epithelial and syncytial cells were found in the lungs of 74% of 50 elephants culled in the KNP[11]. This was caused by a Herpes virus. The disease appears to be subclinical or latent. Solid nodules were more frequently noticed in younger elephants and the spongy ones in older elephants. Areas of associated pneumonia were never found.

Examine and open the pericardium and aorta

The pericardium is attached to the diaphragm at its caudal end. It consists of an outer fibrous sheath and an inner serous membrane, which is reflected onto the outer surface of the great vessels. Between the serous membrane and the epicardium is a quantity of slightly yellow pericardial fluid.

Aorta

The aorta of a large bull elephant is about 185 cm long with a maximum lumen circumference of 20 cm (proximal end) and a minimum of 14 cm (distal end). The thoracic portion of the aorta is surrounded in its early course by a venous plexus.

Considerable individual variation as to the detailed arrangement of the arteries occurs within the general pattern common to the African elephant.

Spontaneous arteriosclerosis has been described. The lesions described were essentially similar to those found in man, i.e.: Medial sclerosis which is characterised by the deposition of calcium in the tunica media. In advanced cases so much calcium salt accumulates that they resemble rigid pipes. At the same time the normal elastic fibres of the walls degenerate.

Elephant atheroma differs from medial sclerosis in that it primarily affects the tunica intima. Cardiovascular disease is related to age[7]. It has been suggested that this is primarily a repair reaction to haemodynamic damage[10].

An aortic aneurysm has been described in an elderly elephant. Parasitic lesions sometimes occur in the vessels and muscles of the heart.

Test the urine

The urine of a healthy animal is usually light straw-coloured, but often turbid with no pronounced odour, and generally has a slightly acid reaction. It resembles equine urine in that calcium oxalate crystals are frequently found and the SG ranges from 1,004-1,033. Over 2 kg of total solids are excreted daily in the urine of an adult elephant, of which one-fifth is mineral and four-fifths organic matter[3].

In freshly-killed elephants, the bladder is sometimes emptied in the death throes - this can be an indication of a slow death.

The adrenals, kidneys and testes can now be removed. They are located retroperitoneally on each side of the vertebral column at the level of the dorsolumbar junction.

Remove the tongue and thyroid

The large, fleshy tongue is covered with filiform papillae and sparsely with fungiform papillae. There are also six circumvallate papillae on the posterior part and Mayer's foliate papillae on the margins.

The thyroid is large and bilobular, situated ventrally to the anterior end of the trachea. Two pairs of parathyroids are adherent to its ventral edge.

The male genitalia can now be reflected posteriorly by dissecting them from the abdomen up to the crura.

In the female the pelvic floor can now be removed and a similar procedure can be followed because of the prominent clitoris. When the floor is removed, the female genital tract can be removed *in toto*.

Examine the joints

Sever the head at the atlanto-occipital joint. The trunk can be removed at the base above and between the tusks.

To remove the brain, a sagittal section through the skull can be made just above eye level. This can be done with a chain saw or axe, after the skin and muscles of the head are removed.

Recovering the hypophysis is exceedingly difficult. It is situated in the hypophyseal fossa of the sphenoid bone and the fossa has a somewhat narrow opening.

By examining the molars, age determination can be done. The mandible can be opened and the laminae can be counted. This can indicate which molar is in use. Normal molar pattern of eruption:

M1	1 year	5 laminae
M2	2 years	7 laminae
M3	6 years	10 laminae
M4	15 years	10 laminae
M5	28 years	12 laminae
M6	47 years	13 laminae

This is only an indication for age estimation in the veld. M1 and M2 erupt almost simultaneously soon after birth.

Curious branching outgrowths of cement at the base of the molar sometimes occur. The occurrence of molar tumours has never been noted in African elephants.

The tusks

The tusks can be removed from their alveolar spaces with the aid of an axe.

Deciduous tusks or tushes fall out after a year. The permanent tusks protrude beyond the lips at about 30 months and grow throughout life. They are composed almost entirely of dentine or ivory and are the upper incisors. In the beginning there is a conical cap of enamel, which later wears off.

Usually one tusk is used more than the other - the servant. This tusk generally grows thicker and heavier, but usually has the tip more blunted or worn than the other. The pulp consists of mesenchymal connective tissue and is highly vascular containing both blood and lymph sinuses. It also contains finely branching nerves.

Defective tusks are recognized by:

- central black spot at the tip
- broken tips and longitudinal cracks
- irregularities of the dentine within the pulp cavity.

Black spot. This is the deposition of trees of reactionary dentine within the enclosed pulp canal. The open end of the canal appears as a black spot at the tip of the tusk.

Just behind the base of the trunk on the hard palate, the orifice of Jacobson's organ can be seen.

The trunk can now be examined. It is a prehensile elongation of the lip and rhinarium. A dorsal and ventral process can be seen at its extremity. There are two larger circular orifices separated by a fleshy septum. The canals are lined with a moist epithelium. The trunk is enervated by the maxillary branch of the fifth cranial nerve.

One hundred thousand muscle units are involved with the movement of the trunk. On cut surfaces we can see that these muscles are all sub-divided into thousands of well demarcated longitudinal, transverse, oblique and circumferential fibres.

The head can now be sawn in two with a chain saw.

The middle ear can be opened with a hand saw or axe.

The spinal canal can be opened and the cord removed.

I would suggest that the above three examinations must only be done if there is a specific indication for them - as they are difficult and time consuming.

EXAMINE THE ORGANS

Spleen

It is a very dark red organ, covered by tough whitish-coloured connective tissue. Very often dark red raised nodules, looking like sub-capsular haemorrhages, can be seen. In a number of animals so-called "daughter spleens" have been found attached to the stomach on the same ligament as the main spleen.

Liver

This organ can weigh up to 68 kg in a mature male animal. It usually comprises three lobes, but some individual variation may occur. There is no gall bladder and the main hepatic duct is large. Gall stones are occasionally found in the liver.

Bile duct hookworms (*Grammocephalus* spp.) are frequently found in the bile ducts - causing biliary cirrhosis, and *Dipetalonema* spp. were also found to cause hepatitis.

Kidneys

There is individual variation in the lobulation, which apparently decreases throughout life, although dividing sheets of connective tissue can be located even in the adult kidney. In the healthy wild elephant the capsule of the kidney, which strips easily, is covered with large quantities of fat - an index of condition.

The junction between cortex and medulla are clearly demarcated in the fresh and healthy kidney. In some animals the spermatic artery arises from the renal artery.

Adrenals

They are long, narrow and band-like with a lateral horn. The cortex is yellowish in colour and the medulla a greyish yellow. They are situated retroperitoneally.

The heart

The size of the organ in the elephant is about 50 x 50 x 50 cm and it weighs up to 27,5 kg in mature animals. The proboscidean heart is unusual among mammals in having its apex bifurcated. This becomes more prominent in captive, debilitated or very elderly elephants. The heart also has a paired anterior vena cava (shared with Sirenia).

A useful criterion for estimating body weight is the mass of the blood-free heart. There is a linear relationship between heart weight and body weight: 0,5 g heart tissue indicates 100 g body weight[14].

The amount of fat in the fatty mantle surrounding the heart is indicative of health and body condition. It must be abundant, firm and light coloured. The heart contains no *os cordis* but may become pathologically sclerosed.

The male genital tract

The testes are retained intra-abdominally throughout life. Consistent with this situation the pampiniform plexus, cremaster muscle and inguinal canal are absent. There is no distinct epididymis. The Wolffian duct is highly convoluted. Seminal vesicles are large, thick-walled sacs.

Bulbo-urethral glands are large and full of a viscous secretion. The prostate is situated on the dorsal wall of the urethra immediately posterior to the seminal vesicles.

The penis has a well-developed corpus cavernosum penis and large paired levator penis muscles on its dorsal surface. It does not contain an *os penis* or cartilage. The levator muscles are responsible for the S-shaped flexure at erection.

The process of spermatogenesis must be particularly temperature resistant because of the intra-abdominal location of the testes.

The female genital tract

A striking peculiarity is the long canal whereby the urinary and genital openings are carried to a position anterior to the hind legs and similar to that of the male.

The peniform clitoris is conspicuous, lying in the ventral part of the vulva beneath the orifice of the urogenital canal. It also has levator muscles for movement and the glans contains cartilage. The clitoris can be as long as 50 cm.

The uterus has two horns and a common body. Usually an implantation scar remains permanently, following each pregnancy because the endotheliochorial placenta has a zonary form and deep attachment. The mammary glands are situated between the fore limbs.

Eyes

The iris and pupil are round and the iris is usually hazel in colour. The lacrymal sac duct and pore are lacking, although a vestigial lacrymal gland exists. A Harderian gland opens onto the surface of the nictitating membrane, which glides transversely over the eyes by means of a special deep division of the orbicular muscle. This branch is uniquely proboscidean.

The dried lens weight can be used as an indicator of age.

Examine the muscles - elephants are prone to capture myopathy.

Haemopoietic tissue

Section the femur.

It is interesting to speculate on the origin of the erythrocytes in view of the almost total absence of red marrow in the long bones. It is presumed that the diploe of the cranium, ribs, pelvis, sternum and vertebrae are the sites of haemopoiesis.

Open and examine the gastro-intestinal tract

The parasites of the African elephant are apparently rigidly host-specific and vast numbers normally occur.

A shovel and water are essential to clean the inner surface for examination.

CONCLUSION

The autopsy on the African elephant is an extremely time and effort consuming procedure. It is imperative to have knowledge of the unique and awesome morphology to appreciate macroscopic pathological changes.

Disease does not play any significant role as a population control factor in the free-living elephant population in the KNP, neither does the disease status restrict elephant movement from the Park. They are not prone to any of the so-called controlled diseases, except Anthrax.

The old myth that "wild elephants rarely get diseases" dies hard: it would doubtless be truer to say that the diseases of wild elephants rarely attract investigators.

REFERENCES

Albl, P. 1971. Studies on assessment of physical condition in African elephants. *Biological Conservation* 3: 134-140.

Basson, P.A., McCully, R.M., De Vos., V., Young, E. & Kruger, S.P. 1971. Some parasitic and other natural diseases of the African elephant in the Kruger National Park. *Onderstepoort Journal of Veterinary Research* 38: 239-254.

Benedict, P.G. 1936. *The physiology of the elephant.* Carnegie Institute, Washington, DC.

Brocklesby, D.W. & Campbell, H. 1963. A *Babesia* of the African elephant. *East African Wildlife Journal* 1: 119.

Elringham, S.K. 1982. *Elephants.* Blandford Books, Dorset.

Fowler, M. 1978. *Zoo Animal Medicine.* Chapter 27.

Hanks, J. 1979. *The struggle for survival: The elephant problem.* C. Struik Publishers, Cape Town.

Lindeque, M. 1988. *Population dynamics of elephants in Etosha National Park, SWA/Namibia.* PhD dissertation, University of Stellenbosch.

Malpas, R.C. 1977. Diet and the condition and growth of elephants in Uganda. *Journal of Applied Ecology* 14: 489-504.

McCullagh, K.G. & Lewis, M.C. 1967. Spontaneous arteriosclerosis in the wild African elephant, its relation to disease in man. *Lancet* 11: 492-495.

McCully, R.M., Basson, P.A., Pienaar, J.G., Erasmus, J. & Young, E. 1971. Herpes nodules in the lung of the African elephant [*Loxodonta africana* (Blumenbach, 1797)]. *Onderstepoort Journal of Veterinary Research* 38: 225-236.

Mollel, C.L. 1978. Cervico-vaginal prolapse in an African elephant. *East African Wildlife Journal* 16: 59.

Seaman, J.T. & Finnie, E.P. 1987. Acute myocarditis in a captive African elephant. *Journal of Wildlife Diseases* 23: 170-171.

Sikes, S.K. 1971. *The natural history of the African elephant.* Weidenfeld and Nicholson, London.

ELEPHANT BIBLIOGRAPHY

compiled by

J G du Toit

and

R E J Burroughs

1991

with an addendum compiled by

B L Penzhorn and J G du Toit, 1995

REFERENCE LIST

1. ADAMS, J., GARCIA, A. III, & FOOTE, C.S. 1978. Some chemical constituents of the secretion from the temporal gland of the African elephant, *Loxodonta africana*. *J. Chem. Ecol.* 4(1):17-25
2. ADAMS, J. & BERG, J.K. 1980. Behaviour of female African elephants *Loxodonta africana* in captivity. *Appl. Anim. Ethol.* 6: 257-276
3. AFOLAYAN, T.A. & AJAYI, S.S. 1980. The influence of seasonality on the distribution of large mammals in the Yankari Game Reserve, Nigeria. *Afr. J. Ecol.* 18(1): 87-96
4. AGUIRRE, E. 1969. Evolutionary history of the elephant. *Science, NY* 164(886): 1366-1376
5. AJAYI, S.S., AFOLAYAN, T.A. & MILLIGAN, K.R.N. 1981. A survey of wildlife in Kwiambana Game Reserve, Nigeria. *Afr. J. Ecol.* 19(3): 295-298
6. ALEXANDER, R. McN., JAYES, A.S., MALOIY, G.M.O. & WATHUTA, E.M. 1979. Allometry of the limb bones of mammals from shrews *Sorex* to elephant *Loxodonta*. *J. Zool., Lond.* 189(3): 305-314
7. ALEXANDER, R. McN., MALOIY, G.H.O., HUNTER, B., JAYES, A.S. & NTURIBI, J. 1979. Mechanical stresses in fast locomotion of buffalo, *Syncerus caffer* and elephant, *Loxodonta africana*. *J. Zool., Lond.* 189(2): 135-144
8. ALLEN, K.B., FOLLIS, T.B. & KISTNER, T.P. 1974. Occurrence of *Grammocephalus clathratus* (Baird 1868) Railliet and Henry, 1910 (Nematoda: Ancylostomatidae), in an African elephant imported into the United States. *J. Parasitol.* 60(6): 952
9. ALLEN, J.L., WELSCH, B., JACOBSON, E.R. & KOLLIAS, G.V. 1984. Management of tusk disorders in elephants. *In:* Abstracts of Papers of the Annual Neeting. American Association of Zoo Veterinarians, Louisville, Kentucky, 63-64
10. ALLEN, J.L., WELSCH, B., JACOBSON, E.R., TURNER, T.A. & TABELING, H. 1984. Medical and surgical management of a fractured tusk in an African elephant. *J. Am. Vet. Med. Assoc.* 185(11); 1447-1449
11. ALLEN, J.L., JACOBSON, E.R., HARVEY, J.W. & BOYCE, W. 1985. Hematologic and serum chemical values of young African elephants *Loxodonta africana* with variations for sex and age. *J. Zoo An. Med.* 16(3): 98-101
12. ALLEN, J.L. 1986. Use of tolazoline as an antagonist to xylazine-ketamine-induced immobilization African elephants. *Am. J. Vet. Res.* 47(4): 781-783
13. ALTMANN, D., HEIMANN, D. & TUNGER, R.J. 1976. Tusk fracture and anaesthesia in an African elephant. *In:* IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XVIII. Symposiums über die Erkrankungen der Zootiere* 307-313
14. ALTMANN, D. & KREBS, W. 1981. Combined Vetalar-Combelen anaesthesia of elephant for surgical removal of foreign body from eye In: IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XXIII. Symposiums über die Erkrankungen der Zootiere.* 261-265
15. ALWIS, H.C.L. de. 1982. *Pasteurella multocida* serotype 6:B from an elephant (Correspondence). *Sri Lanka Vet. J.* 30(2): 28
16. ANANTHASUBRAMANIAM, C.R. 1980. A note on the nutritional requirements of the Asian elephant, *Elephas maximus indicus*. *Elephant* suppl 1: 72-73
17. ANDERSON, I.L. 1968. Toto poisoning in two circus elephants. *N. Z. Vet. J.* 16(8): 146-147
18. ANDERSON, J.H. & COE, H.J. 1974. Decomposition of elephant dung in an arid, tropical environment. *Oecologia (Berl).* 14: 111-125
19. ANDERSON, G.D. & WALKER, B.H. 1974. Vegetation composition and elephant damage in Sengwa Research Area, Rhodesia. *J. S. Afr. Wildl. Mgmt. Assoc.* 4(1): 1-14
20. ANGELO, S.J., HISRA, S.S. & RAWAL, S.P.S. 1976. Enucleation of a granuloma from the stifle of an elephant *(Elephas maximus)*. *Kerala J. Vet. Sci.* 7(2): 174-177
21. ANGHI, C.S.G. 1962. Breeding Indian elephants, *Elephas maximus*, at the Budapest Zoo. *Int. Zoo Yearbook* 4: 83-86
22. ANONYMOUS. 1966. Elephant negotiates strong fence. *Afr. Wildl.* 20(3): 252
23. ANSELL, W.F.H. 1960. *Mammals of Northern Rhodesia*. The Government Printer, Lusaka
24. ATTWELL, R.I.G. 1954. A note on wounds in elephants. *Afr. Wildl.* 9(3): 204-205
25. BARANGA, J. 1984. The adrenal gland weights of the African elephant, *Loxodonta africana*. *Z. Säugetierk.* 49(6): 341-348
26. BARNES, R.F.W. 1980. The decline of the baobab tree in Ruaha National Park, Tanzania. *Afr. J. Ecol.* 18(4): 243-252
27. BARNES, R.F.W. 1982. Mate searching behaviour of elephant bulls in a semi-arid environment. *Anim. Behav.* 30: 1217-1223
28. BARNES, R.F.W. 1983. The elephant problem in Ruaha National Park, Tanzania. *Biol. Conserv.* 26: 127
29. BASSON, P.A., MCCULLY, R.M., DE VOS, V., YOUNG, E. & KRUGER, S.P. 1972. Some parasitic and other natural diseases of the African elephant in the Kruger National Park. *Onderstepoort J. Vet. Res.* 38(4): 239-254
30. BAUER, C. & STOYE, H. 1985. Endoparasites of African and Asian elephants (Endoparasiten beim afrikanischen und asiatischen Elefanten). *Praktische Tierarzt* 66(1): 55-56

31. BAX, P.N. & SHELDRICK, D.L.W. 1963. Some preliminary observations on the food of elephants in the Tsavo Royal National Park (East) of Kenya. *E. Afr. Wildl. J.* 1: 40-53
32. BAXBY, D. & GHABOOSI, B. 1977. Laboratory characteristics of poxviruses isolated from captive elephants in Germany. *J. Gen. Virol.* 37 (2): 407-414
33. BAXBY, D., SHACKLETON, W.B., WHEELER, J. & TURNER, A. 1979. Comparison of cowpox-like viruses isolated from European zoos. Brief report. *Archives of Virology* 61(4) 337-340
34. BECKETT, J. 1932. Death of an elephant from rabies. *J. Bombay Nat. Hist. Soc.* 36: 242
35. BEDEM, H. 1983. Family Elephantidae. *In:* HARRIS, J.H.(ed). *Koobi Fora Research Project. Vol 2. The fossil ungulates: Proboscidea, Perissodactyla, and Suidae.* Clarendon Press, Oxford. pp 40-129
36. BELL, R.H.V. & PARKER, I.S.C. 1972. Men and elephant. *Africana* 4(11) 20-21
37. BELL, R.H.V. & JACHMANN, H. 1984. Influence of fire on the use of *Brachystegia* woodland by elephants. *Afr. J. Ecol.* 22(3): 157-163
38. BELLINGE, W.H. & WOODLEY, F.W. 1964. Some notes on the rearing of young African elephants. *E. Afr. Wildl. J.* 2: 71
39. BEN SHAUL, D.H. 1962. The composition of the milk of wild animals. *Int. Zoo Yearbook.* 4: 333-342
40. BENEDICT, F.G. 1936. The physiology of the elephant. Carnegie Institute, Washington, D C.
41. BENEDICT, F. & LEE, R. 1938. Further observations on the physiology of the elephant. *J. Mammal.* 19: 175
42. BEQUAERT, J.C. 1966. Parasite muscid larvae collected from the African elephant and the white rhinoceros by the Congo Expedition. *Bull. Am. Mus. Nat. Hist.* 35: 377-387
43. BERE, R.H. 1966. *The African elephant.* A. Barker: London
44. BERG, J.K. 1981. Vocalizations and associated behaviors of the African elephant *Loxodonta africana* in captivity. Unpubl. Master's thesis, California State University, Dominguez Hills, Carson, 127 pp
45. BERG, J. 1986. Report on the behavioural development of three captive born African elephant calves. *Elephant* 2(2): 39-42
46. BEST, A.A. (ed) 1981. *Rowland Ward's records of big game.* 18th Ed (Africa). Rowland Ward (Publ) Ltd., Newbridqe Mill (Enqland), 560pp (Elephants, pp 452-461)
47. BIGALKE, R. 1957. The ages to which elephants live. *Afr. Wildl.* 11(2): 140-142
48. BOLWIG, N. 1965. Observations on the early behaviour of a young African elephant. *Int. Zoo Yearbook* 5: 149
49. BONGSO, T.A. & PERERA, B.H.A.O. 1978. Observations on the use of etorphine alone and in combination with acepromazine maleate for immobilisation of aggressive Asian elephants, *Elephas maximus. Vet. Rec.* 102 (5): 339-340
50. BONGSO, T.A. 1979a. Sedation of the Asian elephant *Elephas maximus* with xylazine. *Vet. Rec.* 105: 442-443
51. BONGSO, T.A. 1979b. Clinical observation on the effects of Rompun in Asian elephant, *Elephas maximus. Ceylon Vet. J.* 27(1/4): 34
52. BONGSO, T.A. 1980. Sedation of the Asian elephant with xylazine. *J. Amer. Vet. Med. Assoc.* 177(9): 783
53. BORNER, N. & SEVERRE, E. 1986. Rhino and elephant poaching trends in the Selous Game Reserve. *Pachyderm* 6: 3-4
54. BOSMAN, P. & HALL-HARTIN, A.J. 1986. Elephants of Africa. Struik publishers, Cape Town. 120 pp
55. BRAACK, L. 1984 A note on the presence of the louse *Haematomyzus elephantis* Piaget (Hallophaga: Rhychophthirina) in the Kruger National Park. *Koedoe* 27: 139-140
56. BRATTSTROM, B.H., STAPILE, A.J., WILLIAMS, F.R., LAUIERS, J.D. & POPE, D. 1963. Body temperature of Indian elephants. *J. Mammal.* 44(2): 282
57. BRIAND-PETERSEN, J.C. & CASEBEER, R.L. 1971. A bibliography relating to the ecology and energetics of East African large mammals. *E. Afr. Wildl. J.* 9: 1-23
58. BRIGGS, N., SCHMIDT, H., BLACK, D., ROACH, R., OPDAHL, J., STARK, G., OWENS, D. & DRIVER, N. 1988. Extraction of an infected tusk in an adult African elephant. *J. Am. Vet. Med. Assoc.* 192(10): 1455-1456
59. BROCKLESBY, D.W. & CAMPBELL, H. 1963. A *Babesia* of the African elephant. *E. Afr. Wildl. J.* 1:119
60. BROOKS, A.C. & BUSS, I.O. 1962a. Past and present status of the elephant in Uganda. *J. Wildl. Mgmt.* 26(1): 38-50
61. BROOKS, A.C. & BUSS, I.O. 1962b. Trend in tusk size of the Uganda elephant. *Mammalia* 26(1): 10-34
62. BROWN, C.E. 1934. Captive pygmy elephants in America. *J. Mammal.* 15: 248-250
63. BROWN, R.J., KUPPER, J.L., TREVETHAN, W.P. & JOHNSTON, N.L. 1973. Fibrosarcoma in an African elephant. *J. Wildl. Dis.* 9(3): 227-228
64. BROWN, I.F.R. & WHITE, P.T. 1976. Serum enzyme activities in the African elephant, *Loxodonta africana. Experientia* 32(8): 980-982
65. BROWN, I.R.F. & WHITE, P.T. 1977a. Serum calcium, magnesium, phosphorus and alkaline phosphatase in the African elephant, *Loxodonta africana. Comp. Biochem. Physiol.* 56B (2): 159-162
66. BROWN, G. & MOULE, A.W. 1977a. The structural characteristics of elephant ivory. *The Australian Gemnologist* (Febr): 13-17

67. BROWN, G. & MOULE, A.W. 1977. The structural characteristics of various ivories. *The Australian Gemnologist*, (May): 48-60
68. BROWN, I.R.F., WHITE, P.T. & MALPAS, R.C. 1978. Protein and other nitrogenous constituents in the blood serum of the African elephant, *Loxodonta africana. Comp. Biochem. Physiol.* 59A (3): 267-270
69. BROWN, I.R.F. & WHITE, P.T. 1979. Serum electrolytes, lipids and cortisol in the African elephant, *Loxodonta africana. Comp. Biochem. Physiol.* 62A (4) 899-901
70. BROWN, I.R.F. & WHITE, P.T. 1980. Elephant blood haematology and chemistry. *Comp. Biochem. Physiol.* 65B (1): 1-12 (A review)
71. BROWNLEE, J.W. & HANKS, J. 1977. Notes on the growth of young male African elephants. *Lammergeyer* 23: 7-12
72. BUECHNER, H.K., BUSS, I.O., LONGHURST, W.N. & BROOKS, A.C. 1963. Numbers of migration of elephants in Nurchison Falls National Park, Uganda. *J. Wildl. Mgmt.* 27: 36-53
73. BUECHNER, H.K. & DAWKINS, H.C. 1961. Vegetation change induced by elephants and fire in Murchison Falls National Park, Uqanda. ECOLOGY 42: 752-766
74. BULPIN, T.V. 1954. *The ivory trail.* Books of Africa, Cape Town
75. BURKE, T.J. 1975. Probable tetanus in an Asian elephant. *J. Zoo Anim. Med.* 6: 22
76. BURTON, J.A. 1977. The ivory connection, Part 2. *New Scientist* 76(1074) 168-169
77. BURRIDGE, H.J., REID, H.W., PULLAN, N.B., SUTHERST, R.W. & WAIN, E.B. 1970. Survey for trypanosome infections in domestic cattle and wild animals in areas of east Africa. II Salivarian trypanosome infections in wild animals in Busoga District, Uganda. *Br. Vet. J.* 126(12): 627-633
78. BUSH, H., HELLER, R.N., GRAY, C.W. & JAMES, A.E. Jr. 1974. Radiological practice in exotic animals. *Appl. Radiol.* 3(5): 23-64
79. BUSH, N., HEESE, D.W., GRAY, C.W. & JAMES, A.E. 1976. Surgical repair of tusk injury (pulpectomy) in an adult, female forest elephant, *Loxodonta cyclotis. J. Am. Dent. Assoc.* 93(2): 372-375
80. BUSS, I.O. 1961. Some observations on food habits and behaviour of the African elephant. *J. Wildl. Mgmt.* 25: 131-148
81. BUSS, I.O. & BROOKS, A.C. 1961. Observations on number, mortality and reproducton of elephants in Uganda. CCTA/IUCN Symposium: Arusha
82. BUSS, I.O. 1963. Prelude to management - home life of the African elephant. *Anim. Kingd.* 66(3): 74-79
83. BUSS, I.O., LONGHURST, W.H. & BROOKS, A.C. 1963. Numbers of migrations of elephants in Murchison Falls National Park Uqanda. *J. Wildl. Mgmt.* 27: 36-53
84. BUSS, I.O. & WALLNER, A. 1965. Body temperature of the African elephant. *J. Mammal.* 46(1): 104-107
85. BUSS, I.O. & SAVIDGE, J.N. 1966. Change in population numbers and reproductive rate of elephants in Uganda. *J. Wildl. Mgmt.* 30: 791-809
86. BUSS, I.O. & SMITH, S. 1966. Observations on reproduction and breeding behaviour of the African elephant. *J. Wildl. Mgmt.* 30: 375-388
87. BUSS,.I.O. & JOHNSON, O.W. 1967. Relationships of Leydig cell characteristics and intratesticular testosterone levels to sexual activity in the African elephant. *Anat. Rec.* 157(2): 192-196
88. BUSS, I.O. & ESTES, J.A. 1971. The functional significance of movements and positions of the pinnae of the African elephant, *Loxodonta africana. J. Mammal.* 52(1): 21-27
89. BUSS, I.O. 1972. The natural history of the African elephant (Review of). *J. Wildl. Mgmt.* 36(2): 667-670
90. BUSS, I.O. 1977. Management of big game with particular reference to elephants. *Malayan Nat. J.* 31(1): 59-71
91. BUSS, I.O. 1980. Management suggestions for the African elephant. *Elephant* Suppl 1: 19-35
92. BYRON, H.T., OLSEN, J., SCHMIDT, N., COPELAND, J.R. JR & BYRON, O.L. 1985. Abdominal surgery in three adult male Asian elephants. *J. Am. Vet. Med. Assoc.* 187(11): 1236-1237
93. CAPLE, I.W. *et al.* 1978. Some clinico-pathologic findings in elephants, *Elephas maximus*, infected with *Fasciola jacksoni. J. Wildl. Dis.* 14: 110
94. CARR, N.J. 1950. Elephants in the Eastern Province. *Nth. Rhod. J.* 2: 25-28
95. CARR, N. 1980. *Valley of the elephants: the story of Luangwa Valley and its wildlife.* Collins, London.
96. CAUGHLEY, C. & GODDARD, J. 1975. Abundance and distribution of elephants in the Luangwa Valley, Zambia. *E. Afr. Wildl. J.* 13: 39-48
97. CAUGHLEY, G. 1976. The elephant problem - an alternative hypothesis. *E. Afr. Wildl. J.* 14: 256-283
98. CAVE, A.J.E. & AUMONIER, F.L. 1962. Elephant and rhinoceros lymph node histology. *J. Royal Microsc. Soc.* 80(30): 209-214
99. CAVE, A.J.E. & AUMONIER, F.J. 1964. Lymph node structure in an Asiatic elephant. *J. Royal Microsc. Soc.* 82(4): 251-255
100. CHANDRASEKHARAN, K., PYTHAL, C., RADHAKRISHNAN, K. & SUNDARAM, R.K. 1979. Methyridine as an effective anthelmintic against strongylosis in elephants. *Kerala J. Vet. Sci.* 10(1): 163-166
101. CHANDRASEKHARAN, K., RAJAMOHANAN, K. & SUNDARAM, R.K. 1979. A case of cestode infection in an Indian elephant. *Kerala J. Vet. Sci.* 10(1): 157-158
102. CHANDRASEKHARAN, K., SATHIANESAN, V., PYTHAL, C. & SUNDARAM, R.K. 1979. Anthelmintic activity of thiophanate (Nemafax) in elephants and zoo animals. *Kerala J. Vet. Sci.* 10(1): 167-170

