Pachyderm

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Postmortem pathological miscellanea recorded in African savannah elephants

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Abstract

During elephant culling programmes in Uganda, Kenya and Tanzania between 1965 and 1969, data were routinely collected to elucidate population dynamics (including 12 body measurements, 23 organ weights and reproductive status). Inevitably, during dissections, other observations emerged but were not catalogued. Some of these are presented here as an eclectic assembly of pathological notes to extend knowledge of savannah elephant biology. These specimens were obtained during government-authorized elephant-culling operations undertaken in East Africa in the 1960s. The prevailing management view was that elephants were so radically changing woodlands in favour of grassland that parks were losing both vertebrate and invertebrate faunas dependent upon trees and woodland. Controlled population reduction was therefore undertaken as a conservation-management intervention intended to stop habitat change.

Résumé

Pendant les programmes d'abattage d'éléphants pratiqués en Ouganda, au Kenya et en Tanzanie entre 1965 et 1969, les données physiques des individus étaient systématiquement collectées (dont douze mesures corporelles, vingt-trois pesées d'organes et le statut reproducteur) en vue de mesurer les dynamiques de populations. Des observations supplémentaires ne manquaient pas de se faire jour pendant la dissection mais n'étaient pas inventoriées. Certaines d'entre elles sont présentées ici comme un ensemble de notes à caractère pathologique afin d'approfondir les connaissances en matière de biologie de l'éléphant de savane. Ces spécimens ont été obtenus pendant les opérations d'abattage d'éléphants autorisées par les gouvernements en Afrique de l'Est dans les années 1960. En termes de gestion, la vision dominante en cette période considérait que les éléphants modifiaient radicalement les zones forestières au profit des prairies, entraînant, dans les parcs nationaux, la disparition des espèces vertébrées et invertébrées dépendantes des arbres et des zones boisées. La réduction contrôlée des populations a, par conséquent, été entreprise en tant qu'intervention de gestion afin de mettre un terme à la modification des habitats.

Introduction

The data and notes presented here derive primarily from 2,887 savannah elephants (*Loxodonta africana*) dissected during culling operations of five

different clans conducted between 1965 and 1969 in Uganda, Kenya and Tanzania (Parker and McCullagh 2021). The locations and clan designations are given in Table 1.

Previously, knowledge of elephant anatomy came largely from individual animals found dead or killed in defence of crops or property, for research and by trophy hunters or poachers. The culls therefore provided a unique opportunity to collect population-level data. Research led by the late RM Laws (Croxall et al. 2015) documented growth, age and population dynamics. Data from the culled elephants were collected systematically, as described in Appendix B of Laws et al. (1975), and have supported at least 61 papers in 31 scientific journals. However, these publications do not encompass all observations from the dissection of 2,887 elephants. This paper presents diverse pathological findings that are individually too limited to warrant separate publication—but collectively broaden understanding of savannah elephant biology. Most observations were recorded by experienced fieldworkers without formal academic qualifications. Laws initially supervised the collection of data until he was satisfied that the team could reliably identify the required anatomy and record data routinely. Keith McCullagh, DVM, who was collecting data for his PhD, attended the Murchison Falls National Park, South (MFPN), Murchison Falls National Park, North (MFPS) and Tsavo Koito (TSO) culls and provided veterinary assessments of pathological findings. Veterinarians Christian Stark and Jack Debby similarly attended the Mkomazi East (MKE) culls for their own studies and contributed professional expertise as members of the team.

Materials and methods

Locations and cull sizes are shown in the Introduction above.

Detailed descriptions of the culling methods and data collection are provided by Laws and Parker (1968); Laws (1970); Laws et al. (1975) and Parker and McCullagh (2021). All members of entire herds were shot and died in close proximity to one another. Each elephant was immediately assigned a serial number and an individual field data sheet on which all pertinent data were recorded. The original field sheets are held by the University of Florida and are available for researchers to examine and reanalyse. The spreadsheet that accompanies Parker and McCullagh (2021) contains 139 columns and 3,190 rows); as it also includes records of elephants culled by the Uganda Forest Department that were not dissected.

The elephants from which the observations were derived are identified by the serial numbers allocated to them in the field and by their clan designations. No abattoir facility was established; as described in several previous manuscripts in this series, the elephants were generally dissected in the field within six hours after death. With increasing experience, this interval was reduced to as little as one hour, depending on the size of the herd culled (range: 1–29 elephants). The target was to process one herd per working day. Thus, in Tsavo, we culled and dissected 300 elephants in 18 working days, an average of approximately 17 per day.

Table 1. Locations and numbers of