103. CHANDRASEKHARAN, K., RADHAKRISHNAN, K. & CHEERAN, J.V. 1982. Efficacy of Distodin in the treatment of amphistomiasis in Indian elephants. *Kerala J. Vet. Sci.* 13(1): 55-58
104. CHANDRASEKHARAN, K., RADHAKRISHNAN, K., CHEERAN, J.V., NAIR, K.N.N. & RAMANUJAM, K.N. 1982. Comparative efficacy of six anthelmintics aqainst stronqylosis in elephants. *Kerala J. Vet. Sci.* 15(1): 15-20
105. CHAPPEL, S.C. & SCHMIDT, N. 1979. Cyclic release of luteinizing hormone and the effects of luteinizing hormone releasing hormone injection in Asiatic elephants. *Am. J. Vet. Res.* (3): 451-453
106. CHATTERJEE, A. 1984. Association of a Stephanofilaria indistinguishable from *S. assamensis* with lesions on the feet of Indian elephants, *Elephas maximus*. *Ind. J. Anim. Health* 23(1): 29-35
107. CHEERMAN, J.V., CHANDRASEKHARAN, K. & RADHAKRISHNAN, K. 1981. Immobilization of Indian elephants with nicotine. *Cheiron* 10(6): 268-274
108. CHOI, W.P. 1981. Studies on ringworm in common seals and an elephant. *Korean J. Vet. Res.* 21(2): 113-116
109. CHOOI, K.F. & ZAHARI, Z.Z. 1988. Salmonellosis in a captive Asian elephant. *J. Zoo Anim. Med.* 19(1-2): 48-50
110. CHURCHER, C.S. 1980. Did the North American mammoth migrate? *Can. J. Anthropol.* 1(1): 103-105
111. CLARK, H.W., BAILEY, J.S., LAUGHLIN, D.C. & BROWN, T.McP. 1978. Isolation of myocoplasma from the genital tracts of elephants. *Zentralbl. Bakteriol. Parasitenkd. Infektionskr. Hyg., Erste Abteilung Originale* 241A (2): 262
112. CLARK, H.W., LAUGHLIN, D.C., BAILEY, J.S. & BROWN, T.McP. 1980. Mycoplasma species and arthritis in captive elephants. *J. Zoo Anim. Med.*11: 3-15
113. CLARK, H.W., LAUGHLIN, D.C. & BROWN, T.McP. 1981. Rheumatoid arthritis in elephants - a review to date. American Association of Zoo Veterinarians. Annual proceedings. Seattle, Washington: 95-100
114. CMELIK, S.W.H. & LEY, H. 1978 Neutral lipids from the temporal gland of the African elephant, *Loxodonta africana*. *Lipids* 13(3): 195-198
115. CMELIK, S. & LEY, H. 1974. Fatty acid composition of some cellular and subcellular elements of the elephant adrenal gland. *Hoppe Seylers Z. Physiol. Chem.* 355(7): 797-802
116. CMELIK, S. & LEY, H. 1974. Composition of the lipids from the cell sap of the elephant adrenal cortex. *Hoppe Seylers Z. Physiol. Chem.* 355(11): 1463-1465
117. CMELIK, S.H.W. & LEY, H. 1977. A further contribution to knowledge of blood lipid fractions from African elephant, *Loxodonta africana*. *Comp. Biochem. Physiol.* (B) 58(2): 205-209
118. CODRINGTON, R. 1908. Exhibition of a collection of stones taken from the stomach of an elephant shot in N Rhodesia. *Proc. Zool. Soc. Lon.* 1908: 203
119. COE, H.J., CUMMING, D.H. & PHILLIPSON, J. 1976. Biomass and production of larqe African herbivores in relaton to rainfall and primary production. *Oecologia* 22(3): 341-354
120. COE, H. 1972. Defaecation by African elephants *Loxodonta africana* (Blumenbach 1797). *E. Afr. Wildl. J.* 10: 165-174
121. COETZEE, B.J., ENGELBRECHT, A.H., JOUBERT, S.C.J. & RETIEF, P.F. 1979. Elephant impact on *Sclerocarya caffra* trees in *Acacia niqrescens* tropical plains thornveld of the Kruger National Park. *Koedoe* 22: 39-60
122. COLYER, F. & HILES, A.E.W. 1957. Injury to and rate of growth of an elephant tusk. *J. Mammal.* 38(2): 243-247
123. CONDY, J.B. 1974. Observations on internal parasites in Rhodesian elephant, *Loxodonta africana*. *Proc. Trans. Rhod. Sci. Assoc.* 55(2): 67-99
124. COOPER, R.A., CONNELL, R.S. & WELLINGS, S. 1964. Placenta of the Indian elephant, *Elephas indicus*. *Science, NY* 146(3642): 410-412
125. CORFIELD, T.F. 1973. Elephant mortality in Tsavo National Park, Kenya. *E. Afr. Wildl. J.* 11: 339-368
126. CORFIELD, T. 1975. Elephant die-off in Tsavo. *Africana* 5(9): 17-21
127. COWIE, H.H. 1956. The elephant story. *Afr. Wildl.* 10(4): 283-287
128. CRAIG, G.C. 1984. Foetal mass and date of conception in African elephants: A revised formula. *S. Afr. J. Sci.* 80: 512-516
129. CROZE, H. 1974a. The Seronera bull problem I: the elephants. *E. Afr. Wildl. J.* 12: 1-18
130. CROZE, H. 1974b. The Seronera bull problem II: the trees. *E. Afr. Wildl. J.* 12: 29-48
131. CROZE, H.J., HILLMAN, A.K.K. & LANG, E.N. 1981. Elephants and their each other. Dynamics of Large Mammal Populations (ed. C W Fowler) New York: John Wiley, 297-316
132. CROZE, H. 1972. A modified photogrammetric technique for assessing age-structures of elephant populations and its use in Kidepo National Park. *E. Afr. Wildl. J.* 10: 91-115
133. DANIEL, J.C. 1980. The status of the Asian elephant in India. *Elephant* 1(4): 16-22
134. DARIN-BENNETT, A., MORRIS, S., JONES, R.C. & WHITE, G. 1976. The glyceryl-phsphoryl choline and phosopholipid pattern of the genital duct and spermatozoa of the African elephant, *Loxodonta africana*. *J. Reprod. Fert.* 46(2): 5-06-507
135. DAVIES, F.G. & OTIENO, S. 1977. Elephants and zebras as possible reservoir hosts for African horse sickness virus. *Vet. Rec.* 100(14): 291-292

136. DAWKINS, H.C. 1961. Vegetation changes induced by elephants and fire in Murchison Falls National Park, Uganda. *Ecology* 42: 752-766
137. DEBBIE, J.G. & CLAUSEN, B. 1975. Some hematological values of free-ranging African elephants. *J. Wildl. Dis.* 11(1): 79-82
138. DECKER, R.A. & KROHN, A.F. 1973. Cholelithiasis in an Indian elephant. *J. Am. Vet. Med. Assoc.* 163: 546-547
139. DE JONG, W.W., NUY-TERWINDT, E.C. & VERSTEEG, H. 1977. Primary structures of alpha crystallin A chains of elephant, whale, hyrax and rhinoceros. *Biochem. Biophys. Acta* 491(2): 573-580
140. DEVINE, J.E., BOEVER, W.J. & HILLER, E. 1983. Isoniazid therapy in an Asiatic elephant, *Elephas maximus. J. Zoo Anim. Med.* 14(4) 130-133
141. DHINDSA, D.S., SEDGWICK, C.J. & METCALFE, J. 1972. Comparative studies of the respiratory functions of mammalian blood. VIII. Asian elephant, *Elephas maximus*, and African elephant, *Loxodonta africana africana. Respir. Physiol.* 14: 332-342
142. DILLMAN, J.S. & CARR, W.R. 1970. Observations on arteriosclerosis, serum cholesterol and serum electrolytes in the wild African elephant, *Loxodonta africana. J. Comp. Path.* 80: 81-87
143. DIPEOLU, O.O. 1976. The occurrence of ticks on a baby African elephant in Nigeria. *E. Afr. Wildl. J.* 14(3): 227
144. DIPEOLU, O.O. & GOLDING, R.R. 1977. Transportation of wild animals and the spread of infection (correspondence). *Vet. Rec.* 191(24): 492
145. DITTRICH, L. 1966 .Breedinq Indian elephants at Hanover Zoo. *Int. Zoo Yearbook* 6: 193-196
146. DITTRICH, L. 1974 Replacement of the deciduous incisor by the tusk in the Indian elephant, *Elephas maximus. Z. Säugetierk.* 39(1): 58-64
147. DOMROW, R. & LADDS, P.W. 1984. A new ear mite from the Indian elephant (Acari: Anoetidae). *J. Nat. Hist.* 18(5): 759-764
148. DOUGALL, H.W. 1963. On the chemical composition of elephant faeces. *E. Afr. Wildl. J.* 1: 123
149. DOUGAL, H.W. & SHELDRICK, D.L.W. 1964. The chemical composition of a day's diet of an elephant. *E. Afr. Wildl. J. 2: 51-59*
150. DOUGLAS-HAMILTON, I. 1971. Radio-tracking of elephants. *Proc. Symp. on Biotelemetry*. CSIR, Pretoria, South Africa: 336-341
151. DOUGLAS-HAMILTON, I. 1972. *On the ecology and behaviour of the African elephant.* PhD thesis, University of Oxford
152. DOUGLAS-HAMILTON, I. 1973. On the ecology and behaviour of the Lake Manyara elephants. *E. Afr. Wildl. J.* 11: 401-403
153. DOUGLAS-HAMILTON, I. & DOUGLAS-HAMILTON, O. 1975. *Among the elephants.* Collins, London
154. DOUGLAS-HAMILTON, I. 1980. African elephant ivory trade study: final report (excerpts). *Elephant* 1(4): 69-99
155. DOUGLAS-HAMILTON, I. 1980. African elephant population table. *Africana* 7(2): 36
156. DOUGLAS-HAMILTON, I., HILLMAN, A.K.K. & HOSS, C.J. 1981. Notes on vertical photography of elephants for aqe determination. *ILCA Monographs* 4: 131-142
157. DOUGLAS-HAMILTON, I. 1987. African elephant population study. *Pachyderm* 8: 1-10
158. DOUGLAS-HAMILTON, I. 1987. African elephants: population trends and their causes. *Oryx* 21: 11-74
159. DOUGLAS-HAMILTON, O. 1980. Africa's elephants. Can they survive? *National Geographic* 158: 568-603
160. DUDLEY, J.P. 1986. Notes on traininq captive elephants. *Elephant* 2(2): 15-18
161. DUNCAN, W.R.H. & GARTON, G.A. 1968. The fatty acid composition and intramolecular structure of triglycerides from adipose tissue of the hippopotamus and the African elephant. *Comp. Biochem. Physiol.* 25: 319-325
162. DUNHAM, K.M. 1986. Movements of elephant cows in the unflooded Middle Zambezi Valley, Zimbabwe. *Afr. J. Ecol.* 24: 287-291
163. DUNLOP, C.I., HODGSON, D.S., STEFFEY, E.P. & FOWLER, M.E. 1985. Observations during anesthetic management of an adult elephant. *Vet. Surgery* 14(1): 71-72
164. DUNLOP, C.I., HODGSON, D.S., CANBRE, R.C. & KENNEY, D. 1988. Prolonged isoflurane anaesthesia of an adult elephant on two occasions. *Vet. Surgery* 18(3): 167-168
165. DU PREEZ, J.S. & GROBLER, I.D. 1977. Drinking times and behaviour at waterholes of some game species in the Etosha National Park. *Madoqua* 10(1): 61-69
166. EBEDES, H. 1975 The immobilization of adult male and female elephant *Loxodonta africana*, (Blumenbach 1797) with etorphine and observation on the action of diprenorphine. *Madoqua* 9(2): 19-24
167. EDROMA, E.L. 1973 Poaching and human pressure in Rwenzori National Park. *Uganda J.* 37: 9-18
168. EDROMA, E.L. 1981a. The number and distribution of elephants in Kidepo Valley National Park, Uganda. *Afr. J. Ecol.* 19(3): 299-302
169. EDROMA, E.L. 1981b The role of grazing in maintaining high species composition in *Imperata cylindrica* grassland in Rwenzori National Park, Uganda. *Afr. J. Ecol.* 19(3): 215-224
170. EISENBERG, J.G., MCKAY, G.H. & JAINUDEEN, M.R. 1971. Reproductive behaviour of the Asiatic elephant, *Elephas maximus maximus* L. *Behaviour* 38(3): 193-225

171. EISENBERG, J.F. 1980. Ecology and behaviour of the Asian elephant. *Elephant* suppl 1: 36-56
172. ELAPATA, S.A.I. 1969. The sexual behaviour of wild elephants in Ceylon. *Loris* 11: 246-247
173. ELDER, W.H. & RODGERS, D.H. 1968. Age and growth of elephants: a study in the Luangwa Valley, 1965-1967. *Afr. Wildl.* 22(4): 281-293
174. ELDER, W.H. 1970. Morphometry of elephant tusks. *Zool. Afr.* 5(1): 143-159
175. ELDER, W.H. & RODGERS, D.H. 1974. Immobilization and marking of African elephants and the prediction of body weight from foot circumference. *Mammalia* 38: 33-53
176. ELOFF, A.K. & VAN HOVEN, W. 1980. Intestinal protozoa of the African elephant *Loxodonta africana. S. Afr. J. Zool.* 15(2): 83-90
177. ELTRINGHAM, S.K. 1972. A test of the counting of elephants from the air. *E. Afr. Wildl. J.* 10: 299-306
178. ELTRINGHAM, A.K., WOODFORD, M.H. & WYATT, J.R. 1972. An analysis of mechanical failure of darts and costs involved in drug immobilization of elephant and buffalo. *E. Afr. Wildl. J.* 10: 279-285
179. ELTRINGHAM, S.K. & WYATT, J.R. 1974. The daily activity of the elephant in the Rwenzori National Park, Uganda. *E. Afr. Wildl. J.* 12: 273-289
180. ELTRINGHAM, S.K. & HALPAS, R.C. 1976a. Elephant numbers in Rwenzori and Kabalega Falls National Park, Uganda in Sept 1976. Typescript report to the Trustees of the Uganda National Parks
181. ELTRINGHAM, S.K. & MALPAS, R.C. 1976b. Elephant slaughter in Uganda. *Oryx* 13: 334-335
182. ELTRINGHAM, S.K. 1977. The numbers of distribution of elephant, *Loxodonta africana*, in the Rwenzori National Park and Chambura Game Reserve, Uganda. *E. Afr. Wildl. J.* 15(1): 19-39
183. ELTRINGHAM, S.K. 1979. *The ecology and conservation of large African mammals*. MacMillan, London
184. ELTRINGHAM, S.K. & MALPAS, R.C. 1980. The decline in elephant numbers in Rwenzori and Kabalega Falls National Parks, Uganda. *Afr. J. Ecol.* 18: 73-86
185. ELTRINGHAM, S.K. & STEART, K. 1980. A quantitative assessment of range usage by large African mammals with particular reference to the effects of elephants on trees. *Afr. J .Ecol.* 18(1): 53-71
186. ELTRINGHAM, S.K. & POOLE, D. 1982. *Elephants.* Blandford Press, Link House West Street pp 262
187. ELZE, K., SELBITZ, H.J., SEIFERT, S. & EULENBERGER, K. 1989. Stiff leg lameness in elephants. *Erkrangungen der Zootiere,* 189-194
188. ENGEL, S. 1963. The respiratory tissue of the elephant, *Elephas maximas. Acta Anat.* 55: 105
189. ENGELBRECHT, A.H. 1979. Olifant invloed op *Acacia niqrescens* bome in 'n gedeelte van die Punda-Milia sandveld van die Nasionale Krugerwildtuin. *Koedoe* 22: 73-86
190. ERASMUS, B.J., YOUNG, E., PIETERSE, L.M. & BOSHOFF, S.T. 1978. The susceptibility of zebra and elephants to African horsesickness virus. In: BRYANS, J.T. & GERBER, H. (eds.). *Equine infectious diseases IV.* Princeton, New Jersey USA
191. ESTES, J.A. 1970. Observations on the temporal gland of the African elephant. Masters Thesis, Washington State University (Washington, USA), pp 77
192. ESTES, R.D. & SMALL, R. 1981. The large herbivore populations of Ngorongoro Crater. *Afr. J. Ecol.* 19: 175-185
193. FAIRALL, N. 1979. A radio tracking study of young translocated elephants. In: *A handbook on biotelemetry and radio tracking*. Pergamon press, Oxford pp 673-678
194. FATTI, L.P., SMUTS, G.L., STARFIELD, A.M. & SPURDLE, A.A. 1980. Age determination in African elephants. *J. Mammal.* 6: 657-551
195. FERRIER, A.J. 1947. *The care and management of elephants in Burma*. London: Williams, Lea & Co
196. FIELD, C.R. 1971. Elephant ecology in the Queen Elizabeth National Park, Uganda. *E. Afr. Wildl. J.* 9: 99-123
197. FINAUGHTY, W. 1980. *The recollections of William Finaughty - Elephant hunter 1864-1875*. Books of Zimbabwe, Bulawayo
198. FLANAGAN, H.O. & FLANAGAN, F.O. 1982 Castration of African elephant *Loxodonta africana africana. Zimb. Vet. J.* 13(3/4): 50-51
199. FLOWER, S.S. 1943. Notes on age at sexual maturity, gestation period and growth of the Indian elephant, Elephas maximus. Proc. Zool. Soc. Lond. (Ser.A) 113: 21-26
200. FLOWER, S.S. 1948. Further notes on the duration of life in mammals. V. The alleged and actual ages to which elephants live. *Proc. Zool. Soc. Lond.* 117: 680-688
201. FORBES, A., COLL, S. & CATTELL, McK. 1921. An electrocardiogram and an electromyogram in an elephant. *Am. J. Physiol.* 55: 385
202. FORD, J. 1966. The role of elephants in controlling the distribution of tsetse flies. *Bull. IUCN* 19
203. FOWLER, C.W. & SMITH, T. 1973. Characterizing stable populations: an application to African elephant population. *J. Wildl. Mgmt.* 37(4): 513-523
204. FOWLER, C.W. & SMITH, T. 1974. Characterizing stable populations: An application to the African elephant population. *J. Wildl. Mgmt.* 37: 413-523
205. FOWLER, E. & HART, R. 1973. Castration of an Asian elephant, using etorphine anesthesia. *J. Am. Vet. Med. Assoc.* 163(6): 539-543
207. FOWLER, M.E. 1974. Restraint procedures in large animals, some thoughts on handling large mammals. *J. Zoo Anim. Med.* 5: 27-30

208. FOWLER, H.E. 1980. Hoof, claw and nail problems in nondomestic animals. *J. Am. Vet. Med. Assoc.* 177(9): 885-893
209. FOWLER, M.E. 1981. Problems with immobilizing and anaesthetizing elephants. In American Association of Zoo Veterinarians. Annual proceedings. Seattle, Washington USA 87-91
210. FOWLER, E. 1982. Problems with immobilizing and anesthetizing elephants. *Proc. Ann. Meet. Am. Assoc. Zoo. Vet.* p 87
211. FRANZ, W., SEIDEL, B. & JACOB, A. 1989. Surgical treatment of purulent pododermatitis in an Indian elephant. *Verhandlungsbericht des 31. Symposiums über die Erkrankungen der Zootiere*
212. FUJIMOTO, E., KOTO, N., IMORI, T. & NAKAMA, S. 1971. Gonadotrophin in the urine of a pregnant Indian elephant - a case report. *Zoologia* 55: 73
213. GABRISCH, K. 1978. Proteins and free amino-acids in serum of African and Indian elephants. *Praktische Tierarzt* 59(2): 112-115
214. GAINER, B. 1973 A joint injury in an elephant. *E. Afr. Wildl. J.* 11(2): 209
215. GARLT, C., KIUPEL, H . & EHRENTRAUT, W. 1979 Botulism in elephants. Verhandlungsbericht des XXI. Symposiums über die Erkrankungen der Zootiere. 207-211
216. GARY, C.W. & NETTASINGHE, A.P.W. 1970. A preliminary study of the immobilization of the Asiatic elephant, *Elephas maximus* utilizing Etorphine (M99). *Zoologica* 55(3): 51-54
217. GASS, H. 1987. Complication in tusk eruption in an African elephant, *Loxodonta africana. Kleintierpraxis* 32(8): 387-388
218. GEDDES, L.A., HOFF, H.E. & COHEN, B.S. 1967. The electrocardiogram of the elephant. *Southwest Vet.* 20: 211
219. GEHRING, H. & MAYER, H. 1978. Diagnosis and treatment of pox in the elephant. *Praktische Tierartz* 59(2): 106, 109
220. GEHRING, H. & SCHRÖDER, H.D. 1982. Partial castration of a male elephant, *Elephas maximus. Zoologische Garten* 52(5/6): 365-368
221. GHOSH, K.N.A. & NAIR, K.P. 1982. Agalactia in an elephant - a case report. 8(1): 74-75
222. GLOVER, J. 1963. The elephant problem at Tsavo. *E. Afr. Wildl. J.* 1: 30-39
223. GLOVER, T.D. 1973. Aspects of sperm production in some east African mammals. *J. Reprod. Fert.* 35(1): 45-53
224. GOROVITZ, C. 1962. Tuberculosis in an African elephant. *Proc. 4th Int Symp Dis Zoo Anim. Nord Vet-Med.* 14: 351-352
225. GOWDA, C.D.K. 1969. A brief note on breeding Indian elephants, *Elephas maximus*, at Mysore Zoo. *Int. Zoo Yearbook* 9:99
226. GRABER, M. & THAL, J. 1979. Myiasis of wild Artiodactyla and elephants in central Africa. *Revue d'Elevage et de Médécine Veterinaire des Pays Tropicaux* 32(3): 257-262
227. GRAF, Z., MESZAROS, J. & BOROS, G. 1980. Contribution on diseases of elephants. *Verhandlungsbericht des XXII. Symposiums über die Erkrankungen der Zootiere* 241-245
228. GRAHAM, A.D. & LAWS, R.M. 1971. The collection of found ivory in Hurchison Falls National Park, Uganda. *E. Afr. Wildl. J.* 9: 57-65
229. GREVE, J.H. 1969. *Strongyloides elephantis* Sp. N from an Indian elephant, *Elephas indicus. J. Parasitol.* 55(3): 498-499
230. GROMADZKA-OSTROWSKA, J., JAKUBOW, K., ZALEWSKA, B. & KRZYWICKI, Z. 1988. Haematological and blood biochemical studies in female domesticated Indian elephants, *Elephas maximus. Comp. Biochem. Physiol.* 89(3): 313-315
231. GRUENBERG, K. & JAROFKE, D. 1978. Surgical removal of excessive callous growth froD the vulva of an Indian elephant, *Elephas maximus. In:* IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XX. Symposiums über die Erkrankungen der Zootiere.* 301-304
232. GULLAND, F.M.D. & CARWARDINE, P.C. 1987. Plasma metronidazole levels in an Indian elephant, *Elephas maximus* after rectal administration. *Vet. Rec.* 120(18): 440
233. GUSSGEN, B. 1988. Comparative surgical anatomy of the Indian and African elephants, based on a review of the literature. Inaugural-Dissertation, Tierärztliche, Hochschule, Hannover, German Federal Republic pp 276
234. GUTTER, A. 1981. *Mycobacterium tuberculosis* in an Asian elephant. In: American Association of Zoo Veterinarians. Annual proceedings. Seattle, Washington USA 105-106
235. GUY, P. 1974. *Feeding behaviour of the African elephant in the Sengwa Research Area of Rhodesia.* MSc thesis: University of Rhodesia
236. GUY, P.R. 1976 Diurnal activity patterns of elephant in the Sengwe Area, Rhodesia. *E. Afr. Wildl. J.* 14: 285-295
237. GUY, P.R. 1977. Coprophagy in the African elephant, *Loxodonta africana. E. Afr. Wildl. J.* 15(2): 174
238. GUY, P.R. 1981. Changes in the biomass and productivity of woodlands in the Sengwa Wildlife Research Area, Zimbabwe. *J. Appl. Ecol.* 18(2): 507-520
239. HAAS, G. 1978. Behavioural disorders in a female Indian elephant with bony structures on the intermediofacial and stratoacoustic nerves. *Zoologische Garten* 48(4): 297-298

240. HAIGH, J.C., PARKER, I.S.C., PARKINGSON, D.A. & ARCHER, A. 1979. An elephant extermination. *Environmental Conservation* 6: 305-310

241. HALL-MARTIN, A.J. & DE BOOM, H.P.A. 1979. Dislocation of the elbow and its social consequences for an African elephant. *Jl. S. Afr. Vet. Assoc.* 50: 19-22

242. HALL-HARTIN, A.J. & RUTHER, H. 1979. Application of stereo photogrammetric techniques for measuring African elephants. *Koedoe* 22: 187-198

243. HALL-MARTIN, A.J. 1987. Role of musth in the reproductive strategy of the African elephant, *Loxodonta africana. S. Afr. J. Sci.* 83: 616-620

244. HANKS, J..1969a. Techniques for marking large African mammals. *Puku* 5: 65-86

245. HANKS, J. 1969b. The capture of young elephant in the Zambezi Valley. *Puku* 5: 87-90

246. HANKS, J. 1969c. Growth and weight of the female African elephant in Zambia. *E. Afr. Wildl. J.* 7: 7-10

247. HANKS, J. 1969d. Seasonal breeding of the African elephant in Zambia. *E. Afr. Wildl. J.* 7: 167

248. HANKS, J. 1971a. The reproductive physiology of the African elephant, *Loxodonta africana*. PhD thesis, University of Cambridge

249. HANKS, J. 1971b..The elephant problem. *World Wildlife Yearbook* 1970-1971: 277-284

250. HANKS, J. 1972a. Reproduction of the elephant, *Loxodonta africana* in the Luangwa Valley, Zambia, *J. Reprod. Fert.* 30: 13-26

251. HANKS, J. 1972b. Growth of the African elephant, *Loxodonta africana. E. Afr. Wildl. J.* 10: 251-272

252. HANKS, J. 1972c. Aspects of dentition of the African elephant, *Loxodonta africana. Arnoldia (Rhod)* 36: 1-8

253. HANKS, J. & SHORT, R.V. 1972. The formation and function of the corpus luteum in the African elephant, *Loxodonta africana. J. Reprod. Fert.* 29(1): 79-89

254. HANKS, J. 1973a. Growth and development of the ovary of the African elehant, *Loxodonta africana* (Blumenbach 1797). *Puku* 7: 125-131

255. HANKS, J. 1973. Reproduction in the male African elephant in the Luangwa Valley, Zambia. *J. S. Afr. Wildl. Mgmt. Ass.* 3: 31-38

256. HANKS, J. 1973. *A struggle for survival - The elephant problem.* C Struik Publishers, Cape Town. 176pp

257. HANKS, J. & McINTOSH, J.E.A. 1973. Population dynamics of the African elephant. *J. Zool., Lond.* 169: 29-38

258. HANKS, J. 1977. Comparative aspects of reproduction in the male hyrax and elephant. *In:* CALABY, J.H. & TYNDALE-BISCOE, C.H. (eds.) *Reproduction and Evolution.* 155-164.

259. HARTHOORN, A.H. 1975. *The chemical capture of animals.* Ballière Tindall, London.

260. HARTMANN, E. 1972. A comparative study of transepidermal water loss through the skin of various animals. *Comp. Biochem. Physiol.* (A) 43(4): 715-718

261. HATTINGH, J. 1984. Effects of etorphine and succinyldicholine on blood composition in elephant and buffalo. *S. Afr. J. Zool.* 19(4): 286-290

262. HATTINGH, J., WRIGHT, P.G., DE VOS, V., MCNAIRN, I.S., GANHAO, M.F., SILOVE, M., WOLVERSON, G. & CORNELIUS, S.T. 1984. Blood composition in culled elephants *(Loxodonta africana)* and buffaloes *(Syncerus caffer). Jl S. Afr. Vet. Assoc.* 55(4): 157-164

263. HEARD, D.J., JACOBSON, E.R. & BROCK, K.A. 1986. Effects of oxygen supplementation on blood gas values in chemically restrained juvenile African elephants. *J. Am. Vet. Med. Assoc.* 189(9): 1071-1074

264. HEARD, D.J., KOLLIAS, G.V., WEBB, A.I., JACOBSON, E.R. & BROCK, K.A. 1988. Use of halothane to maintain anesthesia induced with etorphine in juvenile African elephants. *J. Am. Vet. Med. Assoc.* 193(2): 254-256

265. HEATH, B.R. & FIELD, C.R. 1974. Elephant endurance on Galana Ranch, Kenya. *E. Afr. Wildl. J.* 12: 239

266. HEATH, E., JEYENDRAN, R.S. & GRAHAM, E.F. 1983. Ultrastructure of spermatozoa of the Asiatic elephant, *Elephas maximus. Anatomia Histologia Embryologia* 12(3): 245-252

267. HEDGER, R.X. & BROOKSBY, J.B. 1976. FHD in an Indian elephant (correspondence). *Vet. Rec.* 99(5): 93

268. HEFFNER, R. & HEFFNER, H. 1980. Hearing in the elephant, *Elephas maximus. Science, NY* 208 (4443) 518-520

269. HEINRICH, B. & BARTHOLOMEW, G.A. 1979. Roles of endothermy and size in inter- and intraspecific competition for elephant dung in an African dung beetle, *Scarabaeus laevistriatus. Physiol. Zool.* 52(4): 484-496

270. HESS, D.L., SCHMIDT, A.H. & SCHMIDT, M.J. 1983. Reproductive cycle of the Asian elephant, *Elephas maximus* in captivity. *Biol. Reprod.* 28: 767

271. HILDEBRAND, M. & HURLEY, J.P. 1985. Energy of the oscillating legs of a fast-moving cheetah, pronghorn, jackrabbit and elephant. *J. Morphol.* 184(1): 23-31

272. HILEY, P.G. 1975. How the elephant keeps its cool. *Natural History* 84(10): 34-41

273. HILL, W.C.O. 1953a. The evolution of the African elephant. *In:* WARD, R. (ed). *The elephant in East Central Africa.* Rowland Ward Ltd, London. pp 11-14

274. HILL, W.C.O. 1953. The anatomy of the African elephant. *In:* WARD, R. (ed.) *The elephant in East Central Africa.* Rowland Ward Ltd., London. pp 15-60

275. HILL, W.C.O. 1953. The reproduction of the African elephant. *In:* WARD, R. (ed.) *The elephant in East Central Africa*. Rowland Ward Ltd., London. pp 61-67
276. HILLMAN, A.K.K. 1978. Elephant survey in Kenya: about a fifty percent die-off since 1973. *Africana* 6(8): 18-20; 32-33
277. HODGES, J.K., HENDERSON, C. & McNEILLY, A.S. 1983. Circulating oestrogen concentrations during pregnancy in the African elephant, *Loxodonta africana*. *J. Reprod. Fert.* 67(1): 121-127
278. HOLMAN, D. 1967. *The elephant people*. Murray, London
279. HOLT, W.V., JONES, R.C. & SKINNER, J.D. 1980. Studies of the different ducts from the testis of the African elephant, *Loxodonta africana*. II. Histochemistry of the epididymis. *J. Anat.* 130(2): 367-379
280. HOIJER, D.A. 1980. Remarks on the dentition and tooth replacement in elephants. *Neth. J. Zool.* 30(3): 510-515
281. HOWARD, J., BUSH, M., DE VOS, V. & WILDT, D.E. 1984. Electroejaculation, semen characteristics and serum testosterone concentrations of free-ranging elephants, *Loxodonta africana*. *J. Reprod. Fert.* 72(1): 187-195
282. HOWELL, P.G., YOUNG, E. & HEDGER, R.S. 1973. Foot-and-mouth disease in the African elephant, *Loxodonta africana*. *Onderstepoort J. Vet. Res.* 40(2): 41-52
283. HUBBARD, W.D. 1928. Observations on the elephants of Northern Rhodesia and Portuguese East Africa. *J. Mammal.* 9: 39-49
284. HUNDLEY, G. 1934. Statistical record of growth in the Indian elephant. *J. Bombay Nat. Hist. Soc.* 37: 487
285. HUNDLEY, G. 1934. Statistics of height increments of Indian calf elephants. *Proc. Zool. Soc. Lond.* p 697
286. HUNGERFORD, D.A., CHANDRA, H.S., SNYDER, R.L. & OLMER, F.A. Jr. 1966. Chromosomes of three elephants, two Asian, *Elephas maximus* and one African, *Loxodonta africana*. *Cytogenetics* 5(3): 243-246
287. ISHWARAN, N. 1978. *Ecological studies on population of elephants in the Gal Oya area in relation to distribution, habitat preferences, competition and food availability*. MSc thesis, University of Sri Lanka (Sri Lanka)
288. ISHWARAN, N. 1981. Comparative study of Asiatic elephant *Elephas maximus* populations in Gal Oya, Sri Lanka. *Biol. Conserv.* 21(4): 303-313
289. ISHWARAN, N. 1983. Elephant and woody-plant relationships in Gal Oya, Sri Lanka. *Biol. Conserv.* 3: 255-270
290. JACHMANN, H. & BELL, R.H.V. 1979. The assessment of elephant numbers and occupancy by means of dropping counts in the Kasungu National Park, Malawi. *Afr. J. Ecol.* 17: 231-239
291. JACHMANN, H. 1980. Population dynamics of the elephants in the Kasungu National Park, Malawi. *Neth. J. Zool.* 30: 622-634
292. JACHMANN, H. 1985. Estimating age in African elephants. *Afr. J. Ecol.* 23: 199-202
293. JACHMANN, H. 1986. Notes on the population dynamics of the Kasungu elephants. *Afr. J. Ecol.* 24: 215-226
294. JACHMANN, H. & BELL, R.H.V. 1984. Why do elephants destroy woodland? *Pachyderm* 3: 9-10
295. JACHMANN, H. & BELL, R.H.V. 1985. Utilization by elephants of the *Brachystegia* woodlands of the Kasungu National Park, Malawi. *Afr. J. Ecol.* 23: 245-258
296. JACHMANN, H. 1987. Elephants and woodlands (II). *Pachyderm* 8: 11-12
297. JACHMANN, H. 1987. Estimating age in African elephants (II): revising Laws' molar evaluation technique. *Afr. J. Ecol.* 25.
298. JACKSON, P. 1982. *Elephants and rhinos in Africa - A time for decision*. Special report, IUCN. 36pp
299. JACOBSON, E.R., HEARD, D.J. & BROCK, K.A. 1984. Effects of oxygen supplementation on blood gas values in African elephants. In: Abstracts of Papers of the Annual meeting, American Association of Zoo Veterinarians. Louisville Kentucky, p 60
300. JACOBSON, E.R., ALLEN, J., MARTIN, H. & KOLLIAS, G.V. 1985. Effects of yohimbine on combined xylazine-ketamine-induced sedation and inDobilization in juvenile African elephants. *J. Am. Vet. Med. Assoc.* 187(11): 1195-1198
301. JACOBSON, E.R., SUNBERG, J.P., GASKIN, J.H., KOLLIAS, G.V. & O'BANION, M.K. 1986. Cutaneous papillomas associated with a herpesvirus-like infection in a nerd of captive African elephants. *J. Am. Vet. Med. Assoc.* 189(9): 1075-1078
302. JACOBSON, E.R., CHEN, L., GRONWALL, R. & TILLER, A. 1986. Serum concentrations of etorphine in juvenile African elephants. *J. Am. Vet. Med. Assoc.* 189(9): 1079-1081
303. JACOBSON, E.R., KOLLIAS, G.V., HEARD, D.J. & CALIGIURI, R. 1988. Immobilization of African elephants with carfentanil and antagonism with nalmefene and diprenorphine. *J. Zoo Anim. Med.* 19(1/2): 1-7
304. JAINUDEEN, M.R. 1970. The use of etorphine hydrochloride for restraint of a domesticated elephant *(Elephas maximus)*. *J. Am. Vet. Med. Assoc.* 157(5): 624-626
305. JAINUDEEN, M.R., BONGSO, T.A. & PERA, M.O.A.A. 1971. Immobilization of aggressive working elephants, *Elephas maximus*. *Vet. Rec.* 89: 686-688

306. JAINUDEEN, M.R., EISENBERG, J.F. & TILAKERATNE, N. 1971. Oestrous cycle of the Asiatic elephant, *Elephas maximus* in captivity. *J. Reprod. Fertil.* 27(3): 321-328
307. JAINUDEEN, M.R. & JAYASINGHE, J.B. 1971. Hemogram of the domesticated Asiatic elephant *(Elephas maximus). J. Zoo An. Med.* 2(3): 5-11
308. JAINUDEEN, M.R., FERNANDO, S.T. & SENTHESHANMUGANATHAN, S. 1972. Certain biochemical constituents of seminal plasma of elephant, *Elephas maximus. Am. J. Vet. Res.* 33(3): 649-651
309. JAINUDEEN, M.R., KATONGOLE, C.B. & SHORT, R.V. 1972. Plasma testosterone levels in relation to musth and sexual activity in the male Asiatic elephant, *Elephas maximus. J. Reprod. Fert.* 29: 99-103
310. JAINUDEEN, M.R., McKAY, G.M. & EISENBERG, J.F. 1972. Observations on musth in the domesticated Asiatic elephant. *Mammalia* 36(2): 247-261
311. JAINUDEEN, M.R. & SCHEURMANN, E. 1975. Diseases of the working elephant, *Elephas maximus*, in Sri Lanka (Ceylon) with special reference to diagnostic and therapeutic possibilities within the country. *Dtsch. Tierärztl. Wochenschr.* 82(9): 355-359
312. JAINUDEEN, M.R. & KHAN, M. 1977. Immobilization and translocation of wild Asian elephant, *Elephas maximus*, in peninsular Malaysia. *Kajian Veterinar* 9(1): 1-7
313. JANSSEN, D.L., KARESH, W.B., COSGROVE, G.E. & OOSTERHUIS, J.E. 1984. Salmonellosis in a herd of captive elephants. *J. Am. Vet. Med. Assoc.* 185(11): 1450-1451
314. JAROFKE, D. 1981. Use of haltothane oxygen anesthesia in elephants, *Elephas maximus. J. Zoo Anim. Hed.* 12: 93-95
315. JAROFKE, D., KELLER, H., KLÖS, H.G. & WINTZER, H.T. 1981. Halothane-oxygen anaesthesia of elephant. *In:* IPPEN, R. & SCHRÖDER, H.D.(eds.) Verhandlungsbericht des XXIII. Symposiums über die Erkrankungen der Zootiere, 24-28 Juni, in Halle/Saale, 273-275
316. JAROFKE, D. & ADAMI, A. 1985. Illustrated account of methods of euthanasia of the elephant. (Ein Bildbericht über Totungsmethoden von Elefanten). *Kleintierpraxis* 30(4): 205-206
317. JAYASINGHE, J.B., FERNANDO, S.D.A. & BRITO-BABAPULLE, L.A.P. 1963. The electrocardiographic patterns of *Elephas maximus* - the elephant of Ceylon. *Br. Vet. J.* 119: 559-564
318. JAYASINGHE, J.B., FERNANDO, S.D.A. & BRITO-SABAPULLE, L.A.P. 1964. The electrocardiogram of a baby eLephant. *Am. Heart J.* 67: 388-390
319. JAYASINGHE, J.B. & JAINUDEEN, M.R. 1970. A census of tame elephants in Ceylon with reference to location and distribution. *Ceylon J. Sci.* 8(2): 63-68
320. JEFFREY, S.N. 1979. Elephants on the farm (Ghana). *Oryx* 10(5): 302-304
321. JOHNSON, O.W. 1964. Histological and quantitative characteristics of the testes, observations on the teeth and pituitary gland, and the possibility of reproductive cyclicity in the African elephant, *Loxodonta africana*. PhD thesis, Washinqton State University
322. JOHNSON, O.W. 1967. Relationships of Leydig cells characteristics and intratesticular testosterone levels to sexual activity in the African elephant. *Anat. Rec.* 157: 191-6
323. JOHNSON, D.L. 1980. Problems in the land vertebrate zoogeography of certain islands and the swimming powers of elephants. *J. Biogeogr.* 7(4): 383-398
324. JOHNSON, O.W. & BUSS, I.O. 1965. Molariform teeth of male African elephants in relation to age, body dimensions, and growth. *J. Mammal.* 46(3): 373-384
325. JOHNSON, O.W. & BUSS, I.O. 1967. The testis of the African elephant, *Loxodonta africana.* I Histological features. *J. Reprod. Fert.* 13: 11-21
326. JOHNSON, O.W. & BUSS, I.O. 1967. The testis of the African elephant, *Loxodonta africana* II. Development puberty and weight. *J. Reprod. Fert.* 13: 23-30
327. JOHNSON, B., BURTON, N. & QUALLS, C.W. Jr. 1986. Interstitial pulnonary fibrosis in an African elephant. *J. Am. Vet. Med. Assoc.* 189(9): 1188-1190
328. JONES, R.C. 1973. Collection, mortality and storage of spermatozoa from the African elephant, *Loxodonta africana. Nature, Lond.* 243(5401): 38-39
329. JONES, R.C. 1978. Studies on handling spermatozoa from the African elephant, *Loxodonta africana. In:* WATSON, P.F. (ed.) Artificial breeding of non-domestic animals. *Symp Zool. Soc. Lond.* 43: 261-269
330. JONES, R.C. 1980. Luminal composition and maturation of spermatozoa in the genital ducts of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 60(1): 87-93
331. JONES, R.C., ROWLANDS, I.W. & SKINNER, J.D. 1974. Spermatozoa in the genital ducts of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 41: 189-192
332. JONES, R.C., SKINNER, J.D. & ROWLANDS, I.W. 1974. The role of the urogenital ducts of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 36(2): 441-442
333. JONES, R.C., BAILEY, D.W. & SKINNER, J.D. 1975. Studies on the collection and storage of semen from the African elephant, *Loxodonta africana. Koedoe* 18: 147-164
334. JONES, R.C. & BROSNAN, H.F. 1981. Studies of the deferent ducts from the testis of the African elephant, *Loxodonta africana*. I Structural differentiation. *J. Anat.* 132(3): 371-386
335. JORDAN, J.A. & PREBBLE, J. 1956. *Elephants and ivory*. Rinehart & Co, New York
336. KACHARI, M. 1963. Cow elephant helps her calf. *Afr. Wildl.* 17(1): 74
337. KANE, K.K., CORWIN, R.H. & BOEVER, W.J. 1976. Louse infestation of Asian elephants. *J. Am. Vet. Med. Assoc.* 169 (9): 906-908

338. KARESH, W.B. & ROBINSON, P.T. 1985. Ivermectin treatment of lice infestations in two elephant species. *J. Am. Vet. Med. Assoc.* 187(11): 1235-1236
339. KERR, H.A. & FRAZER, J.A. 1975. Distribution of elephant in a part of the Zambezi Valley, Rhodesia. *Arnoldia (Rhodesia)* 7(21): 1-14
340. KERR, H.A. 1978. Reproduction of elephant in the Hana Pools National Park, Rhodesia. *Arnoldia (Rhodesia)* 8(29): 1-11
341. KINGSTON, T.J. 1977. *Natural manuring by elephants in Tsavo National Park, Kenya.* PhD thesis, University of Oxford (England)
342. KLEINHAUER, E., BUSS, I.O., LUCK, C.P. & WRIGHT, P.G. 1965. Haemoglobins of adult and foetal African elephants. *Nature, Lond.* 2025:
343. KOCH, E., ELSAESSER, F., BOER, H., DITTRICH, L. & ELLENDORFF, F. 1988. Pregnancy diagnosis in Asian and African elephants. *Deutsche Tierärtzliche Wochenschrift* 95(3): 111-114
344. KOCK, H., KOCK, N., ARIF, A. & WAHID, H.N.S.A. 1984. Immobilization techniques and complications associated with a bull Indian elephant, *Elephas maximus indicus* during musth. In Abstracts of Papers of the Annual Meeting American Association of Zoo Veterinarians, 1984, Louisville, Kentucky 68-72
345. KOCK, N. & KOCK, M. 1984. Management of two Indian elephants, *Elephas maximus indicus* in a Middle Eastern zoo. *Annual Proceedings of Am Assoc of Zoo Vet* 23: 75-81
346. KOGOVSEK, J. & GERSAK, T.J. 1982. Treatment of large wound in foot of female elephant. *In:* IPPEN, R. & Schröder, H.D. (eds.) Verhandlungsbericht des XXIV. Symposiums über die Erkrankungen der Zootiere. 173-175
347. KORTLAND, A. 1976. Tree destruction by elephant in Tsavo National Park and the role of man in African ecosystems. *Neth. J. Zool.* 26: 319-344
348. KOTO, N., FUJIMOTO, E. & CHASHI, H. 1977. Some notes on the shortening of tusks of Indian elephants. *J. Jap. Assoc. Zool. Gardens Aquariums* 19(3/4): 46-48
349. KOVATS, E. & GRAF, Z. 1987. Successful treatment of hoof cancer in an Indian elephant using Naksol (plant extracts in ethanol). *Verhandlungsbericht des Internationalen Symposiums über die Erkrangungen der Zootiere* 29: 173-178
350. KOZAWA, Y. 1976. A study on the enamel of the tusk of *Elephas maximus. J. Geol. Soc. Jpn.* 82(11): 741-742
351. KRISHNAMOORTHI, R., LA MAR, G.N., MIZUKAMI, H. & ROMERO, A. 1984. A proton NMR investigation of the influence of distal glutamine on structural and dynamic properties of elephant methoglobin. *J. Biol. Chem.* 259(1): 265-270
352. KRUMREY, W.A. & BUSS, I.O. 1968. Age estimation, growth and relationships between body dimensions of the female African elephant. *J. Mammal.* 49: 22-31
353. KRUMREY, W.A. & BUSS, I.O. 1969. Observations on the adrenal gland of the African elephant. *J. Mammal.* 50(1): 90-101
354. KÜHME, W. 1962. Ethology of the African elephant *Loxodonta africana* (Blumenbach 1797) in captivity. *Int. Zoo Yearbook* 4: 113-121
355. KUNTZE, A. & HUNSDORFF, P. 1978. Haematological and biochemical findings (Ca, P, Mg, Fe, glucose, enzymes) in Asiatic female elephants. *In:* IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XX. Symposiums über die Erkrankungen der Zootiere* 309-313
356. KUNTZE, A. & HANETZKY, V. 1978. Poxvirus titres in elephants. *In:* IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XX. Symposiums über die Erkrankungen der Zootiere* 305-308
357. KUNTZE, A. 1979. Treatment of colic elephants, *Elephas maximus. Verhandlungsbericht des XXI. Symposiums über die Erkrankungen der Zootiere* 281-284
358. KUNTZE, A..1980. Diseases of limbs in elephants *(Elephas maximus)* with emphasis on the hoof. *Verhandlungsbericht des XXII. Symposiums über die Erkrankungen der Zootiere* 247-253
359. KUNTZE, A. 1981. Sedation and anaesthesia of elephant in standing position with xylazine. *In:* IPPEN, R. & SCHRÖDER, H.D. (eds.) *Verhandlungsbericht des XXIII. Internationalen Symposiums über die Erkrankungen der Zootiere* 267-271
360. KUNTZE, A. 1982a. Amputation of a prolapsed prepuce in a standing elephant. *Monatshefte für Veterinärmedizin* 37(17): 663-667
361. KUNTZE, A. 1982b. Further experience of the clinical aspects and treatment of pox in elephants. *Monatshefte für Veterinärmedizin* 37(12): 460-462
362. KUNTZE, A. & HUNSDORFF, P. 1979. Further haematological and biochemical findings (Ca, inorganic P, Hg, Na, K, Fe glucose, enzymes) with references to iron deficiency anaemia in young elephants, *Elephas maximus. In: Verhandlungsbericht des XXI. Internationalen Symposiums über die Erkrankungen der Zootiere* 147-150b
363. KUNTZE, A. & HUNSDORFF, P. 1981. Evaluation of haematological and biochemical findings obtained from healthy and diseased female elephants, *Elephas maximus. In:* IPPEN, R. & SCHRÖDER, H.D. (eds) *Verhandlungsbericht des XXIII. Internationalen Symposiums über die Erkrankungen der Zootiere* 337-343
364. KUNTZE, A. 1987. Surgery on elephants. *Monatshefte für Veterinärmedizin* 42(11): 399-403

365. KUNTZE, A. 1987. Wound healing in elephants. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zootiere* 29, 167-171
366. KUNTZE, A. 1989. Disorders of performing elephants: perineal hernia, prepatellar bursitis and olecranal tyloma. Erkrankungen der Zootiere. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zootiere* 31: 185-187
367. KURT, F. & NETTASINGHE, A.P. 1968. Estimation of body weight in the Ceylon elephant. *Ceylon Vet. J.* 16: 24
368. KUTSCHMANN, K. & PUSCHMANN, W. 1982. Vesicular mucosal disease of unknown aetiology in three Asiatic elephants. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zootiere* 24: 267-272
369. LAMPREY, H.F., GLOVER, P.E., TURNER, H.I.H. & BELL, R.H.V. 1967. Invasion of the Serengeti National Park by elephants. *E. Afr. Wildl. J.* 5: 151-167
370. LANG, E.M. 1967. The birth of an African elephant at Basle Zoo. *Int. Zoo Yb.* 7: 154-157
371. LANG, E.H. 1980. Observations on growth and molar change in the African elephant. *Afr. J. Ecol.* 18: 217-234
372. LARK, R.M. 1984. A comparison between techniques for estimating the ages of African elephants. *Afr. J. Ecol.* 22: 69-71
373. LASH, S.S. (compiler). 1980. Ban-the-ivory campaign II. *Elephant* 1(4): 143-157
374. LATEUR, N. & STOLK, P. 1986. Repeated general anaesthesia in a male Indian elephant. *Proceedings of the Annual Meeting, American Association of Zoo Veterinarians,* 128-131
375. LAURSEN, L.H. 1975. *The ethology of the African elephant*. Univ. Colorado, Boulder 256pp (mimeographed)
376. LAWS, R.H. 1966 Age criteria for the African elephant, *Loxodonta africana africana. E. Afr. Wildl. J.* 4: 1-37
377. LAWS, R.M. 1967. Eye lens weight and age in African elephants. *E. Afr. Wildl. J.* 5: 46-52
378. LAWS, R.H. 1967. Occurrence of placental scars in the uterus of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 14: 445-449
379. LAWS, R.H. 1968a. Interactions between elephant and hippopotamus populations and their environments. *E. Afr. Agric. For. J.* 33: 140-147
380. LAWS, R.M., PARKER, I.S.C. & ARCHER, A. 1967. Estimating live weights of elephants from hind leg weight. *E. Afr. Wildl. J.* 5: 105-111
381. LAWS, R.M., PARKER, I.S.C. & ARCHER, A. 1967 Estimating live weights of elephants from hind leg weights. *E. Afr. Wildl. J.* 5: 106-111
382. LAWS, R.H. & PARKER, I.S.C. 1968. Recent studies on elephant populations in East Africa. *Symp. Zool. Soc. Lond.* 21: 319-359
383. LAWS, R.M. & PARKER, I.S.C. 1969. Recent studies of elephant populations in East Africa. *Symp. Zool. Soc. Lond.* 20:59
384. LAWS, R.H. 1969a. Aspects of reproduction in the African elephant, *Loxodonta africana. J. Reprod. Fert.* Suppl. 6: 193-217
385. LAWS, R.M. 1969b. The Tsavo Research Project. *J. Reprod. Fert.* Suppl 6: 495-531
386. LAWS, R.M. 1970a. Biology of African elephants. *Science Prog. Oxford* 58: 251-262
387. LAWS, R.H. 1970b. Elephants as agents of habitat and landscape change in East Africa. *Oikos* 21: 1-15
388. LAWS, R.M., PARKER, I.S.C. & JOHNSTONE, R.C.B. 1970. Elephants and habitats in North Bunyoro, Uganda. *E. Afr. Wild. J.* 8: 163-180
389. LAWS, R.M., PARKER, I.S.C. & JOHNSTONE, R.C.B. 1975. *Elephants and their habitats. The ecology of elephants in North Bunyoro, Uganda.* Clarendon Press, Oxford, London
390. LAWTON, R.H. & GOUGH, M. 1970. Elephants or fire-which is to blame? *Oryx* 10(4): 244-248
391. LEE, P.C. & MOSS, C.J. 1985. Early maternal investment in male and female African elephant calves. *Behav. Ecol. Sociobiol.* 18: 353-361
392. LEE, P.C. 1986. Early social development among African elephant calves. *National Geographic Research* 2: 388-401
393. LEE, P.C. 1987. Allomothering among African elephants. *Animal Behaviour* 35: 278-291
394. LEKAGUL, B. & NcNEELY, J.A. 1977. Elephants in Thailand: importance, status and conservation. *Conserv. News* (June 1977): 1-8
395. LEUTHOLD, W. 1976a. Group size in elephants of Tsavo National Park and possible factors influencing it. *J. Anim. Ecol.* 45: 425-439
396. LEUTHOLD, W. 1976b. Age structure of elephants in the Tsavo National Park Kenya. *J. Appl. Ecol.* 13: 435-444
397. LEUTHOLD, W. 1977. Spatial organization and strategy of habitat utilization of elephants in Tsavo National Park, Kenya. *Z. Säugetierk.* 42: 358-379
398. LEUTHOLD, W. & SALE, J.B. 1973. Movements and patterns of habitat utilization of elephants in Tsavo National Park, Kenya. *E. Afr. Wildl. J.* 11: 369-384
399. LEUTHOLD, W. & LEUTHOLD, B.H. 1975. Parturition and related behaviour in the African elephant. *Z. Tierpsychol.* 39: 75-84

400. LEWIS, J.H. 1974. Comparative hematology: Studies on elephants, *Elephas maximus. Comp. Biochem. Physiol.* (A) 49: 175
401. LEWIS, A.L. & GASKIN, J.M. 1977. Encephalomyocarditis virus infection of captive elephants. *J. Am. Vet. Med. Assoc.* 171(9): 902-905
402. LEWIS, A.R. & WILSON, V.J. 1977. An evaluation of a fence in the control of wild ungulates under extensive conditions in Africa. *Br. Vet. J.* 133(4): 379-387
403. LEWIS, D.H. 1984 .Demographic changes in the Luangwa Valley elephant. *Biol. Conserv.* 29: 7-14
404. LILLYWHITE, H.B. & STEIN, B.R. 1987. Surface sculpturing and water retention of elephant skin. *J. Zool., Lond.* 211: 737-734
405. LIMPOKA, H., CHAI-ANAN, P., SIRIVEJPANDU, S., KANCHANOMAI, R., RATTANAMONTHIANCHAI, S. & PUANGKUM, P. 1988. Plasma concentrations of oxytetracycline in elephants following intravenous and intramuscular administration of Terramycin/LA injectable solution. *Acta Veterinaria Brno* 56(1/2): 173-179
406. LINDSAY, S. *et al.* 1956. Arteriosclerosis in an elephant. *Arch. Pathol.* 61: 207
407. LINDSAY, W.K. 1982. *Habitat selection and social group dynamics of African elephants in Amboseli, Kenya.* MSc thesis, University of British Columbia, 200 pp
408. LINDSAY, W.K. 1983. Elephants, trees and people. *Wildlife News* 18(2): 8-11
409. LINDSAY, W.K. 1986. Elephant problems and human attitudes. *Swara* 9(3) 24-27
410. LINDSAY, W.K. 1986. Trading elephants for ivory. *New Scientist* 112(1533): 48-52
411. LUGARD, F.D. 1893. *The rise of our East African empire*. Blackwood, Edinburgh.
412. MABERRY, M.B. 1962. Breeding Indian elephants, *Elephas maximus*, at Portland Zoo. *Int. Zoo. Yb.* 4: 80-83
413. MAGLIO, V.J. 1970. Early Elephantidae of Africa and a tentative correlation of African Plio-pleistocene deposits. *Nature, Lond.* 225(230): 328-332
414. MAGLIO, V.J. 1973. Origin and evolution of Elephantidae. *Trans. Am. Phil. Soc. New Series* 63: 3
415. MALPAS, R.C. 1977. Diet and the condition and growth of elephants in Uganda. *J. Appl. Ecol.* 14: 489-504
416. MALPAS, R.C. 1978a. The decline and the conditions of growth of elephants in Uganda. *J. Appl. Ecol.* 14(2): 489-504
417. MALPAS, R.C. 1978b. *The ecology of the African elephant in Rwenzori and Kabalega Falls National Park, Uganda*. PhD thesis, University of Cambridge (England)
418. MANNERS, H. 1980. *Kambuku*. Frederick Muller, London
419. MAQSOOD, M..1982. Skin depigmentation in an elephant. *Zootechnia* 31(4/6): 137
420. MARSHALL, B. & BRENDON, R.M. 1963. The chemical composition and nutritive value of elephant grass *Pennisetum purpureum*. *Trop. Agric Trin.* 40: 63-6
421. MARTIN, R. 1985. New procedures for controlling the ivory trade. *Pachyderm* 5: 16-17
422. McCULLAGH, K.G. & LEWIS, N.G. 1967. Spontaneous arteriosclerosis in the African elephant. Its relation to disease in man. *Lancet* ii, 492-495
423. McCULLAGH, K.G. 1969a. The growth and nutrition of the African elephant I. Seasonal variations in the rate of growth and the urinary excretions of hydroxyproline. *E. Afr..Wildl. J.* 7: 85-90
424. McCULLAGH, K.G. 1969b. The growth and nutrition of the African elephant II. The chemical nature of the diet. *E. Afr. Wildl. J.* 7: 91-97
425. McCULLAGH, K.G. & GRESHAM, G.A. 1969. Eye lesions in the African elephant, *Loxodonta africana. Res. Vet. Sci.* 10: 587-9
426. McCULLAGH, K.G., LINCOLN, H.G. & SOUTHGATE, D.A.T. 1969. Fatty acid composition of milk fat of the African elephant. *Nature, Lond.* 222: 493-4
427. McCULLAGH, K.G. 1970. *Arteriosclerosis in the African elephant*. PhD thesis, Cambridge University
428. McCULLAGH, K.G. & WIDDOWSON, E.M. 1970. The milk of the African elephant. *Br. J. Nutr.* 24(1): 109-117
429. McCULLAGH, K.G. 1973. Studies on elephant aortic elastic tissue. I The histochemistry and fine structure of the fiber. *Exp. Mol. Pathol.* 18(2): 190-201
430. McCULLAGH, K.G. 1973. Are African elephants deficient in essential fatty acids? *Nature, Lond.* 242 (5395): 267-268
431. McCULLAGH, K.G. 1975. Arteriosclerosis in the African elephant. *Artherosclerosis* 21(1): 37-60
432. McCULLY, R.M., BASSON, P.A., PIENAAR, J.G., ERASMUS, J. & YOUNG, E. 1971. Herpes nodules in the lung of the African elephant *Loxodonta africana*, (Blumenbach, 1797). *Onderstepoort J. Vet. Res.* 38(4): 225-235
433. McGAVIN, H.D., SCHROEDER, E.C., WALKER, R.D. & McCRACKEN. 1981 Fatal aspiration pneumonia in an African elephant. *J. Am. Vet. Med. Assoc.* 179(11): 1249-1250
434. McGAVIN, M.D., WALKER, R.D., SCHROEDER, E.C., PATTON, C.S. & McCRACKEN, M.D. 1983. Death of an African elephant from probable toxemia attributed to chronic pulpitis. *J. Am. Vet. Med. Assoc.* 183(11): 1269-1273

435. McNEILLY, A.S. *et al.* 1983. Blood concentrations of gonadotrophins, prolactin and gonadal steroids in males and in non-pregnant and pregnant female African elephants, *Loxodonta africana. J. Reprod. Fert.* 67: 113

436. MELLAND, F. 1938. *Elephants in Africa.* Country Life, London

437. MELTON, D.A. 1985. The status of elephants in northern Botswana. *Biol. Conserv.* 31(4): 317-333

438. MERKT, H., AHLERS, D., BADER, H., BRANDT, H.P., BOER, M. & DITTRICH, L. 1985. Episiotomy, a new obstetrical intervention in the elephant cow. *Deutsche Tierärztliche Wochenschrift* 92(10): 428-432

439. MERKT, H., AHLERS, D., BADER, H., BRANDT, H.P., BOER, M. & DITTRICH, L. 1985 Illustrated report of the removal of a dead elephant fetus by perineotomy at the 645th day of gestation and 65 hours after the start of parturition. *Praktische Tierarzt* 66(5): 377-378

440. MERKT, H., AHLERS, D., BADER, H., RATH, D., BRANDT, H.P., BOER, H. & DITTRICH, L. 1986. Postoperative care and recovery of a female elephant after delivery of a dead fetus by episiotomy. *Berliner under Münchener Tierärztliche Wochenschrift* 99(10): 329-333

441. MERZ, G. 1986. The status of the forest elephant, *Loxodonta africana cyclotis*, Matchie, 1900, in the Gola Forest Reserves, Sierra Leone. *Biol. Conserv.* 36: 83-94

442. MIALL, L.C. & GREENWOOD, F. 1977. The anatomy of the Indian elephant. Part I. *J. Anat. Physiol.* 12: 261

443. MIALL, L.C. & GREENWOOD, F. 1977 The anatomy of the Indian elephant Part II. *J. Anat. Physiol.* 12: 384

444. MIALL, L.C. & GREENWOOD, F. 1979. The anatomy of the Indian elephant. Part III. *J. Anat. Physiol.* 13: 77

445. MILES, A.E.W. & BOYDE, A. 1961. Observations on the structure of elephant ivory. *J. Anat., Lond.* 95: 450

446. MILES, A.E.W. 1972. Healed injuries of elephant tusks. *Br. Dent. J.* 133(9): 395-400

447. MILL, J. & KUNTZE, A. 1978. ECG studies in healthy elephants and in one diseased elephant, *Elephas maximus. Verhandlungsberich des XX. Iternationalen Symposiums über die Erkrankungen der Zootiere* 315-326

448. MILL, J. & KUNTZE, A. 1983. Electrocardiography in lying and standing elephants, with reference to the use of xylazine. *Verhandlungsbericht des 25. Internationalen Symposiums über die Erkrankungen der Zootiere* 349-355

449. MILLER, R.M. 1977a. Segmental gangrene and sloughing of elephants' ears after intravenous injection of phenylbutazone. *Veterinary Medicine & Small Animal Clinician* 72(4): 633-637

450. MILLER, R.M. 1977b. Butazolidin reported to cause sloughing of ears following intravenous administration in elephants. *J. Zoo Anim. Med.* 8(4): 6

451. MILLIKEN, T. 1985. Recent developments in the Japanese ivory trade and the implementation of CITES in Japan. *Pachyderm* 5: 15-16

452. MISRA, S.S. & ANGELO, S.J. 1979. Clinical appraisal of triflupromazine hydrochloride (Siguil) sedation for certain surqical interventions in three elephants, *Elephas maximus. Vet. Res. Bull.* 2(1) 49-53

453. MITCHELL, B.L. 1963. A possible visual signal by elephant. *Puku* 1: 217

454. MIZUKAMI, H. & BARTNICKI, D.E. 1986. Unusual myoglobin of elephant. *Elephant* 2(2): 80-81

455. MOLLEL, C.L. 1978. Cervico-vaginal prolapse in an African elephant. *E. Afr. Wildl. J.* 16(1): 59

456. MONTALI, R.J., MANN, P.C., JONES, D.M., GRINER, L.A., KUEN, G.R., NARUSHIMA, E. & BUSH, M. 1984. Leiomyomas in the genital tract of large zoo mammals (elephant and rhinoceros). *Verhandlungsbericht des XXIV. Internationale Symposiums über die Erkrankungen der Zootiere* 117-122

457. MORRIS, R.C. 1927. On "natural deaths" in wild elephants. *J. Bombay Nat. Hist. Soc.* 32: 794-795

458. MORRISON-SCOTT, T.C.S. 1947. A revision of our knowledge of African elephants' teeth, with notes on forest and "pygmy" elephants. *Proc. Zool. Soc. Lond.* 117(2 and 3): 505-527

459. MOSES, J.S. & GOPALAKRISHNAN, A.V. 1979. A note on agar gel electrophoresis of sera of Indian elephants. *Cheiron, Tamil, Nadu J. Vet. Sci. Anim. Husbandry* 8(2) 145-148

460. MOORE, D.E. & DOYLE, C.D. 1986. Elephant training and ride operation. Part I animal health, cost/benefit and philosophy. *Elephant* 2(2): 19-31

461. MOSS, W. 1977. The Amboseli elephants. *Wildlife News* 12(2): 9-12

462. MOSS, C.J. 1983. Oestrous behaviour and female choice in the African elephant. *Behaviour* 86(3/4): 167-196

463. MOSS, C.J. & POOLE, J.H. 1983. Relationships and social structure of African elephants. *In:* HINDE, R.A. (ed.) *Primate Social Relationships.* Blackwell Scientific Publ., Oxford. 380 pp

464. MOSS, C. 1988. *Elephant memories.* William Horrow and Company, Inc. 336 pp

465. MOUNTER, J., MONKS, E. & CUBITT, J. 1977. The elephant game: report on poachinq and the ivory trade. *Africana* 6(7): 13-14, 29-30

466. MUELLER-DOMBOIS, D. 1972. Crown distortion and elephant distribution in the woody vegetations of Ruhuna National Park, Ceylon. *Ecology* 53(2): 208-227

467. MULDER, M.B. & CARO, T. 1980. Slaughter of the elephants. *New Scientist* 87(1208): 32-34

468. MUNSON, L., HEUSCHELE, W., O'BANION, M.K., SUNDBERG, J.P. & OOSTERHUIS, J.E. 1986. Polyp in the urogenital canal of an African elephant. *J. Am. Vet. Med. Assoc.* 189(9): 1190-1191
469. MURRAY, N. 1976. *The love of elephants*. Octopus, London
470. MUSTAFA, A.H.M. 1984. Isolation of anthrax bacillus from an elephant in Bangladesh. *Vet. Rec.* 14(24): 590
471. MYERS, N. 1973. Tsavo National Park, Kenya, and its elephants: An interim appraisal. *Biol. Conserv.* 5: 123-132
472. NAMBIAR, M.O.R. 1981. Leptaden (Vet) as a galactagogue in an elephant with deficient lactation. *Indian Vet. J.* 58(8): 667-668
473. NETTASINGHE, A.P.W. 1973. *The interrelationship of livestock and elephants at Themankaduwa Farm, with special reference to feeding and environment.* MVSc thesis, University of Sri Lanka, Peradeniya (Sri Lanka)
474. NEUMANN, A.H. 1982. *Elephant hunting in East Equatorial Africa*. Books of Zimbabwe, Bulawayo
475. NICHOLSON, B.D. 1956. The African elephant: how to shoot it humanely, when necessary. *Afr. Wildl.* 10(1): 25-36
476. NIRMALAN, G., NAIR, S.G. & SIMON, K.J. 1967. Hematology of the Indian elephant, *Elephas maximus. Can. J. Physiol.* 45: 985
477. NIRMALAN, G. & NAIR, S.G. 1969. Biochemical studies on the blood of Indian elephants *Elephas maximus. Res. Vet. Sci.* 10(2): 176-180
478. NIRMALAN, G. & NAIR, S.G. 1971. Plasma proteins and certain non-protein nitrogenous constituents in the blood of Indian elephants *Elephas maximus. Br. Vet. J.* 127(5): 207-213
479. NORTON-GRIFFITHS, M. 1979. The infuence of grazing, browsing, and fire on the vegetation dynamics of the Serengeti Tanzania, Kenya. *In:* SINCLAIR, A R.E & NORTON-GRIFFITHS, M. (eds.) *Serengeti: dynamics of an ecosystem* . University of Chicago Press, Chicago. pp 310-352
480. OBI, T.U. 1978. Traumatic granuloma in an African elephant, *Loxodonta africana*, and its treatment with Yatren-Casein. *E. Afr. Wildl. J.* 16(1): 69-71
481. O'DONAGHUE, P.H., SIKES, S.K. & TURVEY, A. 1967. Notes on the adrenal of the African elephant, *Loxodonta africana. J. Zool., Lond. 152: 281-286*
482. OFFERMANN, P.P.M. 1953. The elephant in the Belgian Congo. *In: The Elephant in East Central Africa.* Rowland Ward: London
483. OGLE, T.F., BRAACH, H.H. & BUSS, I.O. 1973. Fine structure and progesterone concentration in the corpus luteum of the African elephant. *Anat. Rec.* 175(4): 707-723
484. OGILVIE, P.W., MOODY, A. & SEITZ, S. 1974. Vital statistics of a self-perpetuating elephant herd. Presented at the Am Assoc Zool Parks and Aquar. Western Regional Conference
485. OKULA, J.P. & SISE, W.R. 1986. Effects of elephant browsing on *Acacia senegal* in Waza National Park, Cameroon. *Afr. J. Ecol.* 24: 1-6
486. OLIVIER, R.C.D. 1978. *On the ecology of the Asian elephant*. PhD. thesis, University of Cambridge (England), 2 vols. 454 pp
487. OLSEN, J.M. 1978. Captive elephant populations. *Elephant* 2: 32-34
488. OTTICHOLO, W.K. 1986. Population estimates and distribution pattens of elephants in Tsavo ecosystem, Kenya in 1980. *Afr. J. Ecol.* 24: 53-57
489. OTTICHILO, W.K. 1987. The causes of the recent heavy elephant mortality in the Tsavo ecosystem, Kenya 1975-1980. *Biol. Conserv.* 41(4): 279-289
490. OWEN-SMITH, N. 1966. The incidence of tuskless elephants in Mana Pools Game Reserve. *Afr. Wildl.* 20(1) 69-73
491. PARKER, I.S.C. 1971. *The East African ivory trade: 1925-1969*. Botswana Game Industries (Pty) Ltd, Francistown
492. PARKER, I.S.C. 1979. The Ivory Trade. Typescript Report to the Fish & Wildlife Service, US, Dept of the Interior, Washinqton DC, USA
493. PARKER, I. & AMIN, M. 1983. *Ivory Crisis*. Chatto and Windus, London
494. PARKER, I.S.C. 1983. The Tsavo story: an ecological case history. *In:* OWEN-SMITH, R.N. (ed) *Management of large mammals in African conservation areas*. HAUM, Pretoria. pp 37-49
495. PARKER, I.S.C. 1991. Conservation of the African elephant. *In: Proceedings of the meeting of elephant and rhino specialists,* Wankie, Zimbabwe, August 1981. IUCN, Gland, Switzerland
496. PATTERSON, A.H. 1898. The genito-urinary organs of the female Indian elephant. *J. Anat. Physiol.* 12: 582
497. PELLEGRINI, N., BRACA, G., ARISPICI, M., MACCHIONI, G. & MARCONCINI, A. 1976. Parasitological and histopathological studies of *Grammocephalus* infection in the Indian elephant. *Annali della Facolta di Medicina Veterinaria di Pisa* 28: 139-149
498. PELLEW, R.A.P. 1983. The impact of elephant, qiraffe and fire upon the *Acacia tortilis* woodlands of the Serenqeti. *Afr. J. Ecol.* 21: 41-74
499. PENNYCUICK, C.J., SALE, J.B., PRICE, H.S. & JOLLY, G.H. 1977. Aerial systematic sampling applied to censuses of large mammal populations in Kenya. *E. Afr. Wildl. J.* 15(2): 139-146

500. PENZHORN, B.L., ROBBERTSE, P.J. & OLIVIER, M.C. 1975. The influence of the African elephant on vegetation of the Addo Elephant National Park. *Koedoe* 17: 137-158
501. PERKINS, E.A.T. 1947. Island elephants again. *Uganda J.* 11: 38-41
502. PERRY, J.S. 1952. The growth and reproduction of elephants in Uganda. *Uganda J.* 16: 51-66
503. PERRY, J.S. 1953. The reproduction of the African elephant, *Loxodonta africana*. *Phil. Trans. R. Soc. B* 237: 93-149
504. PERRY, J.S. 1954. Some observations on growth and tusk weight in male and female African elephants. *Proc. Zool. Soc. Lond.* 124(1): 97-104
505. PERRY, J.S. 1964. The structure and development of the reproductive organs of the female African elephant. *Phil. Trans. R. Soc. B* 248: 35-51
506. PERRY, J.S. 1974. Implantation, foetal membranes and early placentation of the African elephant, *Loxodonta africana*. *Phil. Trans. R. Soc. B* 269, 109-135
507. PETERS, J.M., MAIER, R., HAWTHORNE, B.E. & STORVIK, C.A. 1972. Composition and nutrient content of elephant, *Elephas maximus*, milk. *J. Mammal.* 53: 717
508. PETRIDES, G.A. & WENDELL, G.S. 1965. Population densities and range-carrying capacity for large mammals in Queen Elizabeth Nationa Park, Uganda. *Zool. Afr.* 1(1): 209-225
509. PICHAICHARNARONG, A., LOYPETJRA, P.S., CHAIYABUTR, N., KOMONMENA, V., USANAKORNKUL, S., BOONNAMSIRI, V. & DEVAKUL, C. 1983 The thyroid activity of Asiatic elephants in Thailand. *Acta Veterinaria, Yugoslavia* 33: (2/3): 73-80
510. PICHAICHARNARONG, A., CHAIYABUTR, N., TEPRAATEEP, T., LOYPETJRA, P.S., KUNAVOODHI, C., LEENANURUKSA, K.V., USANAKORNKUL, S. & DEVAKULA, S. 1985. Haematological studies of Asiatic elephants in various parts of Thailand. *Thai J. Vet. Med.* 15(3): 197-213
511. PIENAAR, U. DE V., VAN WYK, P. & FAIRALL, N. 1966. An aerial census of elephant and buffalo in the Kruger National Park and the implications thereof on the intended management schemes. *Koedoe* 9: 40-107
512. PIENAAR, U. DE V., VAN NIEKERK, J.W., YOUNG, E., VAN WYK, P. & FAIRALL, N. 1966. The use of oripavine hydrochloride (M99) in the drug-immobilization and marking of wild African elephants *Loxodonta africana* (Blumenbach 1797) in the Kruger National Park. *Koedoe* 9: 108-124
513. PIENAAR, U. DE V., VAN NIEKERK, J.W., YOUNG, E., VAN WYK, P. & FAIRALL, N. 1966. Neuroleptic narcosis of large wild herbivores in South African National Parks with the new potent morphine analogues M99 and M183. *J. S. Afr. Vet. Med. Assoc.* 37: 277-291
514. PIENAAR, U. DE V. 1967 Operation "Khomandlopfu". *Koedoe* 10: 158-165
515. PIENAAR. U DE V. 1969 Why elephant culling is necessary. *Afr. Wildl.* 23(3): 181-194
516. PIENAAR, U. DE V. 1972. The culling of game ... why? *Custos* 1(2): 3-7, 11
517. PILASKI, J., BOSCH, B., MARSCHALL, H.H., FREY, H.R., LIESS, B. & MAYER, H. 1983. Contribution on further outbreaks of elephant pox in Europe with hints on diganosis. *Verhandlungsbericht des 25. Internationalen Symposiums über die Erkrangungen der Zootiere* 249-254
518. PILASKI, J., SCHALLER, K., MATERN, B., KLOPPEL, G. & MEYER, H. 1984. Poxvirus infection in elephants and rhinoceros. *Verhandlungsbericht des XXIV. Internationale Symposiums über die Erkrangungen der Zootiere* 257-265
519. PILASKI, J., FOSTER, J.W., MATERN, B., KLOPPEL, G. & SCHALLER, K. 1984. Further contributions on the epidemiology of cowpox-like diseases in zoo animals. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zootiere* 26: 349-354
520. PILASKI, J., MAGUNNA, E. & HAGENBECK, C. 1985. Pox in Asiatic elephants in the Carl Hagenbeck Zoo, Hamburg. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zootiere* 27: 437-447
521. PILASKI, J., ROSENBRUCH, M., GELDERBLOM, H., OLDERDING, P. & HAGENBECK, C. 1987. Herpesvirus infection in an Asiatic elephant. *Verhandlungsbericht des Internationalen Symposiums über die Erkrangungen der Zootiere* 29: 179-184
522. PILASKI, J., JENTSCHKE, J., SINN, D., FRANCKE, R., ROSENBRUCH, H., OLBERDING, P. & HOLLE, G. 1988. Two different viral diseases (pox and herpes) in Asian elephants in a small travelling circus. *Verhandlungsbericht des Internationalen Symposiums über die Erkrangungen der Zootiere* 30: 263-269
523. PILGRAM, T. & WESTERN, D. 1984. Managing elephant populations for ivory production. *Pachyderm* 4: 9-11
524. PILGRAM, T. & WESTERN, D. 1986. Inferring the sex and age of African elephants from tusk measurements. *Biol. Conserv.* 36: 39-52
525. PILLAY, K.R.S., RAHMAN, S.A., HEGDE, K.S. & RAJASEKARAN, D. 1976. *Grammocephalus* in an Indian elephant in Karnataka. *Indian Vet. J.* 53(9): 670-671
526. PILLAY, K.R. 1976. A note on the diagnosis of pregnancy in elephants. *Indian Vet. J.* 53: 19-21
527. PILLAY, K.R. & SUKUMARA. 1979. Duration of pregnancy in elephants. *Indian Vet. J.* 56(1): 75
528. PINTO, N.R., JAINUDEEN, N.R. & PANABOKKE, R.G. 1973. Tuberculosis in a domesticated Asiatic elephant, *Elephas maximus*. *Vet. Rec.* 93(26): 662-664
529. PITMAN, C.R.S. 1953. The elephant in Uganda. *In:* WARD, R. (ed.) *The elephant in East Central Africa*. Rowland Ward, London. pp 99-113

530. PLOTKA, E.D., SEAL, U.S., SCHOBERT, E.E. & SCHMOLLER, G.C. 1975. Serum progesterone and estrogens in elephants. *Endocrinology* 97(2): 485-487

531. POCHE, R.H. 1974. Ecology of the African elephant, *Loxodonta africana*, in Niger, West Africa. *Mammalia* 38(4): 567-580

532. POCHE, R.N. 1980. Elephant management in Africa. *Wildl. Soc. Bull.* 8: 199-207

533. POCOCK, R.I. 1918. The ages of elephants, as inferred from the molar teeth. *Proc. Zool. Soc. Lond.* 1918: 303

534. POGLAYEN-NEUWALL, I..1971. Elephant display at Louisville Zoo. *Int. Zoo Yearbook* 11: 64-66

535. POOLE, J.H. & HOSS, W. 1981. Musth in the African elephant, *Loxodonta africana. Nature, Lond.* 292(5826): 830-831

536. POOLE, J.H. 1982. *Musth and male-male competition in the African elephant.* PhD thesis, University of Cambridge, 158 pp

537. POOLE, J.H., KASMAN, L.H., RAMSAY, E.C. & LASLEY, B.L. 1984. Musth and urinary testosterone concentration in the African elephant, *Loxodonta africana. J. Reprod. Fert.* 70: 255-2608

538. POOLE, J.H. 1987. Elephants in musth, lust. *Natural History* 96(II): 46-5

539. PRASLOV, N.D. 1986. A mammoth figurine from site Kostenki 1 found in 1985. *Mammals of the Quaternary Fauna of the USSR*, USSR Academy of the Sciences, Proceedings of the Zoological Institute (Leningrad), Vol. 149: 107-108

540. PRESCOTT, C.W. 1971. Blackleg in an elephant. *Vet. Rec.* 88(23): 598-599

541. PYAKURAL, S., SINGH, U. & SINGH, N.G. 1976. An outbreak of foot-and-mouth disease in Indian elephants, *Elephas maximus. Vet. Rec.* 99(2): 28-29

542. RACINE, R.N. 1980. Behaviour associated with feeding in captive African and Asian elephants. *Elephant* Suppl 1: 57-71

543. RAHMAN, H., DUTTA, P.K. & DEWAN, J.N. 1988. Foot and mouth disease in elephant *(Elephas maximus). J. Vet. Med. B (Inf. Dis., Immunol., Food Hyg., Vet. Publ. Health* 35(1): 70-71

544. RAJAGOPAL, N.D. & AYER, A.A. 1954. Hairs and hair tracts of two foetuses of the Indian elephant *(Elephas indicus). Anat. Soc. India* 3(1): 1-10

545. RAJAN, A. & REDDI, M.V. 1981. Demonstration of alpha naphthyl acid esterase activity in the leucocytes of the peripheral blood smear of Indian elephants. *Indian Vet. J.* 58(12): 932-933

546. RAMIAH, B. 1935. An outbreak of foot and mouth disease in elephants. *Indian Vet. J.* 12: 28

547. RAMIAH, B. 1942. An obscure abscess in an elephant. *Indian Vet. J.* 29: 200

548. RAMSAY, E.C., LASLEY, B.L. & STABENFELDT, G.H. 1981. Monitoring the estrous cycle of the Asian elephant, *Elephas maximus*, using urinary estrogens. *Am. J. Vet. Res.* 42(2): 256-260

549. RAO, H.S., RAMACHANDRA, R.N., RAGHAVAN, R. & KESHAVAMURTHY, B.S. 1983. Suppurative pneumonia in an elephant calf due to *Corynebacterium pyogenes. Indian J. Comp. Microbiol. Immunol. Inf. Dis.* 4(3): 177

550. RASMUSSEN, L.E., SCHMIDT, H.J., KENNEOUS, R. & GROVES, D. 1982. Asian bull elephants: Flehmen-like responses to extractable components in female elephant estrous urine. *Science, NY* 217: 159

551. RATNESAR, P. 1966. The nutritive value of herbage. *In:* ABRAMS, J.T. (ed.) *Recent advances in animal nutrition,* Chapt 3. Churchill, London

552. RAUBENHEIMER, E.J., DAUTH, J., DREYER, N.J. & DE VOS, V. 1988. Parotid salivary gland of the African elephant, *Loxodonta africana*: structure and composition of saliva. *J. S. Afr. Vet. Assoc.* 59(4): 184-187

553. RENSCH, B. & HARDE, K.W. 1956. Growth gradients of Indian elephants. *J. Bombay Nat. Hist. Soc.* 52: 841

554. RENSCH, B. 1957. The intelligence of elephants. *Sci. Amer.* 196(2): 44-49

555. REUTHER, R.T. 1969. Growth and diet of young elephants in captivity. *Int. Zoo Yearbook* 9: 168-178

556. RICE, D.W. 1963. Birds associating with elephants and hippopotamuses. *Auk* 80: 196-197

557. RICHTER, W., DRÄGER, N, PATTERSON, L. & SOMMERLATTE, M. 1978. Observations on the immobilization and marking of Africa elephants, *Loxodonta africana* in Botswana. *Verhandlungsbericht des XX. Internationalen Symposiums über die Erkrankungen der Zootiere* 185-191

558. RICCIUTI, E.R. 1980a. The ivory wars. *Anim. Kingd.* 83(1): 6-15

559. RICCIUTI, E.R. 1980b. Counting elephants. *Anim. Kingd.* 83(1): 16-19

560. RICCIUTI, E.R. 1980c. The ivory trail crisscrosses Africa. *Anim Kingd.* 83(1): 37-42

561. RICCIUTI, E.R. 1980d. The elephant protection Act of 1979 - pros and cons. *Anim. Kingd.* 83(1): 51-58

562. RIEGEL, K., BANTELS, H., BUSS, I.O., WRIGHT, P.G., KLEIHAUER, E., LUCK, C.P., PARER, J.T. & METCALFE, J.1967. Comparative studies of the respiratory functions of mammalian blood IV. Fetal and adult African elephant blood. *Resp. Physiol.* 2: 182

563. RIEMANN, H.P., BURRIDGE, N.J., BEHYMER, D.E. & FRANTI, C.E. 1975. *Toxoplasma gondii* antibodies in free-living African mammals. *J. Wildl. Dis.* 11(4): 529-533

564. RIGGS, A. 1963. The amino acid composition of some mammalian hemoglobins: mouse, guinea pig, and elephant. *J. Biol. Chem.* 238(9): 2983-2987

565. RITCHIE, B.W., THOMAS-BAKER, B. & LATIMER, K.S. 1986. Dermoid cyst in an African elephant. *J. Am. Vet. Med. Assoc.* 189 (9): 1192
566. ROBERTSON-BULLOCK, W. 1960. Elephants eat baobab trees in Northern Rhodesia. *Afr. Wildl.* 14(2): 143-145
567. ROBERTSON-BULLOCK, W. 1962. The weight of the African elephant, *Loxodonta africana. Proc. Zool. Soc. Lond.* 138: 133-135
568. ROBINSON, P.T. & MEIER, J.E. 1977. Surgical removal of a tumor from an Asian elephant. *Vet. Med. & Small. Anim. Clinician* 72(10) 1638-1640
569. RODGERS, D.H. & ELDER, W.H. 1977. Movements of elephants in Luangwa Valley, Zambia. *J. Wildl. Mgmt.* 41(1): 56-62
570. ROMBOLI, B., PELLEGRINI, N., BRACA, G. & NACCHIONI, G. 1976. *Grammocephalus hybridatus* infection in the liver of an Indian elephant. Histopathological and parasitological findings. *Atti della Societa Italian delle Scienze Veterinarie* 29: 540-543
571. ROTH, V.L. & SHOSHANI, J. 1988. Dental identification and age determination in *Elephas maximus. J. Zool., Lond.* 214(4): 567-588
572. RUEDI, D., KUPFER, U., GUTSWILLER, A., RINDISBACHER, F. & WIESNER, H. 1981. Collection of semen from African elephant, *Loxodonta africana,* and planning of artificial insemination. *Verhandlungsbericht des Internationale Symposiums über die Erkrangungen der Zootiere* 23: 349-351
573. RUEDI, D., KUPFER, U., GIRARD, J. & GUTZWILLER, A. 1983 Reproductive physiology in African elephants. Semen collection from wild bulls, anatomy of wild cows, further progress towards artificial insemination. *Verhandlungsbericht des Internationale Symposiums über die Erkrangungen der Zootiere* 25: 341-348
574. SALE, J.B., RISHI, V., SINGH, K.N. & VERMA, V.K. 1986. Drug immobilisation of Indian elephant. *J. Bombay Na.t Hist. Soc.* 83(1): 49-56
575. SALZERT, W. 1976. Elephants. *In:* KLÖSS, J.G. & LANG, E.M. (eds). *Zootier Krankeiten.* Paul Parey, Berlin
576. SANTIAPILLAI, C., CHAMBERS, N.R. & ISCHWARAN, N. 1984. Aspects of the ecology of the Asian elephant in the Ruhuna National Park, Sri Lanka. *Biol. Conserv.* 29: 47-61
577. SATHIANESAN, V., CHANDRASEKHARAN, K., SUNDARAM, R.K. & PYTHAL, C..1979. Anthelmintic efficiency of oxibendazole against the common strongylids in elephants. *Kerala J. Vet. Sci.* 10(1): 153-156
578. SAUNDERS, G. 1983 Pulmonary *Mycobacterium tuberculosis* infection in a circus elephant. *J. Am. Vet. Med. Assoc.* 183(11): 1311-1312
579. SAVIDGE, J.N. 1966. Change in population number and reproductive rate of elephants in Uganda. *J. Wildl. Mgmt.* 30: 791-809
580. SCHAAF, C.D. 1972. Elephants, fire and the environment. *Anim. Kingd.* 75(2): 8-15
581. SCHALLER, K. 1981. Delayed dentition of an Indian elephant causing obstipation and colic. *Deutsche Tierärztliche Wochenschrift* 88(10): 439-440
582. SCHALLER, K. 1983 *Rhododendron* poisoning in a circus elephant. *Kleintierpraxis* 28(1): 53-56
583. SCHMIDT, J. 1964 Haematological studies in elephants. *Vet Med. Rev. Lev.* 2: 87-95
584. SCHMIDT, M.J. 1975. The use of xylazine in captive Asian elephants. *Proc. Ann. Meet. Am. Assoc. Zoo Vet.* 1-11
585. SCHMIDT, M.J. 1975. A preliminary report on the use of Rompun in captive Asian elephants. *J. Zoo Anim. Med.* 6: 13
586. SCHMIDT, M.J. 1978. *In:* FOWLER, M.C. (ed.) *Zoo and wild animal medicine.* WB Saunders, Philadelphia. pp 709-752
587. SCHMIDT, M.J. 1978. Penicillin G and amoxicillin in elephants: a study comparing dose regimens administered with serum levels achieved in healthy elephants. *J. Zoo. Anim. Med.* 9(4): 127-136
588. SCHMIDT, M.J. 1981. Technique and applications of venipuncture in the elephant. *In:* NELLEN, J. & LITTLEWOOD, A. (eds) *Recent developments in research and husbandry at the Washington Park Zoo.* Washington Park Zoo, Portland, Oregon. pp 63-69,
589. SCHMIDT, M.J. 1982. Studies on Asian elephant reproduction at the Washington Park Zoo. *Zoo Biol.* 1(2): 141-147
590. SCHMIDT, M.J. 1983. Antagonism of xylazine sedation by yohimbine and 4-aminopyridine in an adult Asian elephant, *Elephas maximus*, achieved in healthy elephants. *J. Zoo Anim. Med.* 14(3): 94-97
591. SCOTT, W.A. 1984. Salmonellosis in an African elephant. (in a zoo, with fatal outcome; correspondence). *Vet. Rec.* 115(15): 391
592. SEIFERT, S., ELZE, K. & SELBITZ, H.J. 1986. Adaptation to new quarters and occurrence of enteric *Escherichia coli* infection two young Asiatic elephants. *Zoologische Garten* 56(2): 106-112
593. SMITH, T.P., JOLLIE, K.G. & NOHR, J.L. 1982. Gut protozoans of 200 elephants (abstract). *J. Protozool.* 29(3): 482
594. SCHMITT, J. 1964. Haematological studies in elephants. *Vet. Med. Rev. Lev.* 2: 87
595. SCHULTE, T.L. 1937. The genito-urinary system of the, *Elephas indicus*, male. *Am. J. Anat.* 61: 131

596. SCHULZE, W. & HERTRAMPF, B. 1983. Technique and indication for slow drip infusion in elephants. *Kleintierpraxis* 28(3): 159-162
597. SCHULZE, W. 1986. Keeping of circus elephants and their minimum nutritional requirements. *Praktische Tierarzt* 67(9): 809-811
598. SEAMAN, J.T. & FINNIE, E.P. 1987. Acute myocarditis in a captive African elephant, *Loxodonta africana. J. Wildl. Dis.* 23(1): 170-171
599. SHELDRICK, D.L.W. 1964. The chemical composition of a day's diet of an elephant. *E. Afr. Wildl. J.* 2: 51-59
600. SENEVIRATNA, P., HAYASINGHE, J.B. & JAINUDEEN, N.R. 1969. Filariasis of elephants in Ceylon. *Vet. Rec.* 81(27): 716-717
601. SHERRY, B.Y. 1975. Reproduction of elephant in Gonarezhou, South-eastern Rhodesia. *Arnoldia (Rhodesia)* 7: 1-13
602. SETH-SMITH, A.N.D. & PARKER, I.S.C. 1967. A record of twin foetuses in the African elephant. *E. Afr. Wildl. J.* 5: 167
603. SHERRY, B.Y. 1978. Growth of elephant in the Gonarezhou National Park, South Eastern Rhodesia. *S. Afr. J. Wildl. Res.* 8: 49-58
604. SHORT, R.V. 1962. The peculiar lungs of the elephant. *New Scientist* 16(316): 570-572
605. SHORT, R.V. & BUSS, I.O. 1965. Biochemical and histological observations on the corpora lutea of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 9: 61-67
606. SHORT, R.V. 1966. Oestrous behaviour, ovulation and the formation of the corpus luteum in the African elephant, *Loxodonta africana. E. Afr. Wildl. J.* 4: 56-68
607. SHORT, R.V., NANN, T. & HAY, M.F. 1967. Male reproductive organs of the African elephant, *Loxodonta africana. .J Reprod. Fert.* 13: 517-536
608. SHORT, R.V. 1969. Notes on the teeth and ovaries of an African elephant, *Loxodonta africana*, of known age. *J. Zool., Lond.* 158: 421-425
609. SHORT, J. 1981. Diet and feeding behaviour of the forest elephant. *Mammalia* 45: 175-185
610. SHORT, J.C. 1983. Density and seasonal movements of forest elephant in Bia National Park, Ghana. *Afr. J. Ecol.* 21: 175-183
611. SHOSHANI, J. 1978. General information on elephants with emphasis on tusks. *Elephant* 1(2): 20-31
612. SHOSHANI, J. & GERON, R. 1986. Field observations of living and dead elephants (including some interpretations), in Kenya, Uganda and Zimbabwe. *Elephant* 2(2): 44-68
613. SHOSHANI, S.L. 1986. Captive elephant population of North America: 1986. *Elephant* 2(2): 123-130
614. Siegel, I.M. 1973. Orthotic treatment of tibiotarsal deformity in an elephant. *J. Am. Vet. Med. Assoc.* 163(6): 544-545
615. SIKES, S.K. 1966a. The African elephant, *Loxodonta africana*: a field method for the estimation of age. *J. Zool., Lond.* 150: 279-295
616. SIKES, S.K. 1966b. The elephant problem in Africa: random slaughter or selective husbandry? *Afr. Wildl.* 20: 225-237
617. SIKES, S.K. 1967. Elephant culling. *Animals* 10(3): 146
618. SIKES, S.K. 1968a The African elephant, *Loxodonta africana*, a field method for the estimation of age. *J. Zool., Lond.* 154: 235-248
619. SIKES, S.K. 1968b. Observations on the ecology of arterial disease in the African elephant, *Loxodonta africana* in Kenya and Uganda. *In:* CRAWFORD, N.A. (ed.) *Comparative nutrition of wild animals. Symp. Zool. Soc. Lond.* 21: 251-173
620. SIKES, S.K. 1971. *The natural history of the African elephant.* Elsevier, New York
621. SILBERMAN, N.S. 1977 Tranquilization of the African elephant, *Loxodonta africana* (Blumenbach 1797) with the neuroleptic azaperone (R 1929). *J. Zoo Anim. Med.* 8(4): 7-8
622. SILLAR, F.C. & MEYLER, R.M. 1968. *Elephants, ancient and modern.* Studio Books, Veleng Press, New York
623. SIMON, K.J. 1962. Haematological studies on elephants. *Indian Vet. J.* 38: 241-245
624. SIMON, K.J. 1965. Preliminary studies on composition of milk of Indian elephants. *Indian Vet. J.* 36: 500
625. SIMONS, H. 1966. Counting elephants by satellite. *New Scientist* 31: 509
626. SIMONS, L.G. & VIRES, C. 1986. Hydraulic squeeze for African bull elephants. *Proceedings of the Annual Meeting, American Association of Zoo Veterinarians* 60-65
627. SIMPSON, C.F., LEWIS, A.L. & GASKIN, J.N. 1977. Encephalomyocarditis virus infection of captive elephants. *J. Am. Vet. Med. Assoc.* 171(9): 902-905
629. SINGH, B.S. 1971. Umbilical hernia in an elephant calf. *Indian Vet. J.* 48(5): 533-536
630. SKINNER, R.K., BROWN, I.R.F. & WHITE, P.T. 1976. Serum amylase in the African elephant, *Loxodonta africana. Comp. Biochem. Physiol.* (B) 55(3): 363-366
631. SMITH, N.S. 1966. Observations on reproduction and breeding behaviour of the African elephant. *J. Wildl. Mgmt.* 30: 375-388
632. SMITH, J.G., HANKS, J. & SHORT, R.V. 1969. Biochemical observations on the corpora lutea of the African elephant, *Loxodonta africana. J. Reprod. Fert.* 20: 111-117

633. SMITH, N.S. 1975. Formation, function and persistence of the corpora lutea of the African elephant, *Loxodonta africana*. *J. Mammal.* 56(1): 30-43
634. SMUTS, G.L. 1974. Game movements in the Kruger National Park, South Africa and their relationship to the segregation of subpopulations and the allocation of culling compartments. *J. S. Afr. Wildl. Mgmt. Ass.* 4(1):
635. SMUTS, G.L. 1975. Reproduction and population characteristics of elephants in the Kruger National Park. *J. S. Afr. Wildl. Mgmt. Ass.* 5(1): 1-10
636. SMUTS, G.L. 1976. Interesting aspects of Kruger Park elephants. *Custos* 5: 7-11
637. SOGNNAES, R.F. 1972. Ivory core of elephant tusks and teeth. *Inf. Dent.* 54(15): 1407-1418
638. SPEARMAN, R.I.C. 1970. The epidermis and its keratinization in the African elephant, *Loxodonta africana. Zool. Afr.* 5: 327-338
639. SPICER, A.J. & McCORMICK, W.O. 1969 .Elephant allergy. *Br. Med J.* 1(636): 116
640. SPINAGE, C.A. & GUINNESS, F.E. 1971. Tree survival in the absence of elephants in the Akagera National Park, Rwanda. *J. Appl. Ecol.* 8: 723-728
641. SPINAGE, C.A. 1973. A review of ivory exploitation and elephant population trends in Africa. *E. Afr. Wildl. J.* 11: 281-289
642. SPINAGE, C.A. 1976. Incremental cementum lines in the teeth of tropical African mammals. *J. Zool., Lond.* 178(1): 117-131
643. SPINAGE, C.A. 1985. The elephants of Burkina-Faso, West Africa. *Pachyderm* 5: 2-5
644. SREEKUMAR, K.P. & NIRMALAN, G. 1989. Estimation of body weight in Indian elephants, *Elephas maximus indicus. Vet. Res. Com.* 13(1): 3-9
645. STEEL, J.H. 1885. *A manual of the diseases of the elephant.* Madras Government Printing Office
646. STEHLIK, M. 1979. Tusk fractures in elephants. *Verhandlungsbericht des Internationale Symposiums über die Erkrangungen der Zootiere* 21: 269-273
647. STOCKLEY, C.H. 1953. The elephant in Kenya. In: WARD, R (ed.) *The elephant in East Central Africa.* Rowland Ward, London. pp 80-98
648. SULOCHANNA, S., PILLAI, R.M. & ABDULLA, P.K. 1981. Erythrocyte rosette forming cells in the peripheral blood of Indian elephants. *Indian J. Comp. Microbiol. Immunol. Inf. Dis.* 2: 42-44
649. SUNDBERG, J.P., RUSSEL, W.C. & LANCASTER, W. 1981. Papillomatosis in Indian elephants. *J. Am. Vet. Med. Ass.* 179(11): l247-l249
650. SWYNNERTON, C.F.M. 1923. *Report on the control of elephants in Uganda.* Government Printer, Entebbe.
651. SWYNNERTON, C.F.M. 1924. *Report on the control of elephants in Uganda.* Government Printer, Entebbe.
652. TAKINO, Y. & ARAI, S. 1976. Foreleg fracture in an Indian elephant at Yatsu-Yuen Zoo. *J. Jap. Assoc. Zool. Gardens Aquariums* 18(1): 1-4
653. TAMAS, P.M. & GEISER, D.R. 1983. Etorphine analgesia supplemented by halothane anesthesia in an adult African elephant. *J. Am. Vet. Med. Assoc.* 183(11): 1312-1314
654. TAYLOR, J.I. 1955. The rearing of an African elephant in captivity. *Vet. Rec.* 67: 301
655. TAYLOR, G.A. 1970. Treating elephants with short-wave diathermy. *Physiotherapy* 56(2): 62-64
656. TINKER, J. 1975. Who's killing Kenya's jumbos? *New Scientist* 66(950): 452-455
657. THOMSON, P.J. 1975. The role of elephants, fire and other agents in the decline of a *Brachystegia boehmii* woodland. *J. S. Afr. Wild. Mgmt. Ass.* 5: 11-18
658. THURIG, D. 1970. Karyotype and sex chromatin of the African elephant, *Loxodonta africana. Acta Anat.* 75(1): 6-12
659. TODD, T.W. 1913. Notes on the respiratory system of the elephant. *Anat. Anz.* 44: 175
660. TREMBATH, P.R. 1985. Restraint of baby elephants with Rompun. *Veterinary Medical Review,* German Federal Republic 2: 169-170
661. TYRRELL, J.G. 1985. Distribution of elephants in the Tsavo region during the late l9th century. *Afr. J. Ecol.* 23(1): 29-33
662. UPADHYE, A.S., KRISHNAPPA, G., AHMED, S.N. & KESHAVAMURTHY, B.S. Serological evidence of leptospiral antibodies in elephants. *Current Science* 48(16): 733
663. USAMI, S., CHIEN, S. & GREGERSEN, M.K .1969. Viscometric characteristics of blood of the elephant, man, dog, sheep and goat. *Am. J. Physiol.* 217(3): 884-890
664. USANAGORNKUL, S. 1984. Curative praxis in working elephants in Thailand. *G sener Beiträge zur Entwicklungsforschung, Reihe* 10: 65-70
665. VAN CUYLENBERG, B.W.B. 1974. *The feeding behaviour of the Asiatic elephant in south-eastern Ceylon.* MS Thesis, Department of Zoology, University of Sri Lanka, Peradeniya (Sri Lanka), 407 pp
666. VAN CUYLENBERG, B.W.B. 1977. Feeding behaviour of the Asiatic elephant in southeast Sri Lanka in relation to conservation. *Biol. Conserv.* 12(1): 33-54
667. VAN HOVEN, W., PRINS, R.A. & LANKHORST, A. 1981. Fermentative digestion in the African elephant, *Loxodonta africana. S. Afr. J. Wildl. Res.* 11(3): 78-86
668. VAN WYK, P. & FAIRALL, N. 1969. The influence of the African elephant on the vegetation of the Kruger National Park. *Koedoe* 12: 57-89

669. VESEY-FITZGERALD, D.F. 1960 Grazing succession among East African game animals. *J. Mammal.* 41(2): 161-172
670. VESEY-FITZGERALD, D.F. 1968. An experiment in adapting an electric fence to elephant behaviour. *E. Afr. Agric. Forest. J.* 33: 185-190
671. VILJOEN, P.J. 1982 The ecology of the desert-dwelling elephants, black rhinoceroses and giraffes of western Kaokoland and Damaraland, SWA - Progress report. *Quagga* 2: 14-15
672. VILJOEN, P.J. 1983. The ecological role of the African elephant in an arid environment. *Namibia Wildlife Trust Newsletter.* Summer edition
673. VILJOEN, P.J. 1984. Ecological role of the African elephant, *Loxodonta africana*, in an arid environment. *S. Afr. J. Sci.* 80: 185-186
674. VILJOEN, P.J. 1985. Unieke Namib olifante voer 'n verlore stryd. *Custos* 13 (11): 31-33
675. VILJOEN, P.J. 1986 A plastic tail collar for marking wild elephants. *S. Afr. J. Wildl. Res.* 16: 158-159
676. VILJOEN, P.J. 1987. Status and past and present distribution of elephants in the Kaokoveld, SWA. *S. Afr. J. Zool.* 22: 247-257
677. VILJOEN, P.J. 1988. *The ecology of the desert-dwelling elephants, Loxodonta africana (Blumenbach, 1797) of western Damaraland and Kaokoland.* DSc thesis, University of Pretoria. 335 pp
678. VILJOEN, P.J. 1988. The desert-dwelling elephant - Hardy survivor. *Afr. Wildl.* 42: 111-115
679. VILJOEN, P.J. 1989. Spatial distribution and movements of elephants, *Loxodonta africana* in the northern Namib Desert region of the Kaokoveld, South West Africa/Namibia. *J. Zool., Lond.* 219: 1-19
680. VILJOEN, P.J. 1989. Habitat selection and preferred food plants of a desert-dwelling elephant population in the northern Namib Desert, South West Africa/Namibia. *Afr. J. Ecol.* 27: 227-240
681. VILJOEN, P.J. & BOTHMA J. du P. 1990. The influence of desert-dwelling elephants on the vegetation of the northern Namib Desert, South Nest Africa/Namibia. *J. Arid Environments* 18: 85-96
682. VILJOEN, P.J. & BOTHMA, J. du P. 1990. Daily movements of the desert-dwelling elephants in the northern Namib Desert. *S. Afr. J. Wildl. Res.* 20: 69-72
683. VILJOEN, P.J. 1990. A method of skull-based sex determination of elephant carcasses. *S. Afr. J. Wildl. Res.* 20: 118-119.
684. VILLIERS, P.A. DE & KOK, O.B. 1984. Verspreidingspatrone van olifant, *Loxodonta africana*, in Suidwes-Afrika met spesiale verwysing na die Nasionale Etoshawildtuin. *Madoqua* 13(4): 281-296
685. VOGEL, J.C., TALMA, A.S., HALL-MARTIN, A.J. & VILJOEN, P.J. 1990. Carbon and nitrogen isotopes in elephants. *S. Afr. J. Sci.* 86: 147-150
686. VITOVEC, J., KOTRLA, B., HAJI, H. & HAYLES, L.B. 1984. Fatal infection of an elephant calf caused by the trematode *Protofasciola robustra* (Lorenz, 1881) in Somaliland. *Zbl. Veterinärmed.* B 31(8): 597-602
687. VON HEGEL, G., HANICHEN, T., MAHNEL, H. & WIESNER, H. 1989. Warts papilloma/sarcoid in two elephants. *Verhandlungsbericht des 31. Internationalen Symposiums über die Erkrankungen der Zoo und Wildtiere* 205-210
688. WALKER, C. 1978. *The ring fence: an anthology of the southern elephants*. Endangered Wildlife Trust, Bedfordview, South Africa, 88pp
689. WALLACE, C. 1978. Chromosome analysis in the Kruger National Park: mitotic and meiotic studies in the African elephant, *Loxodonta africana. Koedoe* 21: 197-200
690. WALLACH, J.D. & ANDERSON, J.L. 1968. Oripavine (M99) combinations and solvents for immobilization of the African elephant. *J. Am. Vet. Med. Assoc.* 153(7): 793-797
691. WALLACH, J.D. & SILBERMAN, M.S. 1977. Foot care for captive elephants. *J. Am. Vet. Med. Assoc.* 171(9): 906-907
692. WALLACH, J.D. & BOEVER, W.J. 1983. Perissodactyla (equids, tapirs, rhinos), Proboscidae (elephants), and Hippopotamidae (hippopotamus). *In: Diseases of exotic animals.* W B Saunders, Philadelphia 761-829
693. WATSON, D.M.S. 1944. History of elephants. *Nature, Lond.* 153 (3870): 5-7
694. WATSON, D.M.S. 1946. The evolution of the Proboscidea. *Biol. Rev. Lond.* 21: 15-29
695. WATSON, R.M., GRAHAM, A.D. & PARKER, I.S.C. 1969. A census of the large mammals of Loliondo Controlled Area, northern Tanzania. *E. Afr. Wildl. J.* 7: 93-59
696. WATSON, R.M., PARKER, I.S.C. & ALLAN, T. 1969. A census of elephant and other large mammals in the Mkomazi region of northern Tanzania and southern Kenya. *E. Afr. Wildl. J.* 7: 11-26
697. WATSON, R.M. & BELL, R.H.V. 1969. The distribution abundance and status of elephant in the Serengeti region of Northern Tanzania. *J. Appl. Ecol.* 6: 115-132
698. WATSON, P.F. & SOUZA, F. 1975. Detection of estrus in the African elephant, *Loxodonta africana. Theriogenology* 4(6): 203-209
699. WEATHERFORD, H.L. 1940 Some observations on the tusks of an Indian elephant. The innervation of the pulp. *Anat. Rec.* 76(1 and Supplement No 1): 81-93
700. WEIR, J.S. 1969. Chemical properties and occurrence on Kalahari sand of salt lick created by elephants. *J. Zool., Lond.* 158: 293-310
701. WEIR, J.S. 1972. Spatial distribution of elephants in an African National Park in relation to environmental sodium. *Oikos* 23: 1-13

702. WEIR, J.S. 1972..Mineral content of elephant dung. *E. Afr. Wildl. J.* 10: 229-230
703. WEIR, J.S. 1973. Exploitation of water soluble soil sodium by elephants in Murchison Falls National Park, Uganda. *E. Afr. Wildl. J.* 11: 1-7
704. WEITZ, B. 1953. Serological relationships of hyrax and elephant. *Nature, Lond.* 171: 261
705. WELLS, M.P. & DOUGLAS-HAMILTON, I. 1986. Analysis of tusks from the Central African Republic. *Pachyderm* 6: 16-17
706. WERKSMAN, R. 1965. The birth of an elephant. *Afr. Wildl.* 19: 335
707. WERLE, E.H., HAENDLE & SCHMALL, A. 1968. A case of carcinoid in an elephant. *Pathol. Vet.* 5(1): 81-83
708. WESTERN, D. 1975. Water availability and its influence on the structure and dynamics of a savanna large mammal community. *E. Afr. Wildl. J.* 13(3/4): 265-286
709. WESTERN, D., MOSS, C.J. & GEORGIADIS, N. 1983. Age estimation and population age structure of elephants from footprint dimensions. *J. Wildl. Mgmt.* 47(4): 1192-1197
710. WESTERN, D. & LINDSAY, W.K. 1984. Seasonal herd dynamics of a savanna elephant population. *Afr. J. Ecol.* 22: 229-234
711. WEYERHAEUSER, F.J. 1985. Survey of elephant damage to boabab in Tanzania's Lake Manyara National Park. *Afr. J. Ecol.* 23: 235-243
712. WHEELOCK, N.D. 1980. Environment sodium as a factor in the behaviour and distribution of African elephants. *Elephant* 1(4): 169-177
713. WHITE, P.T. & BROWN, I.R.F. 1978. Hematological studies on wild African elephants, *Loxodonta africana. J. Zool., Lond.* 185(4): 491-504
714. WHITE, P.T. 1980. Blood parasites in free-living African elephants. *Zoologische Garten* 50(1): 45-48
715. WHITE, P.D., JENKS, J.L. & BENEDICT, F.G. The electrocardiogram of the elephant. *Am. Heart. J.* 16: 744
716. WICKREMASURIYA, U.G.J.S. & KENDERAAGAMA, K.W.T. 1982. A case report of haemorrhagic septicaemia in a wild elephant. *Sri Lanka Vet. J.* 30(2): 24
717. WILLIAMSON, B.R. 1975. The condition and nutrition of elephant in Wankie National Park. *Arnoldia (Rhodesia)* 7: 1-9
718. WILLIAMSON, B.R. 1975. Seasonal distribution of elephant in Wankie National Park. *Arnoldia (Rhodesia)* 7(11): 1-16
719. WILLIAMSON, B.R. 1976. Reproduction in female African elephant in the Wankie National Park, Rhodesia. *S. Afr. J. Wildl. Res.* 6: 89-93
720. WINDSOR, R.S. & ASHFORD, W.A. 1972. *Salmonella* infection in the African elephant and the black rhinoceros. *Trop. Anim. Health Prod.* 4(4): 214-219
721. WINDSOR, R.S. & SCOTT, W.A. 1976. Fascioliasis and salmonellosis in African elephants in captivity. *Br. Vet. J.* 132(3): 313-317
722. WING, L.D. & BUSS, I.O. 1970. Elephants and forests. *Wildl. Monogr.* 19: 1-92
723. WINTER, W.H. 1964. Elephant behaviour. *E. Afr. Wildl. J.* 2: 163-164 (Altruism)
724. WISSDORF, H,, BACH, F., LEOPOLD-KEIGHLEY, B. & KRISTINSSON, G. 1987. Anatomical basis for epidural anaesthesia in the Indian elephant. *Verhandlungsbericht des Internationalen Symposiums uber die Erkrankungen der Zootiere* 29: 157-165
725. WISSDORF, H. & POULSEN NAUTRUP, C. 1989. Presentation of the vena caudalis centralis, a further important anatomical structure for venipuncture in Asian elephant situated dorsally in the tail. *Zentralblatt für Veterinärmedizin Reihe C* 18(3): 279-280
726. WOODFORD, M.H. & TREVOR, S. 1970. Fostering a baby elephant. *E. Afr. Wildl. J.* 8: 204-205
727. WOODFORD, M.H., ELTRINGHAM, S.K. & WYATT, J.R. 1972. An analysis of mechanical failure of darts and costs involved in drug immobilization of elephant and buffalo. *E. Afr. Wildl. J.* 10(3): 279-285
728. WOODFORD, M.H. 1979. Blood characteristics of the African elephant, *Loxodonta africana cyclotis. J. Wildl. Dis.* 15(1): 111-113
729. WRIGHT, A. 1964. Mating habits of elephants. *Afr. Wild Life* 18(4): 301-302
730. WRIGHT, P.G. & LUCK, C.P. 1984. Do elephants need to sweat? *S. Afr. J. Zool.* 19: 270-274
731. WYATT, J.R. & ELTRINGHAM, S:K. 1974. The daily activity of the elephant in the Rwenzori National Park Uganda. *E. Afr. Wildl. J.* 12: 273-289
732. WYATT, J.H. 1986. Medical treatment of tusk pulpitis in an African elephant. *J. Am. Vet. Med. Assoc.* 189(9): 1193
733. WYLIE, K.C. 1980. Ivory, elephants and man: a survey. *Elephant* Suppl 1: 3-18
734. WUNDERSEE, W.J. & WERNER, E. 1978. Use of etorphine hydrochloride in elephants and wild Equidae in the Berlin Animal Park with reference to the legislation on the use of addictive drugs in the German Democratic Republic. *Verhandlungsbericht des 20. Internationalen Symposiums über die Erkrangungen der Zootiere* 193-196
735. YONETANI, K.Y. 1986. Captive elephants in Japan: census and history. *Elephant* 2(2): 3-14
736. YOUNG, T.P. & LINDSAY, W.K. In press. Role of even-age population structure in the disappearance of *Acacia xanthophloea* woodlands. *Afr. J. Ecol.*

737. YOUNG, E. & LOMBARD, C.O. 1969. Intestinal disaccharidase activities in some birds, reptiles and mammals. *Comp. Biochem. Physiol.* 29(1): 289-294
738. YOUNG, E. & OELOFSE, J. 1969. Management and nutrition of 20 newly captured young African elephants, *Loxodonta africana*, in the Kruger National Park. *Int. Zoo Yearbook* 9: 179-184
739. ZIAUDDIN, K.S. & SESHADRI, S.J. 1981. A rare case of post vaccinial non-suppurative encephalitis in an elephant: a case report. *Current Research, University of Agricultural Sciences, Bangalore* 3: 44-455

ADDITIONAL REFERENCE LIST

740. ABEL, N. & BLAIKIE, P. 1986. Elephants, people, parks and development - the case for the Luangwa Valley, Zambia. *Environmental Magazine* 10: 735-751
741. ADAMS, G.P., PLOTKA, E.D., ASA, C.S. & GINTHER, O.J.L. 1991. Feasibility of characterising reproductive events in large nondomestic species by ultrasonic imaging. *Zoo Biology* 10: 247-259
742. AFOLAYAN, T.A. 1975. Effects of elephant activities on forest plantations in Kilimanjaro Forest Game Reserve in northern Tanzania. *Oikos* 23: 405-410
743. AGNEW, A.D.Q. 1968. Observations on the changing vegetation of Tsavo National Park. *East African Wildlife Journal* 6: 75-80
744. ALBL, P. 1971. Studies on assessment of physical condition in African elephants. *Biological Conservation* 3: 134-140.
745. ANDERSON, J.L. 1983. Sport hunting in national parks - sacrilege or salvation? *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 271-280
746. ANDERSON, J.L. 1991. The introduction of elephant into medium-sized conservation areas. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal.* Wildlife Group of the SAVA, Onderstepoort. pp 24-28
747. ANON. 1968. *Knysna Elephant Symposium.* Eastern Cape Branch of the Wildlife Society, Port Elizabeth.
748. ANON. 1970. *Knysna elephants: final report.* Eastern Cape Branch of the Wildlife Society, Port Elizabeth.
749. ANON. 1970. How to destroy Murchison Falls. *Oryx* 10: 207
750. ANON. 1980. Kenyan elephant and rhino survey. *Oryx* 15: 237
751. ARMBRUSTER, P. & LANDE, R. 1993. A population viability analysis for African elephant *(Loxodonta africana)*: how big should reserves be? *Conservation Biology* 7: 602-610.
752. ASHCROFT, M.T. 1959. The importance of African wild animals as reservoirs of trypanosomiasis. *E. Afr. med. J.* 36: 289-297
753. ASTLE, W.L. 1971. Management in the Luangwa Valley. *Oryx* 11: 135-139
754. AYENI, J.S.O. 1975. Utilization of waterholes in Tsavo National Park (East). *E. Afr. Wildl. J.* 13: 305-323
755. BAINBRIDGE, W.R. 1965. Distribution of seed in elephant dung. *Puku* 3: 173-175
756. BAKER, M.K. & KEEP, M. 1970. Checklist of the ticks found on the larger game animals in the Natal game reserves. *Lammergeyer* 12: 41-47
757. BARBIER, E.B., BURGESS, J.C., SWANSON, T.M. & PEARCE, D.W. 1990. *Elephant economics and ivory.* Earthscan Publishers, London.
758. BARBIER, E. & SWANSON, T. 1990. Ivory: the case against the ban. *New Scientist* 128(1743): 52-54
759. BARNES. R.F.W. 1982. Elephant feeding behaviour in Ruaha National Park, Tanzania. *Afr. J. Ecol.* 20: 123-136
760. BARNES. R.F.W. 1982. A note on elephant mortality in Ruaha National Park, Tanzania. *Afr. J. Ecol.* 20: 137-140
761. BARNES. R.F.W. 1983. Effects of elephant browsing on woodlands in a Tanzanian national park - measurement, models, and management. *J. appl. Ecol.* 20: 521-540
762. BARNES. R.F.W. 1983. The numbers and distribution patterns of large mammals in the Ruaha-Rungwa area of southern Tanzania. *J. appl. Ecol.* 19: 411-425
763. BARNES, R.F.W., AGNAGNA, M., ALERS, M.P.T., BLOM, A., DOUNGOUBE, G., FAY, M., MASUNDA, T., NDO NKOUMOU, J.C., SIKUBWABO KIYENGO, C. & TCHAMBA, M. 1993. Elephants and ivory poaching in the forests of equatorial Africa. *Oryx* 27: 27-34
764. BARNES, R.F.W. & BARNES, K.L. 1992. Estimating decay rates of elephant dung piles in forest. *Afr. J. Ecol.* 30: 316-321
765. BARNES, R.F.W., BARNES, K.L., ALERS, M.P.T. & BLOM, A. 1991. Man determines the distribution of elephants in the rain forests of northeastern Gabon. *Afr. J. Ecol.* 29: 54-63
766. BARNES, R.F.W. & KAPELA, E.B. 1991. Changes in the Ruaha elephant population caused by poaching. *Afr. J. Ecol.* 29: 289-294
767. BARTELMUS, C., GIESECKE, D. & HOPPE, P. 1976. Vitamin A storage in the liver of certain African wild ruminants and elephants. *Koedoe* 19: 27-30
768. BARTELS, H., HILPERT, P., BARBEY, K., BETKE, K., RIEGEL, K., LANG, E.M. & METCALFE, J. 1963. Respiratory functions of blood of the yak, llama, camel, Dybowski deer, and African elephant. *Am. J. Physiol.* 205: 331-336

769. BARZDO, J. 1984. The worked ivory trade. *Traffic Bulletin* 6: 21-26
770. BASSON, M., BEDDINGTON, J.R. & MAY, R.M. 1991. An assessment of the maximum sustainable yield of ivory from African elephant populations. *Math. Biosci.* 104(1): 73-95
771. BASSON, P.A. & HOFMEYR, J.M. 1973. Mortalities associated with wildlife capture operations. *In:* YOUNG, E. (ed.) *Capture and care of wild animals*. Cape Town: Human & Rousseau. pp 151-160
772. BASSON, P.A., McCULLY, R.M., KRUGER, S.P., VAN NIEKERK, J.W., YOUNG, E., DE VOS, V., KEEP, M.E. & EBEDES, H. 1971. Disease conditions of game in Southern Africa: recent miscellaneous findings. *Veterinary Medical Review* 2/3: 313-340
773. BEACHY, R.W. 1967. The East African ivory trade in the nineteenth century. *Journal of African History* 8: 269-290
774. BEDDINGTON, J.R. & BASSON, M. 1994. The limits to exploitation on land and sea. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 343(1303): 87-92
775. BELL, R.H.V. 1983. Decision-making in wildlife management with reference to problems of overpopulation. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas*. HAUM, Pretoria. 145-172
776. BELL, R.H.V. 1983. An outline of a management plan for Kasungu National Park, Malawi. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas*. HAUM, Pretoria. 69-89
777. BELL, R.H.V. 1984. Notes on elephant-woodland interactions. *In:* CUMMING, D.H.M. & JACKSON, P. *The status and conservation of Africa's elephants and rhinos*. IUCN, Gland, Switzerland. 98-103
778. BENGIS, R.G. 1993. Care of the African elephant *Loxodonta africana* in captivity. *In:* McKENZIE, A.A. (ed.) *The capture and care manual*. Wildlife Decision Support Services & South African Veterinary Foundation, Lynnwood Ridge. 506-511
779. BENGIS, R.G., HEDGER, R.S., DE VOS, V. & HURTER, L.R. 1984. The role of the African elephant *(Loxodonta africana)* in the epidemiology of foot and mouth disease in the Kruger National Park. *Proceedings of the XIIIth World Congress on Diseases of Cattle, Durban, South Africa*, 1: 39-44
780. BENGIS, R.G., KEET. D.F., RAATH, J. & DE VOS, V. 1991. Experiences with the short-term management and care of newly-captured juvenile African elephants *(Loxodonta africana)* in the Kruger National Park. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 48-54
781. BEN-SHAHAR, R. 1993. Patterns of elephant damage to vegetation in Northern Botswana. *Biological Conservation* 65(3): 249-256
782. BERRY, H.H. 1993. Surveillance and control of anthrax and rabies in wild herbivores and carnivores in Namibia. *Rev. Sci. Tech. Off. Int. Epizoot.* 12(1): 137-146
783. BIGALKE, R.C. 1958. On the present status of ungulate mammals in South West Africa. *Mammalia* 22: 478-497
784. BINEPAL, V.S., WARIRU, B.N., DAVIES, F.G., SOI, R. & OLUBAYO, R. 1992.An attempt to define the host range for African horse sickness virus (Orbivirus, Reoviridae) in East Africa, by a serological survey in some Equidae, Camelidae, Loxodontidae and Carnivore. *Vet. Microbiol.* 31: 19-23
785. BISCHOF, L.L. & DUFFIELD, D.A. 1994. Relatedness estimation of captive Asian elephants *(Elephas maximus)* by DNA fingerprinting. *Zoo Biology* 13: 77-82
786. BLASZKIEWITZ, B. 1992. The new elephant quarters in the Berlin-Friedrichsfelde Zoo. *Zool. Gart.* 62(4): 212-221 (in German)
787. BOOTH, V.R. 1990. The elephant population of north-west Matabeleland: 1960-1990. *In:* JONES, M.A. (ed.) *The management of Hwange National Park*. Proceedings of a workshop held in Hwange National Park, July 1990.
788. BOSHE, J. 1986. The commercial utilization of Africa's wildlife. *Swara* 9(6): 20-22
789. BOUGHEY, A.S. 1963. Interactions between animals, vegetation and fire in Southern Rhodesia. *Ohio Journal of Science* 63(5): 193-209
790. BOURLIÈRE, F. 1965. Densities and biomasses of some ungulate populations in eastern Congo and Rwanda, with notes on population structure and lion/ungulate ratios. *Zoologica Africana* 1: 199-207
791. BOYAZOGLU, P.A., BARRETT, E.L., YOUNG, E. & EBEDES, H. 1972. Liver mineral analysis as indicator of nutritional adequacy. *Proc. 2nd World Congress on Animal Feeding*, 23-28 October 1972, Madrid, Spain. pp 995-1008
792. BRAIN, C. & FOX, V.E.B. 1994. Suspected cardiac glycoside poisoning in elephants *(Loxodonta africana)*. *Jl S. Afr. vet. Ass.* 65: 173-174
793. BRANNIAN, J.D., GRIFFIN, F., PAPKOFF, H. & TERRANOVA, P.F. 1988. Short and long phases of progesterone secretion during the oestrus cycle of the African elephant *(Loxodonta africana)*. *J. Reprod. Fert.* 84: 357-365
794. BRANNIAN, J.D., GRIFFIN, F. & TERRANOVA, P.F. 1989. Urinary androstenedione and luteinizing hormone concentration during musth in a mature African elephant. *Zoo Biology* 8: 165-170
795. BROWN, J.L., BUSH, M., WILDT, D.E., RAATH, J.P., DE VOS, V. & HOWARD, J.G. 1993. Effects of GnRH analogues on pituitary-testicular function in free-ranging African elephants. *J. Reprod. Fert.* 99: 627-634

796. BROWN, J.L., CITINO, S.B., BUSH, M., LEHNHARDT, J. & PHILLIPS, L.G. 1991. Cyclic patterns of luteinizing hormone, follicle stimulating hormone, inhibin, and progesterone secretion in the Asian elephant *(Elephas maximus)*. *J. Zoo Wildl. Med.* 25: 367-375
797. BUSS, I.O. 1990. *Elephant life: fifteen years of high population density.* Iowa State University Press, Ames.
798. BUSS, I.O., RASMUSSEN, L.E. & SMUTS, G.L. 1976. The role of stress and individual recognition in the function of the African elephant's temporal gland. *Mammalia* 40: 437-451
799. BUYS, D. & KEOGH, H.J. 1984. Notes on the microstructure of hair of the Orycteropidae, Elephantidae, Equidae, Suidae and Giraffidae. *S. Afr. J. Wildl. Res.* 14: 111-119
800. CALDWELL, J.R. 1987. The effect of recent legislative changes on the pattern of the world trade in raw ivory. *Traffic Bulletin* 9: 6-10
801. CALEF, G.W. 1988. Maximum rate of increase in the African elephant. *Afr. J. Ecol.* 26: 323-327
802. CAMPBELL, A.C. 1990. History of elephants in Botswana. *In:* HANCOCK, P. (ed.) *The Future of Botswana's Elephants.* Proceedings of Kalahari Conservation Society Symposium on Elephants held in Gaborone, Botswana, 10 November 1990.
803. CAMPBELL, D.G. 1991. Gap formation in tropical forest canopy by elephants, Oveng, Gabon, Central Africa. *Biotropica* 23(2): 195-196
804. CARRINGTON, R. 1958. *Elephants - a short account of their natural history, evolution and influence on mankind.* Chatto & Windus, London
805. CARTER, N. *The elephants of Knysna.* Purnell, Cape Town
806. CARTER, N. 1974. Whatever happened to the Knysna Elephants? *African Wildlife* 28(4): 6-7.
807. CAUGHLEY, G. 1975. Abundance and distribution of elephants in the Luangwa Valley, Zambia. *E. Afr. Wildl. J.* 13: 39-48
808. CAUGHLEY, G. 1983. Dynamics of large mammals and their relevance to culling. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 115-126
809. CAUGHLEY, G., DUBLIN, H. & PARKER, I. 1990. Projected decline of the African elephant. *Biol. Cons.* 54: 157-164
810. CAUGHLEY, G. & GODDARD. 1975. Abundance and distribution of elephants in the Luangwa Valley, Zambia. *E. Afr. Wildl. J.* 13: 39-48
811. CHABAUD, A.G., CUISANCE, D. & COLAS, F. 1989. *Leiperenia moreli* n. sp. (Nematoda: Atractidae), a parasite of the African elephant. *Syst. Parasitol.* 14(2): 135-140 (in French, with English summary)
812. CHAFFKIN, C. 1990. the ivory ban - what is it? *Intervet* 26: 24-25
813. CHAPMAN, L.J., CHAPMAN, C.A. & WRANGHAM, R.W. 1992. *Balanites wilsoniana:* elephant dependent dispersal? *J. Trop. Ecol.* 8: 275-283
814. CHEVALIER-SKOLNIKOFF, S. LISKA, J. 1993. Tool use by wild and captive elephants. *Anim. Behav.* 46(2): 209-219
815. CHILD, G.F.T. 1984. The trade in elephant and elephant products in Zimbabwe. *In:* CUMMING, D.H.M. & JACKSON, P. *The status and conservation of Africa's elephants and rhinos.* IUCN, Gland, Switzerland. 153-158
816. CHILD, G.F.T. & WHITE, J. 1988. The marketing of elephants and field-dressed elephant products in Zimbabwe. *Pachyderm* 10: 6-11
817. CHRISTENSEN, C.L., SCHMIDT, M.J., HESS, D.L. & ALAK, B.M. 1993. Oocyte nuclear maturation *in vitro* in the African *(Loxodonta africana)* and Asian elephants *(Elephas maximus)*. *Biol. Reprod.* 48 (Suppl. 1): Abstract No. 88
818. COETZEE, E.M., VAN DER BANK, F.H. & CRITSER, J.K. 1993. Allozyme variation in a wild African elephant *(Loxodonta africana)* population from the Kruger National Park, South Africa. *Comp. Biochem. Physiol. B Comp. Biochem.* 106(1): 109-114
819. COHN, J.P. 1990. Elephants: remarkable and endangered. *BioScience* 40(1): 10-14
820. COLLY, L. 1991. Diseases of elephants. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 73-78
821. CONYBEARE, A.M.G. 1991. *Elephant occupancy and vegetation change in relation to artificial water points in a Kalahari sand area of Hwange National Park.* DPhil thesis, University of Zimbabwe, Harare
822. CONYBEARE, A.M.G. & HAYNES, G. 1984. Observations on elephant mortality and bones in waterholes. *Quaternary Research* 22: 189-200
823. COOPER, K.A., HARDER, J.D., CLANSON, D.H., FREDRICK, D.L., LODGE, G.A., PEACHEY, H.C., SPELLMIRE, T.J. & WINSTEL, D.P. 1990. Serum testosterone and musth in captive male African and Asian elephants. *Zoo Biology* 9: 297-306
824. CRAIG, G.C. 1991. Present population and distribution of elephants in northern Botswana. *In:* HANCOCK, P. (ed.) *The Future of Botswana's Elephants.* Proceedings of Kalahari Conservation Society Symposium on Elephants held in Gabarone, Botswana, 10 November 1990.
825. CRISSEY, S.D., PAPAS, A. & PETRIC, A. 1992. *In:* SPITZ, F., JANEAU, G., GONZALEZ, G. & AULAGNIER, S. (eds.) Bioavailable forms of vitamin E for correcting a biochemical deficiency in captive

elephants. *"Ongules/Ungulates 91", Proceedings of the International Symposium,* Toulouse, France, September 2-6, 1991. pp. 163-166
826. CUMMING, D.H.M. 1981. The management of elephants and other large mammals in Zimbabwe. *In:* JEWEL, P.A. & HOLT, S. (eds.) *Problems in management of locally abundant mammals.* Academic Press, New York. 91-118
827. CUMMING, D.H.M. 1982. The influence of large herbivores on savanna structure in Africa. *In:* HUNTLEY, B.J. & WALKER, B.H. (eds.) *Ecology of tropical savannas.* Springer-Verlag, New York. 217-245
828. CUMMING, D.H.M. 1983. The decision-making framework with regard to the culling of large mammals in Zimbabwe. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 173-186
829. CUMMING, D.H.M., DU TOIT, R.F. & STUART, S.N. 1990. *African elephants and rhinos: status survey and conservation action plan.* IUCN, Gland, Switzerland
830. CUMMING, D.H.M. & JACKSON, P. (eds.) 1984. *The status and conservation of Africa's elephants and rhinos.* IUCN, Gland, Switzerland.
831. DALE, J. & HUSTLER, K. 1991. Oxpeckers use elephants in Hwange National Park. *Honeyguide* 37: 18
832. DAMIBA, T.E. 1991. *Size, impacts and managerial implications of the Nazinga Game Ranch elephant population in Burkina Faso, West Africa.* M.S. thesis, University of Idaho
833. DAMIBA, T.E. & ABLES, E.D. 1993. Promising future for an elephant population - a case study in Burkina Faso, West Africa. *Oryx* 27: 97-103
834. DAUTH, J., DREYER, M.J., RAUBENHEIMER, E.J., MARÉ, L.K. & DE VOS, V. 1987. Blood lead levels in African elephant in the Kruger National Park. *S. Afr. J. Wildl. Res.* 17: 134-135
835. DAVISON, E. 1966. *Wankie - the story of a great game reserve.* Books of Africa, Cape Town
836. DE BOER, W.F. & PRINS, H.H.T. 1990. Large herbivores that strive mightily but eat and drink as friends. *Oecologia (Berl.)* 82(2): 264-274
837. DEMPSEY, M. 1980. Scanning electron microscopy od the skin surface of elephant and hippopotamus. *Leder* 31:
838. DENNY, R.N. 1970. Body temperatures of some wild East African mammals. *E. Afr. Wildl. J.* 8: 212-216
839. DE VILLIERS, D.J. 1989. *Musth and reproduction in the African elephant* (Loxodonta africana). MSc thesis, University of Pretoria
840. DE VILLIERS, D.J., SKINNER, J.D. & HALL-MARTIN, A.J. 1989. Circulating progesterone concentrations and ovarian functional activity in the African elephant *(Loxodonta africana). J. Reprod. Fert.* 86: 195-201
841. DE VILLIERS, P.A. 1981. *Eto-ekologiese aspekte van olifante in die Nasionale Etoshawildtuin, SWA.* MSc thesis, University of the Orange Free State, Bloemfontein
842. DE VILLIERS, P.A. & KOK, P.B. 1988 Eto-ekologiese aspekte van olifante in die Nasionale Etoshawildtuin. *Madoqua* 15: 319-338
843. DE VILLIERS, P.A., PIETERSEN, E.W., HUGO, T.A., MEISSNER, H.H. & KOK, P.B. 1991. Methods of sampling food consumption by free-ranging elephant. *S. Afr. J. Wildl. Res.* 21: 23-27.
844. DEVOCHT, J. 1950. Overzichtelijke studie der huidige kennis van de Afrikaanse olifant. *Bull. Agric. Congo belge* 41: 442-462
845. DE VOS, V. 1978. Immobilisation of free-ranging wild animals using a new drug. *Vet. Rec.* 103: 64-68
846. DE VOS, V., BENGIS, R.C. & COETZEE, H.J. 1983. Population control of large mammals in the Kruger National Park. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 213-231
847. DE VOS, V. & HATTINGH, J. 1991. An evaluation of culling techniques for free-ranging African elephant *(Loxodonta africana). In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal.* Wildlife Group of the SAVA, Onderstepoort. pp 33-39
848. DINNIK, J.A., WALKER, J.B., BARNETT, S.F. & BROCKLESBY, D.W. 1963. Some parasites obtained from game animals in western Uganda. *Bull. epiz. Dis. Afr.* 11: 37-44
849. DiSILVESTRO, R.L. 1991. *The African elephant: twilight in eden.* John Wiley & Sons, New York.
850. DOMMISSE, E.J. 1951. The Knysna elephants - historical sketch of a world-famous herd. *Afr. Wildl.* 5: 195-199
851. DOTT, H.M. & SKINNER, J.D. 1989. Collection, examination and storage of spermatozoa from some South African mammals. *S. Afr. J. Zool.* 24: 151-160
852. DOUGLAS-HAMILTON, I. 1978. Known elephant numbers and distribution in Africa. *Elephant Newsletter* 1(2): 13-14
853. DOUGLAS-HAMILTON, I. 1978. Known elephant numbers and distribution in Africa: an updated map. *Elephant Newsletter* 1(3): 11
854. DOUGLAS-HAMILTON, I. 1979. Why resurrect the dead elephant issue? *Africana* 6: 100-101
855. DOUGLAS-HAMILTON, I. 1984. Trends in key African elephant populations. *Pachyderm* 4: 7-9
856. DOUGLAS-HAMILTON, I. 1984. Elephant and rhino population trends in Selous, Tanzania. *Pachyderm* 4: 18
857. DOUGLAS-HAMILTON, I. 1987. African elephants: population trends and their causes. *Oryx* 21: 11-24
858. DOUGLAS-HAMILTON, I. 1988. The great East African elephant disaster. *Swara* 11(2): 8-11

859. DOUGLAS-HAMILTON, I. 1988. The Lake Manyara elephants. *Swara* 11(2): 12
860. DOUGLAS-HAMILTON, I. & DOUGLAS-HAMILTON, O. 1992. *Battle for the elephants*. Viking, New York
861. DOUGLAS-HAMILTON, O. 1980. Africa's elephants - can they survive? *National Geographic Magazine* 158(5): 568-603
862. DRYSDALE, T.A. & FLORKIEWICZ, R.F. 1989. Electrophoretic variation within and between the two extant elephant species (Mammalia: Proboscidea). *J. Mammal.* 7): 381-383
863. DUBLIN, H.T. & DOUGLAS-HAMILTON, I. 1987. Status and trends of elephants in the Serengeti-Mara ecosystem. *Afr. J. Ecol.* 25: 19-33
864. DUBLIN, H.T., SINCLAIR, A.R.E. & McGLADE, J. 1990. Elephants and fire as causes of multiple stable states in the Serengeti-Mara woodlands. *J. Anim. Ecol.* 59(3): 1147-1164
865. DUDLEY, J.P., MENSAH-NTIAMOAH, A.Y. & KPELLE, D.G. 1992. Forest elephants in a rainforest fragment: preliminary findings from a wildlife conservation project in southern Ghana. *Afr. J. Ecol.* 30: 116-126
866. DUNHAM, K. 1990. Fruit production by *Acacia albida* trees in Zambesi riverine woodlands. *J. Trop. Ecol.* 6: 445-457
867. DUNHAM, K.M. 1988. Demographic changes in the Zambezi Valley elephants *(Loxodonta africana)*. *J. Zool., Lond.* 215: 382-388
868. DU PREEZ, J.S. & GROBLER, I.D. 1977. Drinking times and behaviour at waterholes of some game pecies in the Etosha National Park. *Madoqua* 10:61-69
869. DU TOIT, J.G. 1991. Behandeling van obstruksiekoliek in die Afrika-olifant *(Loxodonta africana)*. *South African Veterinary Medicine* 4(1): 3.
870. DU TOIT, J.G. 1991. The African elephant *(Loxodonta africana)* as a game-ranch animal. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 55-63
871. DU TOIT, J.G. & BENGIS, R. 1993. Accommodation of the African elephant *Loxodonta africana*. *In:* McKENZIE, A.A. (ed.) *The capture and care manual*. Wildlife Decision Support Services & South African Veterinary Foundation, Lynnwood Ridge. 498-504
872. DYCE, A.L. & MARSHALL, B.D. 1989. An early record of *Culicoides* species (Diptera: Ceratopogonidae) developing in the dung of game animals in southern africa. *Onderstepoort J. Vet. Res.* 56: 85-86
873. EALES, N.B. 1928. The anatomy of a foetal African elephant. III. The contents of the thorax and abdomen and the skeleton. *Transactions of the Royal Society of Edinburgh* 56: 203-246
874. EAST, R. 1984. Rainfall, soil nutrient status and biomass of large African savanna mammals. *Afr. J. Ecol.* 22: 245-270
875. EBEDES, H. 1977. Anthrax epizootics in Etosha National Park. *Madoqua* 10: 98-118.
876. EBEDES, H., VERNON, C. & GRUNDLING, I. 1991. Past, present and future distribution of elephants in southern Africa. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal*. Wildlife Group of the SAVA, Onderstepoort.
877. EDROMA, E.L. 1975. A count of large mammals in a Uganda national park. *Oryx* 13: 176-178
878. ELDER, W.H. & RODGERS, D.H. 1975. Body temperature in the African elephant as related to ambient temperature. *Mammalia* 39:3
879. FAIRALL, N. 1968. The reproductive seasons of some mammals in the Kruger National Park. *Zoologica Africana* 3: 189-210
880. FAY, J.M. 1991. An elephant *(Loxodonta africana)* survey using dung counts in the forests of the Central African Republic. *J. Trop. Ecol.* 7(1): 25-36
881. FAY, J.M. & AGNAGNA, M. 1991. A population survey of forest elephants *(Loxodonta africana cyclotis)* in Northern Congo. *Afr. J. Ecol.* 29: 177-187
882. FIELD, C.R. & LAWS, R.M. 1970. The distribution of the larger herbivores in Queen Elizabeth National Park, Uganda. *J. appl. Ecol.* 7: 273-294
883. FIELD, C.R. & ROSS, I.C. 1976. The savanna ecology of Kidepo Valley National Park. II. Feeding ecology of elephant and giraffe. *E. Afr. Wildl. J.* 14: 1-15
884. FISCHER, M.S. 1990. The unique ear of elephants and manatees (Mammalia): a phylogenetic paradox. *C. R. Acad. Sci.* Sr. III, Sci. Vie 311(4): 157-162
885. FITHIAN, C.L. & BRIGGS, M.B. 1990. Leukocyte counts in african elephants. *Am. Assoc. Zool. Parks Aquariums Reg. Conf. Proc.* 1990: 189-193
886. FOERNER, J.J., HOUCK, R.I., COPELAND, J.F., SCHMIDT, M.J., BYRON, H.T. & OLSEN, J.H. 1994. Surgical castration of the elephant (*Elephas maximus* and *Loxodonta africana*). *J. Zoo Wildl. Med.* 25: 355-359
887. FOOSE, T.L. 1982. *Tropic strategies of ruminant vs non-ruminant ungulates*. PhD thesis, University of Chicago.
888. FORMENTY, J.P., DOMENECH, J., LAUGINIE, F., QUATTARA, M., DIAWARE, S., RAATH, J.P., GROBLER, D., LEFORBAN, Y. & ANGBA, A. 1994. Epidemiological study of bluetongue in sheep, cattle and various animal species in the Côte d'Ivoire. *Rev. Sci. Tech. Off. Int. Epizoot.* 13(3): 737-751 (in French, with English summary)

889. FOSBROOKE, H.A. 1968. Elephants in the Serengeti National Park: an early record. *E. Afr. Wildl. J.* 6: 150-152
890. FOWLER, M. 1960. Scurvy in an elephant. *Cornell Veterinarian* 50: 171-176
891. FRISON, G.C. 1989. Experimental use of Clovis weaponry and toold on African elephants. *Am. Antiq.* 54(4): 766-784
892. GAINER, R.S. 1986. Tertiary dentine in the root of an elephant tusk. *J. Zoo Anim. Med.* 17: 69-72
893. GANHAO, M.F., HATTINGH, J., BRAACK, L.E.O., RAATH, J.P. & PITTS, N.I. 1989. Blood composition of wild animals during immobilization. *S. Afr. J. Sci.* 85: 281-282
894. GEORGIADIS, N., BISCHOF, L., TEMPLETON, A., PATTON, J., KARESH, W. & WESTERN, D. 1994. Structure and history of African elephant populations: I. Eastern and Southern Africa. *J. Hered.* 85(2): 100-104.
895. GLOVER, P.E. 1970. The Tsavo and the elephants. *Oryx* 10: 323-325
896. GLOVER, P.E. & SHELDRICK, D.L.W. 1964. An urgent research problem on the elephant and rhinoceros populations of the Tsavo National Park in Kenya. *Bull. epizoot. Dis. Afr.* 12: 33-38
897. GRAF, Z. & TUBOLY, S. 1982. In vitro cellular test for diagnosis of tuberculosis in monkeys and elephants in Budapest Zoological and Botanic Gardens. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zoo- und Wildtiere* 24: 225-233
898. GRAHAM-JONES, O. 1964. Restraint and anaesthesia of some captive wild mammals. *Vet. Rec.* 76: 1216-1228
899. GUY, P.R. 1975. The daily food intake of the African elephant, *Loxodonta africana* Blumenbach, in Rhodesia. *Arnoldia, Rhodesia* 7(26): 108.
900. GUY, P.R. 1976. The feeding behaviour of elephant in the Sengwa Area, Rhodesia. *S. Afr. J. Wildl. Res.* 6: 55-64
901. GUY, P.R. 1982. Baobabs and elephants. *Afr. J. Ecol.* 20: 215-220
902. GUY, P.R. 1989. The influence of elephants and fire on a *Brachystegia-Julbernardia* woodland in Zimbabwe. *J. Trop. Ecol.* 5(2): 215- 226
903. HALLAGAN, J.B. 1990. Effects of the regulation of the international ivory trade on African elephant conservation. *Trans. N. Am. Wildl. Nat. Resour. Conf.* 55: 423-433
904. HALL-MARTIN, A. 1980. Elephant survivors. *Oryx* 15: 355-362
905. HALL-MARTIN, A. 1984. Conservation and management of elephants in the Kruger National Park. *In:* CUMMING, D.H.M. & JACKSON, P. (eds.) *The status and conservation of Africa's elephants and rhinos.* IUCN, Gland, Switzerland. 104-108
906. HALL-MARTIN, A. 1991. Elephant conservation in the Kruger National Park, South Africa - from protection to management. *In:* HANCOCK, P. *The future of Botswana's elephants.* Kalahari Conservation Society & Dept of Wildlife and National Parks, Gaberone, Botswana.
907. HALL-MARTIN, A.J. 1992. Distribution and status of the African elephant *Loxodonta africana* in South Africa, 1652-1992. *Koedoe* 35: 65-88
908. HALL-MARTIN, A.J & VAN DER WALT, L.A. 1984. Plasma testosterone levels in relation to musth in the male African elephant. *Koedoe* 27: 147-149
909. HANCOCK, P. (ed.) 1991. *The future of Botswana's elephants*. Kalahari Conservation Society & Dept of Wildlife and National Parks, Gaberone, Botswana.
910. HANKS, J. 1967. The capture of young elephants in the Zambesi Valley. *Puku* 5: 87-90
911. HANKS, J. 1971. The elephant problem. *WWF Yearbook* 1970/71: 277-284
912. HANSEN, R.M., MUGAMBI, M.M. & BAUNI, S.M. 1985. Diets and trophic ranking of ungulates of the northern Serengeti. *J. Wildl. Mgmt* 49: 823-829
913. HARRINGTON, G.N. & ROSS, I.C. 1974. The savanna ecology of Kidepo Valley National Park. I. The effects of burning and browsing upon the vegetation. *E. Afr. Wildl. J.* 12: 93-105
914. HARTHOORN, A.M. 1966. The Tsavo elephants. *Oryx* 7: 233-236
915. HARTHOORN, A.M., LOCK, J.A. & LUCK, C.P. 1961. The handling and marking of wild African elephants *(Loxodonta africana)* with the use of the drug immobilizing technique: a preliminary report. *Br. Vet. J.* 117: 89-91
916. HARTHOORN, A.M. & LUCK, C.P. 1962. The handling and marking of wild African elephants *(Loxodonta africana)* with the use of the drug immobilizing technique: second preliminary report. *Br. Vet. J.* 118: 526-530
917. HARTHOORN, A.M. 1973. The drug immobilization of large wild herbivores other than the antelopes. *In:* YOUNG, E. (ed.) *The capture and care of wild animals.* Cape Town: Human & Rousseau
918. HATTINGH, J. 1986. Physiological measurement of stress. *S. Afr. J. Sci.* 82: 612-614
919. HATTINGH, J., KNOX, C.M. & RAATH, J.P. 1994. Arterial blood pressure of the African elephant *(Loxodonta africana)* under etorphine anaesthesia and after remobilisation with diprenorphine. *Vet. Rec.* 135: 458-459
920. HATTINGH, J., KNOX, C.M., RAATH, J.P. & KEET, D.F. 1994. Arterial blood pressure in anaesthetised African elephants. *S. Afr. J. Wildl. Res.* 24: 15-17

921. HATTINGH, J., PITTS, N.I., GANHAO, M.F., MOYES, D.G. & DE VOS, V. 1990. Blood constituent responses of animals culled with succinyldicholine and hexamethonium. *Jl S. Afr. Vet. Ass.* 61: 117-118
922. HATTINGH, J., PITTS, N.I., DE VOS, V., MOYES, D.G. & GANHAO, M.F. 1991. The response of animals to suxamethonium (succinyldicholine) and succinylmonocholine. *Jl S. Afr. vet. Ass.* 62: 126-129
923. HATTINGH, J., WRIGHT, P.G., DE VOS, V., GANHAO, M.F., SILOVE, M., KNOX, C., RITCHIE, A.L., BARNOY, J., CORNELIUS, S.T. & FONSECA, F. 1985. Cessation of electroencephalographic activity in animals exposed to a lethal dose of succinyldicholine. *S. Afr. J. Zool.* 20: 123-128
924. HAYNES, G. 1991. *Mammoths, mastodonts, and elephants: biology, behavior, and the fossil record.* Cambridge Univ. Press, New York.
925. HEDGER, R.S., CONDY, J.B. & GOLDING, S.M. 1972. Infection of some species of African wild life with foot-and-mouth disease virus. *J. Com. Path.* 82: 455-461
926. HEFFNER, R., HEFFNER, H. & STICHMAN, N. 1982. Role of elephant pinna in sound location. *Anim. Behav.* 30: 628-630
927. HEISTERMANN, M., VAN AARDE, R.J. & HODGES, J.K. 1993. Progestin biosynthesis by the African elephant corpus luteum. *J. Reprod. Fert. Abstr. Ser.* 11: 11
928. HENSHAW, J. 1972. Notes on conflict between elephants and some bovids and other inter-specific contacts in Yankari Game Reserve, N.E. Nigeria. *E. Afr. Wildl. J.* 10: 151-153
929. HENWOOD, R.R. 1991. Construction of elephant bomas. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 44-47
930. HILL, F.W.G. & SMITH, D.A. 1990. Clinical chemistry values for free-ranging elephants *(Loxodonta africana)* in Hwange National Park, Zimbabwe. *Zimb. Vet. J.* 21: 33-42
931. HIRST, S.M. 1969. Road-strip techniques for wild ungulates in African woodland. *J. Wildl. Mgmt* 33: 40-48
932. HIRST, S.M. 1970. Ungulate-habitat relationships in a South African woodland-savanna ecosystem. *Wildl. Monogr.* 44: 1-106
933. HOARE, R.F. 1992. Present and future use of fencing in the management of larger African mammals. *Environmental Conservation* 19(2): 160-164
934. HOFFMAN, M.T. 1993. Major P.J. Pretorius and the decimation of the Addo elephant herd in 1919-1920: important reassessments. *Koedoe* 36(2): 23-44
935. HONEYMAN, V.L., PETTIFER, G.L. & DYSON, D.H. 1992. Arterial blood pressure and blood gas values in normal standing and laterally recumbent African *(Loxodonta africana)* and Asian *(Elephas maximus)* elephants. *J. Zoo Wildl. Med.* 23: 205-210
936. HOWARD, D.A. 1964. The copper content of the liver of some game animals in Kenya. *E. Afr. Wildl. J.* 2: 47-50
937. HUXLEY, C.R. 1984. CITES activities in relation to the ivory and rhino trade. *In:* CUMMING, D.H.M. & JACKSON, P. (eds.) *The status and conservation of Africa's elephants and rhinos.* IUCN, Gland, Switzerland. 159-163
938. JACHMANN, H. 1980. Population dynamics of the elephants in the Kasungu National Park, Malawi. *Neth. J. Zool.* 30: 622-634
939. JACHMANN, H. 1983. Spatial organization of Kasungu's elephants. *Bijdragen tot de Dierkunde* 53: 179-186
940. JACHMANN, H. 1985. Estimating age in African elephants. *Afr. J. Ecol.* 23: 199-202
941. JACHMANN, H. 1986. Notes on the population dynamics of the Kasungu elephants. *Afr. J. Ecol.* 24: 215-226
942. JACHMANN, H. 1987. Elephants and woodlands II. *Pachyderm* 8: 11-12
943. JACHMANN, H. 1991. Evaluation of four survey methods for estimating elephant densities. *Afr. J. Ecol.* 29: 188-195
944. JACHMANN, H. & BELL, R.H.V. 1984. The use of elephant droppings in assessing numbers, occupance and age structure: a refinement of the methods. *Afr. J. Ecol.* 22: 127-141
945. JACHMANN, H. & CROES, T. 1991. Effects of browsing by elephants on the *Combretum/Terminalia* woodland at the Nazinga Game Ranch, Burkina Faso, West Africa. *Biol. Conserv.* 57: 13-24
946. JACHMANN, H. & CROES, T. 1991. Effects of browsing by elephants on *Combretum-Terminalia* woodland. *Environ. Conserv.* 18(2): 168-171
947. JACOBSON, E.R., HEARD, D.J., CALIGIURI, R. & KOLLIAS, G.V. 1987. Physiologic effects of etorphine and carfentanil in African elephants. *Proceedings of the First International Conference on Zoological and Avian Medicine* 525-527
948. JARMAN, P.J 1971. Diets of large mammals in the woodlands around Lake Kariba, Rhodesia. *Oecologia (Berlin)* 8: 157-178.
949. JORDAN, W. 1964. An outbreak of acute disease in Chester Zoo diagnosed as anthrax. *Veterinary Record* 76: 927-930
950. JOUBERT, E. & MOSTERT, P.K.N. 1975. Distribution patterns and status of some mammals in South West Africa. *Madoqua* 9: 5-44

951. KABIGUMILA, J. 1993. Diurnal activity of elephants in Ngorongoro Crater, Tanzania. *Afr. J. Ecol.* 31: 75-80.
952. KABIGUMILA, J. 1993. Feeding habits of elephants in Ngorongoro Crater, Tanzania. *Afr. J. Ecol.* 31: 156-164
953. KALMERA, M.C. 1989. Observations on feeding preference of elephants in the *Acacia tortilis* woodland of Lake Manyara National Park, Tanzania. *Afr. J. Ecol.* 27: 325-333
954. KAYANJA, F.I.B. 1990. Problems associated with wildlife management in the third world. *Trans. Congr. Int. Union Game Biol.* 19(2): 615-620
955. KEET. D.F. 1991. An approach to the autopsy of the African elephant. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 95-104
956. KELLER, P., RUEDI, D. & GUTZWILLER, A. 1985. Tissue distribution of diagnostically useful enzymes in zoo animals: a comparative study. *Journal of Zoo Animal Medicine* 16: 28-45
957. KLINGELHOEFFER, E.W. 1987. *Aspects of the ecology of the elephant* Loxodonta africana *and a management plan for the Tembe Elephant Reserve in Tongaland, KwaZulu.* MSc thesis, University of Pretoria
958. KOCK, M.D., MARTIN, R.B. & KOCK, N. 1993. Chemical immobilization of free-ranging African elephants *(Loxodonta africana)* in Zimbabwe, using etorphine (M99) mixed with hyaluronidase, and evaluation of biological data collected soon after immobilization. *J. Zoo Wildl. Med.* 24: 1-10
959. KOCK, N.D., GOEDEGEBUURE, S.A., LANE, E.P., LUCKE, D.T. & KOCK, M.D. 1994. Flaccid trunk paralysis in free-ranging elephants *(Loxodonta africana)* in Zimbabwe. *J. Wildl. Dis.* 30: 432-435
960. KOEN, J.H. 1988. Trace elements and some other nutrients in the diet of the Knysna elephants. *S. Afr. J. Wildl. Res.* 18: 109-110.
961. KOEN, J.H., HALL-MARTIN, A.J. & ERASMUS, T. 1988. Macro nutrients in plants available to the Knysna, Addo and Kruger National Park elephants. *S. Afr. J. Sci.* 18: 69-71
962. KOMBE, A. 1983. Government and public reactions to culling in conservation areas in Malawi. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 241-247
963. KOTZÉ, S.H. & COETZEE, H.L. 1994. A histochemical study of mucus glycoproteins or mucins in the intestinal tract of the African elephant *(Loxodonta africana). Onderstepoort J. vet. Res.* 61: 177-181
964. KRAMER, B., & TEIXEIRA, M. 1991. The histology of the adrenal gland of the African elephant, *Loxodonta africana. S. Afr. J. Zool.* 26: 193-198
965. KURT, F. 1974. Remarks on the social structure and ecology of the Ceylon elephant in the Yala National Park. *In:* GEIST, V. & WALTHER, F. (eds.) *The behavior of ungulates and its relation to management. IUCN Publications new series* 24: 618-634
966. LAMBRECHTS, A. von W. 1974. The numerical status of sixteen game species in the Transvaal, excluding the Kruger National Park. *Jl S. Afr. Wildl. Mgmt Ass.* 4: 95-102
967. LAMPREY, H.F. 1963. Ecological separation of the large mammal species in the Tarangire Game Reserve, Tanganyika. *E. Afr. Wild. J.* 1: 63-92
968. LAMPREY, H.F. 1964. Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. *E. Afr. Wild. J.* 2: 1-46
969. LAMPREY, H.F., HALEVY, G. & MAKACHA, S. 1974. Interactions between *Acacia*, bruchid seed beetles and large herbivores. *E. Afr. Wildl. J.* 12: 81-85
970. LANG, E.M. 1965. Zahnbeobachtungen bei Elefanten (Tooth observations in elephants). *Z. Säugetierk.* 30: 287-297
971. LANGBAUER, W.R.Jr., CHARIF, R.A., PAYNE, K.B. & MARTIN, R.B. 1991. Movements of African elephants as observed by radio telemetry. *Am. Zool.* 31(5): 98A (abstract only)
972. LANGBAUER, W.R.Jr., PAYNE, K.B., CHARIF, R.A. & THOMAS, E.M. 1989. Responses of captive African elephants to playback low-frequency calls. *Can. J. Zool.* 67: 2604-2607
973. LANGBAUER, W.R.Jr., PAYNE, K.B., CHARIF, R.A., RAPAPORT, L. & OSBORN, F. 1991. African elephants respond to distant playbacks of low-frequency conspecific calls. *J. Exp. Biol.* 157: 35-46
974. LANGUILLON, J. 1957. Note sur deux parasites sanguicoles de mammiferes du Cameroun. *Bull. Soc. Path. exot.* 50: 362-363
975. LAWS, R.M. 1971. The Tsavo elephants. *Oryx* 11(1): 32-34
976. LAWS, R.M. 1974. Behaviour, dynamics and management of elephant populations. *In:* GEIST, V. & WALTHER, F. (eds.) *The behavior of ungulates and its relation to management. IUCN Publications new series* 24: 513-529.
977. LEADER-WILLIAMS, N. 1990. Allocation of resources for conserving African pachyderms. *Trans. Congr. Int. Union Game Biol.* 19(2): 633-639
978. LEADER-WILLIAMS, N. 1990. Black rhinos and African elephants: lessons for conservation funding. *Oryx* 24: 23-29
979. LEADER-WILLIAMS, N., ALBON, S.D. & BERRY, P.S.M. 1990. Illegal exploitation of black rhinoceros and elephant populations: patterns of decline, law enforcement and patrol effort in Luangwa Valley, Zambia. *J. appl. Ecol.* 27: 1055-1087

980. LEADER-WILLIAMS, N. & MILNER-GULLAND, E.J. 1993. Policies for the enforcement of wildlife laws: the balance between detection and penalties in Luangwa Valley, Zambia. *Conserv. Biol.* 7(3): 611-617.
981. LEGEMAAT, W. & DE BIE, W. 1990. Ungulate carrying capacity research at the Nazinga Game Ranch, Burkina Faso. *Trans. Congr. Int. Union Game Biol.* 19(2): 627-632
982. LEUTHOLD, W. 1977. Changes in tree populations of Tsavo East National Park, Kenya. *E. Afr. Wildl. J.* 15: 61-69
983. LEUTHOLD, W. & LEUTHOLD, B.M. 1976. Density and biomass of ungulates in Tsavo East National Park, Kenya. *E. Afr. Wildl. J.* 14: 49-58
984. LEWIS, D.M. 1984. Demographic changes in the Luangwa Valley elephants. *Biol. Cons.* 29: 7-14
985. LEWIS, D.M. 1986. Disturbance effects on elephant feeding: evidence for compression in Luangwa Valley, Zambia. *Afr. J. Ecol.* 24: 227-241
986. LEWIS, D.M. 1987. Elephant response to early burning in mopane woodland, Zambia. *S. Afr. J. Wildl. Res.* 17: 33-40
987. LEWIS, D.M. 1987. Fruiting patterns, seed germination, and distribution of *Sclerocarya caffra* in an elephant-inhabited woodland. *Biotropica* 19: 50-56
988. LEWIS, D.M. 1991. Observations of tree growth, woodland structure and elephant damage on *Colophospermum mopane* in Luangwa Valley, Zambia. *Afr. J. Ecol.* 29: 207-221
989. LINDEQUE, M. 1988. *Population dynamics of elephants in Etosha National Park, SWA/Namibia.* PhD thesis, University of Stellenbosch.
990. LINDEQUE, M. 1991. Dentition and age estimation of elephants in the Etosha National Park, Namibia. *Madoqua* 18: 17-25
991. LINDEQUE, M. 1991. Age structure of the elephant population in the Etosha National Park, Namibia. *Madoqua* 18: 27-32
992. LINDEQUE, M. & LINDEQUE, P.M. 1991. Satellite tracking of elephants in north-western Namibia. *Afr. J. Ecol.* 29: 196-206
993. LINDEQUE, M. & VAN JAARSVELD, A.S. 1993. Post-natal growth of elephants *Loxodonta africana* in Etosha National Park, Namibia. *J. Zool., Lond.* 229: 319-330
994. LINDSAY, K. 1986. Elephants and woodlands - what are the issues? *Pachyderm* 7: 16-17
995. LLOYD, M., GODDARD, M., ZEINOWICZ, R. & HARPER, J.S. 1993. One approach to the removal of an aural rhabdomyoma in a 7 year old African elephant *(Loxodonta africana)*. *Proc. Am. Essoc. Zoo Vet.* 1993: 115-119
996. LOCK, J.M. 1977. Preliminary results from fire and elephant exclusion plots in Kabalega National Park, Uganda. *E. Afr. Wildl. J.* 15: 229-232
997. LOCK, J.M. 1993. Vegetation change in Queen Elizabeth National Park, Uganda: 1970-1988. *Afr. J. Ecol.* 31: 106-117
998. LODWICK, L.J., DUBACH, J.M., PHILLIPS, L.G., BROWN, C.S. & JANDRESKI, M.A. 1994. Pharmacokinetics of amikacin in African elephants *(Loxodonta africana)*. *J. Zoo Wildl. Med.* 22: 49-57
999. LOWIS, R. 1991. Copography in African elephants. *E. Afr. Nat. Hist. Soc. Bull.* 21(1): 11-12 Knysna
1000. MACKAY, M. 1983. *The Knysna elephants and their forest home.* Eastern Cape Branch of the Wildlife Society, Knysna
1001. MacPHERSON, D., HARDY, M.B. & HURT, C.R. 1994. The impact of elephant on miombo woodland in the Kasungu National Park, Malawi. *Bull. Grassl. Soc. South. Afr.* 5(1) :51-52
1002. MAINKA, S.A., COOPER, R.M., BLACK, S.R. & DIERENFELD, E.S. 1994. Asian elephant *(Elephas maximus)* milk composition during the first 280 days of lactation. *Zoo Biology* 13: 389-393
1003. MAINKA, S.A. & LOTHROP, C.D. 1990. Reproductive and hormonal changes during the estrus cycle and pregnancy in Asian elephants *(Elephas maximus)*. *Zoo Biology* 9: 411-419
1004. MALAN, J.W. & VAN WYK, A.E. 1993. Bark structure and preferential bark utilization by the African elephant. *IAWA Journal* 14(2): 173-185
1005. MALPAS, R.C. 1980. Elephant losses in Uganda - and some gains. *Oryx* 16: 41-44
1006. MAREK, P., MAGANGA, F. & ABIKIRI, R. 1973. A survey of the incidence of Salmonella in northern Tanzania. *Ind. J. Anim. Sci.* 43: 632-638
1007. MARIAPPA, D. 1986. *Anatomy and histology of the Indian elephant.* Indira Publishing House, Michigan.
1008. MARTIN, E.B. 1984. Zimbabwe's ivory carving industry. *Traffic Bulletin* 6(2): 33-38
1009. MARTIN, E.B. 1985. Malawi's ivory carving industry. *Pachyderm* 5: 6-11
1010. MARTIN, E.B. 1986. The ivory carving industry of Zambia. *Pachyderm* 7: 12-15
1011. MARTIN, R.B. 1978. Aspects of elephant social organization. *Rhodesia Science News* 12(8): 184-187
1012. MARTIN, R.B. 1991. Culling: the Zimbabwe experience. *In:* HANCOCK, P. (ed.) *The future of Botswana's elephants.* Kalahari Conservation Society & Dept of Wildlife and National Parks, Gaberone, Botswana.
1013. MARTIN, R.B. & CONYBEARE, A.M.G. 1992. *Elephant management in Zimbabwe* (2nd ed.) Dept of National Parks & Wild Life Management, Harare.
1014. McCULLY, R.M., BASSON, P.A., PIENAAR, J.S., ERASMUS, B., YOUNG, E. & PIETERSE, L.M. 1969. Herpes lesions in elephants. *Jl S. Afr. vet. med. Ass.* 40: 422

1015. McFARLANE, J.R., CARERA, C.M., OOSTHUIZEN, M.J. & PAPKOFF, H. 1990. Elephant pituitary gonadotropins. *Gen. Comp. Endocrinol.* 79(2): 193-200
1016. McGAUGHEY, C. 1950. Ulcerative stomatitis in an elephant, suspected have been caused by acetic acid. *Vet. Rec.* 62: 813-814
1017. McKAY, M. & EISENBERG, J.F. 1974. Movement patterns and habitat utilization of ungulates in Ceylon. *In:* GEIST, V. & WALTHER, F. (eds.) *The behavior of ungulates and its relation to management. IUCN Publications new series* 24: 708-721
1018. McKNIGHT, B.L. 1992. Birth of an African elephant in Tsavo East National Park, Kenya. *Afr. J. Ecol.* 30: 87-89
1019. McSHANE, T.O. 1987. Elephant-fire relationships in *Combretum/Terminalia* woodland in south-west Niger. *Afr. J. Ecol.* 25: 91-97
1020. MEEHAN, T.P. 1991. The captive management of elephants. *Annual Proc. Am. Assoc. Zoo Vet.* 1991: 65-68
1021. MEISSNER, H.H. 1982. Theory and application of a method to calculate forage intake of wild southern African ungulates for purposes of estimating carrying capacity. *S. Afr. J. Wildl. Res.* 12: 41-47
1022. MEISSNER, H.H. 1991. Applied aspects of digestive physiology of elephants. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 87-94
1023. MEISSNER, H.H., SPREETH, E.B., DE VILLIERS, P.A., PIETERSEN, E.W., HUGO, T.A. & TERBLANCHE, B.F. 1990. Quality of food and voluntary intake by elephant as measured by lignin index. *S. Afr. J. Wildl. Res.* 20: 104-110
1024. MEISWINKEL, R. 1987. Afrotropical *Culicoides:* A redescription of *C. (Avaritia) kanagai* Khamala & Kettle, 1971, reared from elephant dung in the Kruger National Park, South Africa. *Onderstepoort J. vet. Res.* 54: 585-590
1025. MEISWINKEL, R. 1992. Afrotropical *Culicoides: C. (Avaritia) loxodontis* sp. nov., a new member of the Imicola group (Diptera: Ceratopogonodae) associated with the African elephant in the Kruger National Park. *Onderstepoort J. vet. Res.* 59: 145-160
1026. MELTZER, D.G.A. 1991. The diagnosis of diseases in elephants *(Loxodonta africana). In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 79-86
1027. MENTIS, M.T. 1974. Distribution of some wild animals in Natal. *Lammergeyer* 20: 1-68
1028. MENTIS, M.T. 1977. Stocking rates and carrying capacities for ungulates on African rangelands. *S. Afr. J. Wildl. Res.* 7: 89-98.
1029. MENTIS, M.T., COLLINSON, R.F.H. & WRIGHT, M.G. 1978. Legal harvests of protected game in Natal, 1973-1976. *Lammergeyer* 24: 13-18
1030. MERTZ, G. 1986. Counting elephants *(Loxodonta africana)* in the tropical rain forests with particular reference to the Tai National Park, Ivory Coast. *Afr. J. Ecol.* 24: 61-68
1031. MERTZ, G. 1986. Movement patterns and group size of the African forest elephant *Loxodonta africana cyclotis* in the Tai National Park, Ivory Coast. *Afr. J. Ecol.* 24: 133-136
1032. MIDGLEY, J.J. & JOUBERT, D. 1991. Mistletoes, their host plants and the effects of browsing by large mammals in Addo Elephant National Park. *Koedoe* 34(2): 149-152
1033. MILNER-GULLAND, E.J. & LEADER-WILLIAMS, N. 1992. A model of incentives for the illegal exploitation of black rhinos and elephants: poaching pays in Luangwa Valley, Zambia. *J. appl. Ecol.* 29: 388-401
1034. MILNER-GULLAND, E. & MACE, R. 1991. The impact of the ivory trade on the African elephant *Loxodonta africana* population as assessed by data from the trade. *Biol. Cons.* 55: 215-229
1035. MILNER-GULLAND, E.J. & BEDDINGTON, J.R. 1993. The exploitation of elephants for the ivory trade: an historical perspective. *Proc. R. Soc. Lond. B Biol. Sci.* 252(1333): 29-37
1036. MITCHELL, B.L. 1963. A possible visual signal by elephant. *Puku* 1: 217
1037. MOORE, R.J. 1991. Can the African elephant earn its keep? *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 70-72
1038. MOORE, R.J. & MUNNION, C. 1989. *Back to Africa.* Southern Books, Johannesburg
1039. MORRIS, P.J., HELD, J.P. & JENSEN, J.M. 1987. Clinical pathologic features of chronic renal failure in an African elephant *(Loxodonta africana). Proceedings of the First International Conference on Zoological and Avian Medicine* 468-472
1040. MOSS, C. 1975. *Portraits in the wild: animal behaviour in East Africa.* Hamish Hamilton, London.
1041. MPHANDE, J.N.B. 1990. *Browsing strategies of the African elephant in a coppice Brachystegia woodland: Kasungu National Park, Malawi.* M.S. thesis, Frostburg State University
1042. MULDER, P.F.S. 1991. The African elephant: legislation and management. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal.* Wildlife Group of the SAVA, Onderstepoort. pp 29-32

1043. MULLER, M. & RYTZ, U. 1989. Dermatomycosis in two African elephants *(Loxodonta africana)*. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zoo- und Wildtiere* 31: 207-209 (in German; English summary)
1044. MUSHI, E.Z., HILL, F.W.G., DAWE, P. & RIESS, R. 1990. Antibodies to bluetongue and African horse sickness viruses in the sera of elephants in Zimbabwe. *Bull. Anim. Health Prod. Afr.* 38: 475.
1045. MWALYOSI, R.B.B. 1977. A count of large mammals in Lake Manyara National Park. *E. Afr. Wildl. J.* 15: 333-335
1046. MWALYOSI, R.B.B. 1987. Decline of *Acacia tortilis* in Lake Manyara National Park, Tanzania. *Afr. J. Ecol.* 25: 51-53
1047. NICHOLSON, B.D. 1968. Observations on the elephant problem in south-east Tanganyika. *E. Afr. Agric. For. J.* 33: 217-220
1048. NORTON-GRIFFITHS, M. 1974. The numbers and distribution of large mammals in Ruaha National Park, Tanzania. *E. Afr. Wild. J.* 13: 121-140
1049. NOVELLIE, P. 1988. The impact of large herbivores on the grassveld of the Addo Elephant National Park. *S. Afr. J. Wildl. Res.* 18: 6-10
1050. NOVELLIE, P., HALL-MARTIN, A.J. & JOUBERT, D. 1991. The problem of maintaining large herbivores in small conservation areas: deterioration of the grassveld in the Addo Elephant National Park. *Koedoe* 34(1): 41-50
1051. NUMMELIN, M. 1990. Relative habitat use of duikers, bush pigs, and elephants in virgin and selectively logged areas of the Kibale Forest, Uganda. *Trop. Zool.* 3(2): 111-120
1052. OKEWOLE, P.A., OYETUNDE, I.L., IROKANULO, E.A., CHIMA, J.C., NWANKPA, N., LALEYE, Y. & BOT, C. 1993. Anthrax and cowdriosis in an African elephant *(Loxodonta africana)*. *Vet. Rec.* 133(7): 168.
1053. OLINDO, P.M, DOUGLAS-HAMILTON, I. & HAMILTON, P. 1988. The 1988 Tsavo elephant count. *Swara* 11(3): 23-24
1054. OLSEN, J.H., CHEN, C-L., BOULES, M.M., MORRIS, L.C. & COVILLE, B.R. 1994. Determination of reproductive cyclicity and pregnancy in Asian elephants *(Elephas maximus)* by rapid radioimmunoassay of serum progesterone. *J. Zoo Wildl. Med.* 25: 349-354
1055. OSTERHOFF, D.R., PETRIE, I.A. & YOUNG, E. 1972. Haemoglobins in wild animals. *Jl S. Afr. vet. med. Ass.* 43: 361-362
1056. OSTERHOFF, D.R., SCHOEMAN, S., OP'T HOF, J. & YOUNG, E. 1974. Genetic differentiation of the African elephant in the Kruger National Park. *S. Afr. J. Sci.* 70: 245-247
1057. OTTICHILO, W.K. 1986. Age structure of elephants in Tsavo National Park, Kenya. *Afr. J. Ecol.* 24: 69-75
1058. OTTICHILO, W.K., KUFWAFWA, J.W. & STELFOX, J.G. 1987. Elephant population trends in Kenya: 1977-1981. *Afr. J. Ecol.* 25: 9-18
1059. OWEN-SMITH, N. 1988. *Megaherbivores: The influence of very large body size on ecology.* Cambridge University Press, Cambridge.
1060. PAGE, C.D., MAUTINO, M. DERENDORF, D. & ANHALT, J.P. 1991. Comparative pharmacokinetics of trimethoprim-sulfamethoxazole administered intravenously and orally to captive elephants. *J. Zoo Wildl. Med.* 22: 409-416
1061. PAPAS, A.M., CAMBRE, R.C., CITINO, S.B. & SOKOC, R.J. 1991. Efficacy of absorption of various vitamin E forms by captive elephants and black rhinoceroses. *J. Zoo Wildl. Med.* 22: 309-317
1062. PARKER, I.S.C. 1984. A report on the raw ivory trade. *In:* CUMMING, D.H.M. & JACKSON, P. (eds.) *The status and conservation of Africa's elephants and rhinos*. IUCN, Gland, Switzerland. 144-148.
1063. PARKER, I.S.C. 1984. Rainfall, geology, elephants and men. *The extinction alternative*. Endangered Wildlife Trust, Johannesburg. 133-177
1064. PARKER, I.S.C. & GRAHAM, A.D. 1989. Men, elephants and competition. *Symp. zool. Soc. Lond.* 61: 241-252
1065. PARKER, I.S.C. & GRAHAM, A.D. 1989. Elephant decline (part 1). Downward trends in African elephant distribution and numbers. *Int. J. Environ. Stud.* 34: 287-305
1066. PARKER, I.S.C. & GRAHAM, A.D. 1989. Elephant decline: downward trends in African elephant distribution and numbers (part 2). *Int. J. Environ. Stud.* 35(1/2): 13-26
1067. PARKER, I.S.C. & MARTIN, E.B. 1983. How many elephants are killed for the ivory trade? *Oryx* 16: 235-239
1068. PARKER, I.S.C. & MARTIN, E.B. 1983. Further insights into the international ivory trade *Oryx* 17: 194-200
1069. PAYNE, K., LANGBAUER, W.R. Jr. & THOMAS, E. 1986. Infrasonic calls of the Asian elephant *(Elephas maximus)*. *Behav. Ecol. Sociobiol.* 18: 297-301
1070. PAYNE, K. 1989. Elephant talk. *National Geographic Magazine* 176(2): 264-277
1071. PELLEW, R.A. 1983. Modelling and systems approach to management problems: the *Acacia*/elephant problem in the Serengeti. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria. 93-114
1072. PETRIDES, G.A. & SWANK, W.G. 1966. Estimating the productivity and energy relations of an African elephant population. *Proc. IX Int. Grasslands Congr., Sao Paolo, Brazil, January 1965* pp. 831-842

1073. PHILLIPS, J.F.V. 1925. The Knysna elephant: a brief note on their history and habits. *S. Afr. J. Sci.* 22: 287-293
1074. PHILLIPS, P.K. & HEATH, J.E. 1992. Heat exchange by the pinnae of the African elephant *(Loxodonta africana)*. *Comp. Biochem. Physiol. A. Comp. Physiol.* 101(4): 693-699
1075. PHILLIPSON, J. 1975. Rainfall, primary production and 'carrying capacity' of Tsavo National Park (East), Kenya. *E. Afr. Wildl. J.* 13: 171-201
1076. PIENAAR, U. de V. 1961. A second outbreak of anthrax amongst game animals in the Kruger National Park, 5th June to 11th October 1960. *Koedoe* 4: 4-17.
1077. PIENAAR, U. de V. 1963. The large mammals of the Kruger National Park - their distribution and present-day status. *Koedoe* 6: 1-37
1078. PIENAAR, U. de V. 1968. Recent advances in field immobilization and restraint of wild ungulates in South African national parks. *Acta Zool. Path. Antverpiensia* 46: 17-38
1079. PIENAAR, U. de V. 1969. Predator-prey relationships amongst the larger mammals of the Kruger National Park. *Koedoe* 12: 108-176
1080. PIENAAR, U. de V. 1970. A lasting method for the marking and identification of elephant. *Koedoe* 13: 123-126
1081. PIENAAR, U. de V. 1983. Management by intervention: the pragmatic/economic option. *In:* OWEN-SMITH, R.N. (ed.) *Management of large mammals in African conservation areas.* HAUM, Pretoria.
1082. PIENAAR, U. de V. & VAN NIEKERK, J.W. 1963. Elephant control in national parks - a new approach. *Oryx* 7: 35-38
1083. PILASKI, J., KULKA, D. & NEUSCHULZ, N. 1992. An outbreak of pox in African elephants *(Loxodonta africana)* in Thuringer Zoopark Erfurt. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen Zoo- und Wildtiere* 34: 111-118 (in German)
1084. PILASKI, J., ROSEN, A. & DARAI, G. 1986. Comparative analysis of the genomes of orthopoxviruses isolated from elephant, rhinoceros, and okapi by restriction enzymes. *Archives of Virology* 88: 135-142
1085. PILGRAM, T. & WESTERN, D. 1986. Inferring hunting patterns on African elephants from tusks in the international ivory trade. *J. appl. Ecol.* 23: 503-514
1086. PILGRAM, T. & WESTERN, D. 1986. Managing African elephants for ivory production through ivory trade regulations. *J. appl. Ecol.* 23: 515-529
1087. PLOTKA, E.D., SEAL, U.S., ZAREMBKA, F.R., SIMMONS, L.G., TEARE, A., PHILLIPS, L.G., HINSHAW, K.C. & WOOD, D.G. 1988. Ovarian function in the elephant: luteinizing hormone and progesterone cycles in African and Asian elephants. *Biol. Reprod.* 38: 309-314
1088. PLUMPTREE, A.J. 1994. The effects of trampling damage by herbivores on the vegetation of the Parc National des Volcans, Rwanda. *Afr. J. Ecol.* 32: 115-129
1089. POOLE, J.H. 1989. Announcing intent: the aggressive state of musth in African elephants. *Animal Behaviour* 37: 140-152
1090. POOLE, J.H. 1989. Mate guarding, reproductive success and female choice in African elephants. *Animal Behaviour* 37: 842-949
1091. POOLE, J.H. 1987. Rutting behaviour in African elephants: the phenomenon of musth. *Behaviour* 102: 283-316
1092. POOLE, J.H., PAYNE, K., LANGBAUER, W.R. Jr & MOSS, C. 1988. The social context of some very low frequency calls of African elephants. *Behav. Ecol. Sociobiol.* 22: 385-392
1093. POOLE, J.H. & THOMSEN, J. 1989. Elephants are not beetles - implications of the ivory trade for the survival of the African elephant. *Oryx* 23: 188-198
1094. PRINS, H.H.T. & DOUGLAS-HAMILTON, I. 1990. Stability in a multi-species assemblage of large herbivores in East Africa. *Oecologia (Heidelb.)* 83(3): 392-400
1095. PRINS, H.H.T. & VAN DER JEUGD, H.P. 1993. Herbivore population crashes and woodland structure in East Africa. *J. Ecol.* 81: 305-314
1096. PROKOPIC, J., HULINSKA, d. & ZAHOR, z. 1984. A nematode found in African elephant *(Loxodonta africana)* from Zoological Gardens in Algiers. *Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zoo- und Wildtiere* 26: 198
1097. RAATH, J.P. 1993. Chemical capture of the African elephant. *In:* McKENZIE, A.A. (ed.) *The capture and care manual.* Wildlife Decision Support Services & South African Veterinary Foundation, Lynnwood Ridge. 484-493.
1098. RAATH, J.P. 1993. Transportation of the African elephant. *In:* McKENZIE, A.A. (ed.) *The capture and care manual.* Wildlife Decision Support Services & South African Veterinary Foundation, Lynnwood Ridge. 493-498.
1099. RAPHAEL, B.L. & CLUBB, F.J. 1985. Atypical salmonellosis in an African elephant. *Proc. Annual Meeting Am. Assoc. Zoo Vet.* 7-10
1100. RASMUSSEN, L.E., BUSS, I.O., HESS, D.L. & SCHMIDT, M.J. 1990. Testosterone and dihydrotestosterone concentrations in elephant serum and temporal gland secretaions. *Biol. Reprod.* 30: 352-363

1101. RAUBENHEIMER, E.J., DAUTH, J., DREYER, M.J., SMITH, P.D. & TURNER, M.L. 1990. Structure and composition of ivory of the African elephant *(Loxodonta africana)*. *S. Afr. J. Sci.* 86: 192-193
1102. RAUBENHEIMER, E.J., OSBORN, J., DAUTH, J., VAN NIEKERK, J., LEMMER, L.B. & DE VOS, V. 1989. Structure of the tusk of the African elephant *Loxodonta africana*. *J. Dent. Res.* 68: 730
1103. RAUBENHEIMER, E.J., VAN HEERDEN W.F.P., TURNER, M.L. & MARÉ, L.K. 1989. Odontoma in an African elephant *(Loxodonta africana)*. *Jl S. Afr. vet. Ass.* 60: 149-150
1104. RAUBENHEIMER, E.J., VAN NIEKERK, J., DAUTH, J., DREYER, M., DE VOS, V., MARÉ, L. & MOKONOTO, P. 1987. Distribution of myoepithelial cells in exocrine glands of the African elephant. *J. Dent. Res.* April 1987: 948
1105. RAUTENBACH, I.L. 1982. Mammals of the Transvaal. *Ecoplan Monograph* No 1.
1106. RAUTENBACH, I.L. 1978. A numerical re-appraisal of the southern African biotic zones. *Bull. Carnegie Mus. Nat. Hist.* 6: 175-187
1107. RAUTENBACH, I.L. 1978. Ecological distribution of the mammals of the Transvaal (Vertebrata: Mammalia). *Annals of the Transvaal Museum* 31: 131-156
1108. REDMOND, I. 1987. Islands of elephants. *Swara* 10(2): 14-19
1109. REDMOND, I.M. & SCHOSHANI, J. 1987. Mount Elgon's elephants are in peril. *Elephant* 2(3): 46-66.
1110. REES, A.F. 1963. Some notes on elephants and their feeding habits. *Tanganyika Notes and Records* 61: 205-208
1111. REES, P.A. 1982. Gross assimilation efficiency and food passage time in the African elephant. *Afr. J. Ecol.* 20: 193-198
1112. ROACH, R., BRIGGS, M. & FITHIAN, C. 1990. Determining the estrus cycle in a group of African elephants by evaluating serum progesterone levels. *Am. Assoc. Zool. Parks Quariums Reg. Conf. Proc.* 1990: 185-188.
1113. ROBSON, E. 1991. Electric fences for elephant management. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 40-43
1114. RODHAIN, J. 1936. Piroplasmes d'okapi et d'elephant dans l'Ouelle. *Bull. Soc. Path. exot.* 29: 877-881 (Description of *Theileria loxodontis* n. sp. - ed.)
1115. ROEHRS, J.M., BROCKWAY, C.R., ROSS, D.V., REICHARD, T.A. & ULLREY, D.E. 1989. Digestibility of timothy hay by African elephants. *Zoo Biology* 8: 331-337
1116. ROSS, I.C., FIELD, C.R. & HARRINGTON, G.N. 1976. The savanna ecology of Kidepo Valley National Park, Uganda. III. Animal populations and park management recommendations. *E. Afr. J. Wildl. Res.* 14: 35-48
1117. ROTH, H.H. 1964. Misplacement of throat bots (*Pharyngobolus africanus* Brauer) in the African elephant. *Jl S. Afr. vet. med. Ass.* 35: 392
1118. ROTH, H.H. & DOUGLAS-HAMILTON, I. 1991. Distribution and status of elephants in West Africa. *Mammalia* 55: 489-527
1119. ROWE-ROWE, D.T. 1991. *The ungulates of Natal.* Natal Parks Board, Pietermaritzburg.
1120. RÜBEL, A. 1987. Physiological and pathological conditions associated with reproduction of female African elephants at the Zürich Zoo. *Proceedings of the First International Conference on Zoological and Avian Medicine* 379
1121. RUESS, R.W. & HALTER, F.L. 1990. The impact of large herbivores on the seronera woodlands, Serengeti National Park, Tanzania. *Afr. J. Ecol.* 28: 259-275
1122. RUGGIERO, R. 1990. The effects of poaching disturbance on elephant behaviour. *Pachyderm* 13: 42-44
1123. RUGGIERO, R. 1990. *The ecology and conservation of the African elephant* (Loxodonta africana cyclotis *Matschie, 1900) in Gounda-St Floris National Parkl, Central African Republic.* PhD dissertation, Rutgers University.
1124. RUGGIERO, R.G. 1991. Opportunistic predation on elephant calves. *Afr. J. Ecol.* 29: 86-89
1125. RUGGIERO, R.G. 1991. Prey selection of the lion (*Panthera leo*, L.) In the Manovo-Gounda-St. Floris National Park, Central African Republic. *Mammalia* 55: 23-34
1126. RUGGIERO, R.G. 1992. Seasonal forage utilization by elephants in Central Africa. *Afr. J. Ecol.* 30: 137-148
1127. RUSSELL, E.W. 1968. The elephant problem in the Serengeti. *Oryx* 9: 404-406
1128. SAVAGE, A., RICE, J.M., BRANGAN, J.M., MARTINI, D.P., PUGH, J.A. & MILLER, C.D. 1994. Performance of African elephants *(Loxodonta africana)* and California sea lions *(Zalophus californianus)* on a two-choice object discrimination task. *Zoo Biology* 13: 77-82
1129. SAVIDGE, J.M. 1968. Elephants in the Ruaha National Park, Tanzania - management problem. *E. Afr. Agric. For. J.* 33: 191-196
1130. SCHANBERGER, A. 1991. Enrichment techniques for elephants at the Phoenix Zoo. *Am. Assoc. Zool. Parks Aquariums Reg. Conf. Proc.* pp 277-283
1131. SCHANBERGER, A., CARLSON, T. & BROWN, J. 1992. Enrichment techniques for elephants. *Animal Keepers' Forum* 19(7): 236-241
1132. SCHMID, J. & ZEEB, K. 1994. The establishment of the paddocks as to keeping elephants in the circus. *Dtsch. Tierärztl. Wochenschr.* 101(2): 50-52 (in German with English summary)

1133. SCHMIDT, M.J. 1989. The role of the veterinarian in a captive elephant breeding program. *Proc. Annual Meet. Am. Assoc. Zoo Vet.* 1989: 44-53
1134. SCHMIDT, M.J. 1993. Breeding elephants in captivity. *In:* FOWLER, M.E. (ed.) *Zoo and wild animal medicine, current therapy 3.* WB Saunders, Denver, Colorado. pp 445-448
1135. SEIDEMAN, R.M. & WHEELER, K.M. 1947. Elephant tusks - a source of human anthrax. *J. Am. med. Ass.* 135: 837-838
1136. SEVER, Z. 1982. An unusual method of feeding behaviour in captive African elephants. *Elephant* 2(1): 140-143.
1137. SHARP, G.J. 1982. *Seasonal variation in the diet and condition of the African elephant in the Sengwa Wildlife Research Area, Zimbabwe.* MSc thesis, University of Zimbabwe, Harare
1138. SHELDRICK, D.L.W. 1972. Tsavo - the hard lessons of history. *Africana* 4(1): 14-15, 26-28
1139. SHELDRICK, D.L.W. 1973. *The Tsavo story.* Collins & Harwill, London
1140. SHEPPE, W. & HAAS, P. 1976. Large mammal population of the lower Chobe River, Botswana. *Mammalia* 40: 223-243
1141. SIKES, S.K. 1966. The African elephant: the background to its present-day ecological status in the Murchison Falls (Uganda) and Tsavo (Kenya) National Parks. *Rev. Zool. Bot. Afr.* 74: 255-272
1142. SIKES, S.K. 1968. Habitat stress and arterial disease in elephants. *Oryx* 9: 286-292
1143. SMART, N.O.E., HATTON, J.C. & SPENCE, D.H.N. 1985. The effect of long-term exclusion of large herbivores on vegetation in Murchison Falls National Park, Uganda. *Biol. Cons.* 33: 229-245
1144. SMITH, D.A. 1989. Elephants and man - a big problem. *Can. vet. J.* 30: 785-787
1145. SMUTS, G.L. 1975. An appraisal of naloxone hydrochloride as a narcotic antagonist in the capture and release of wild herbivores. *J. Am. vet. med. Ass.* 167: 559-561
1146. SMUTS, M.M.S. & BEZUIDENHOUT, A.J. 1993. Osteology of the thoracic limb of the African elephant *(Loxodonta africana). Onderstepoort J. vet. Res.* 60: 1-14
1147. SMUTS, M.M.S. & BEZUIDENHOUT, A.J. 1994. Osteology of the pelvic limb of the African elephant *(Loxodonta africana). Onderstepoort J. vet. Res.* 61: 51-66
1148. SNOW, W.F., TARIMO, S.A., STAAK, C. & BUTLER, L. 1988. The feeding habits of the tsetse, *Glossina pallidipes* (Austen) on the south coast of Kenya, in context of its host range and trypanosome infection rates in other parts of east Africa. *Acta Tropica* 45: 339-349
1149. SOMA, H. & KAWAKAMI, S. 1991. Parturition and placentation in African elephant *(Loxodonta africana). Verhandlungsbericht des Internationalen Symposiums über die Erkrankungen der Zoo- und Wildtiere* 33: 47-51
1150. SOULE, M.E., WILCOX, B.A. & HOLTBY, C. 1979. Benign neglect - a model of faunal collapse in the game reserves of East Africa. *Biol. Cons.* 15: 259-272
1151. SPALA, P., VAHALAJ. & HRADECKY, P. 1990. Lameness in young African elephants *(Loxodonta africana)* caused by inadequate nutrition. *Zool. Gart.* 60(3/4): 244-247
1152. SPIELMAN, D. 1991. Encephalomyocarditis virus (EMC) infections in zoo animals - an often unrecognized cause of sudden death. *Annual Proc. Am. Assoc. Zoo Vet.* 1991: 208-211
1153. SPINAGE, C.A. 1959. An apparent case of precocious tusk growth in a young African elephant. *Proc. zool. Soc. Lond.* 133: 45
1154. SPINAGE, C.A. 1990. Botswana's problem elephants. *Pachyderm* 13: 14-19
1156. STEWART, D.R.M. & ZAPHIRO, D.R.P. 1963. Biomass and density of wild herbivores in different East African habitats. *Mammalia* 27: 483-496
1157. STASSBERGER, F.G.W., NEL, P.P.C. & NEL, M.M. 1990. The light and transmission electron microscopic structure of the adrenals of a non-pregnant, non-lactating African elephant cow *(Loxodonta africana). S. Afr. J. Sci.* 86: 165
1158. STILL, J. 1993. Etorphine-azaperone anaesthesia in an African elephant *(Loxodonta africana). J. Vet. Anaesth.* 20: 54-55
1159. STONE, J. & HALASZ, P. 1989. Topography of the retina in the elephant *Loxodonta africana. Brain Behav. Evol.* 34: 84-95
1160. STUART-HILL, G.C. 1992. Effects of elephants and goats on the Kaffrarian succulent thicket of the eastern Cape, South Africa. *J. appl. Ecol.* 29: 699-710
1161. SUKUMAR, R. 1989. *The Asian elephant.* Cambridge University Press, Cambridge.
1162. SUKUMAR, R. 1991. The management of large mammals in relation to male strategies and conflict with people. *Biol. Cons.* 55: 93-102
1163. SUPER, S.J. 1975. Optometric examination of the African elephant *Loxodonta africana africana* in South West Africa. *Madoqua* 9: 45-51
1164. SWANEPOEL, C.M. 1993. Baobab damage in Mana Pools National Park, Zimbabwe. *Afr. J. Ecol.* 31: 220-225
1165. SWANEPOEL, C.M. & SWANEPOEL, S.M. 1986. Baobab damage by elephant in the middle Zambezi Valley, Zimbabwe. *Afr. J. Ecol.* 24: 129-132
1166. TALBOT, L.M. & STEWART, D.R.M. 1964. First wildlife census of the entire Serengeti-Mara region, East Africa. *J. Wildl. Mgmt* 28: 815-827

1167. TAYLOR, R.D. 1987. Abundance and distribution of elephants in Matusadona National Park, Zimbabwe. *Transaction of the Zimbabwe Scientific Association* 63(7): 58-66
1168. TCHAMBA, M.N. 1992. Defaecation by the African forest elephant *(Loxodonta africana cyclotis)* in the Santchou Reserve, Cameroon. *Mammalia* 56: 155-158
1169. TCHAMBA, M.N. & MAHAMAT, H. 1992. Effects of elephant browsing on the vegetation in Kalamaloue National Park, Cameroon. *Mammalia* 56: 533- 540
1170. TCHAMBA, M.N. & SEME, P.M. 1993. Diet and feeding behaviour of the forest elephant in the Santchou Reserve, Cameroon. *Afr. J.Ecol.* 31: 165-171
1171. TEIXEIRA, M., KRAMER, B., & HATTINGH, J. 1990. The adrenal gland of the African elephant, *Loxodonta africana*: a light and electron microscopic study. *S. Afr. J. Sci.* 86: 161
1172. THOMSON, G. 1978. Natal's last elephants. *Afr. Wildl.* 32: 42-43
1173. THRASH, I., NEL, P.J., THERON, G.K. & BOTHMA, J. du P. 1991. The impact of the provision of water for game on woody vegetation around a dam in the Kruger National Park. *Koedoe* 34: 131-148
1174. TIESZEN, L.L., BOUTTON, T.W., OTTICHILO, W.K., NELSON, D.E. & BRANDT, D.H. 1989. An assessment of long-term food habits of Tsavo elephants based on stable carbon and nitrogen isotope ratios of bone collagen. *Afr. J. Ecol.* 27: 219-226
1175. TURNBULL, P.C.B., BELL, R.H.V., SAIGAWA, K., MUNYENYEMBE, F.E.C., MULENGA, C.K. & MAKALA, L.H.C. 1991. Anthrax in wildlife in the Luangwa Valley, Zambia. *Vet. Rec.* 128(17): 399-403
1176. TURNBULL, P.C.B., CARMAN, J.A., LINDEQUE, P.M., JOUBERT, F., HÜBSCHLE, O.J.B. & SNOEYENBOS, G.H. 1989. Further progress in understanding anthrax in Etosha National Park. *Madoqua* 16: 93-104
1177. TURNBULL, P.C.B., HOFMEYR, J.M., McGETRICK, A.M.T. & OPPENHEIM, B.A. 1986. Isolation of *Bacillus anthracis*, the agent of anthrax, in the Etosha National Park. *Madoqua* 14: 321-333
1178. TWIGG, G.I., SIKES, S.K. & HUGHES, D.M. 1970. Evidence of leptospirosis in some large East African mammals. *E. Afr. Wildl. J.* 8: 197-198
1179. VALE, G.A. & CUMMING, D.H.M. 1976. The effects of selective elimination of hosts on a population of tsetse flies [*Glossina morsitans morsitans* Westwood (Diptera, Glossinidae)]. *Bull. ent. Res.* 66: 713-729
1180. VAN DER MERWE, N.J., LEE-THORP, J.A., THACKERAY, J.F., HALL-MARTIN, A.J., KRUGER, F.J., COETZEE, H., BELL, R.H.V. & LINDEQUE, M. 1990. Source area determination of elephant ivory by isotopic analysis. *Nature, Lond.* 346(6286): 744-746
1181. VAN DER WESTHUYZEN, O.P. 1938. A monograph of the helminth parasites of the elephant. *Onderstepoort J. vet. Sci. Anim. Industry* 10: 49-190
1182. VAN LAVIEREN, L.P. & ESSER, J.D. 1980. Numbers, distribution and habitat preference of large mammals in Bouba Ndjida National Park, Cameroon. *Afr. J. Ecol.* 18: 141-153
1183. VAN ROOYEN, N. 1991. The hunting potential of elephants. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal* (rev. ed.). Wildlife Group of the SAVA, Onderstepoort. pp 64-69
1184. VESEY-FITZGERALD, D.F. 1973. Animal impact on vegetation and plant succession in Lake Manyara National Park, Tanzania. *Oikos* 24: 314-325
1185. VILJOEN, P.J. 1982. The distribution and population status of the larger mammals in Kaokoland, South West Africa/Namibia. *Cimbebasia Ser. A* 7(5): 5-33
1186. VILJOEN, P.J. 1991. Elephants and habitats. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal.* Wildlife Group of the SAVA, Onderstepoort. pp 14-19
1187. VON GADOW, K. 1973. Observations of the utilization of indigenous trees by the Knysna elephants. *Forestry in South Africa* 14: 13-17
1188. WAGNER, R.A. & BENTZ, G.H. 1991. An African elephant tusk pulpotomy: a conservative approach. *Annual Proc. Am. Assoc. Zoo Vet.* 1991: 1-5.
1189. WALKER, C. 1984. The South African ivory trade - a review. *In:* CUMMING, D.H.M. & JACKSON, P. (eds.) 1984. *The status and conservation of Africa's elephants and rhinos.* IUCN, Gland, Switzerland. 149-152
1190. WALKER, C.H. 1991. Factors that may influence the establishment of new elephant populations onto private land. *In:* VAN HEERDEN, J. & PENZHORN, B.L. (eds) *Proceedings of a Symposium on "The African Elephant as a Game Ranch Animal.* Wildlife Group of the SAVA, Onderstepoort. pp 20-23
1191. WATSON, R.M., BELL, R.H.V. & PARKER, I.S.C. 1972. Men and elephant. *Africana* 4(11): 20-21
1192. WATSON, R.M. & TURNER, M.I.M. 1965. A count of the large mammals in Lake Manyara National Park - results and discussion. *E. Afr. Wildl. J.* 3: 95-98
1193. WEIR, J. & DAVISON, E. 1965. Daily occurrence of African game animals at waterholes during dry weather. *Zoologica Africana* 1: 353-368
1194. WELCH, B., JACOBSON, E.R., KOLLIAS, G.V., KRAMER, L., GARDNER, H. & PAGE, C.D. 1989. Tusk extraction on the African elephant *(Loxodonta africana)*. *J. Zoo Wildl. Med.* 20: 446-453

1195. WELLS, M.P. 1989. The use of carcass data in the study and management of African elephants: a modelling approach. *Afr. J. Ecol.* 27: 95-110
1196. WESTERN, D. 1979. Size, life history and ecology in mammals. *Afr. J. Ecol.* 17: 185-204
1197. WHITE, L.J.T. 1994. *Sacoglottis gabonensis* fruiting and the seasonal movements of elephants in the Lope Reserve, Gabon. *J. Trop. Ecol.* 10: 121-125
1198. WHITE, L.J.T., TUTIN, C.E.G. & FERNANDEZ, M. 1993. Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lope Reserve, Gabon. *Afr. J. Ecol.* 31: 181-199
1199. WILLIAMS, T.M. 1990. Heat transfer in elephants: thermal partitioning based on skin temperature profiles. *J. Zool., Lond.* 222(2): 235-245
1200. WILLS, A.J. 1986. Re-establishment of elephant in the Hluhluwe and Umfolozi Game Reserves, Natal, South Africa. *Pachyderm* 7: 10-11
1201. WILSON, V.J. 1975. Game and tsetse fly in eastern Zambia. *Occ. Pap. nat. Mus. Mon. Rhodesia B* 5: 339-404
1202. WOOD, D.T. 1992. Oesophageal choke in an African elephant. *Vet. Rec.* 131(23): 536-537.
1203. WRIGHT, P.G. 1984. Why do elephants flap their ears? *S. Afr. J. Zool.* 19: 266-269
1204. YAOCIEL, S.M. 1981. Changes in the populations of large herbivores and in the vegetation community in Mweya Peninsula, Rwenzori National Park, Uganda. *Afr. J. Ecol.* 19: 303-312
1205. YOUNG, E. 1968. Care of young wild ungulates. *Afr. Wildl.* 22: 126-140
1206. YOUNG, E. 1970. *Water as faktor in die ekologie van wild in die Nasionale Krugerwildtuin.* DSc (Wildlife Management) dissertation, University of Pretoria.
1207. YOUNG, E. 1972. Notes on the chemical immobilisation and restraint of the Addo elephant *(Loxodonta africana). Koedoe* 15: 205-210
1208. YOUNG, E., BURGER, P.J. & WHYTE, I.J. 1972. The use of Dopram-V (doxapram hydrochloride), a potent analeptic, on newly captured wild animals. *Veterinary Clinician* 11: 11-13
1209. YOUNG, E. & LOMBARD, C.J. 1967. Physiological values of the African elephant *(Loxodonta africana). The Veterinarian* 4: 169-172.
1210. ZUMPT, F. 1962. A note on the life-history of *Platycobboldia loxodontis* (Brauer) (Diptera: Gasterophilidae). *J. ent. Soc. S. Afr.* 26: 452-453
1211. ZUMPT, F. 1970. Arthropod parasites of the African elephant (*Loxodonta africana* Blumenbach) and the Indian elephant (*Elephas maximus* Linnaeus): taxonomic and biological aspects. *J. Parasitol.* 56: 380.
1212. ZUMPT, F. & WETZEL, H. 1970. Fly parasites (Diptera: Oestridae and Gasterophilidae) of the African elephant *Loxodonta africana* and their problems. *Koedoe* 13: 109-122

ELEPHANT BIBLIOGRAPHY - CROSS INDEX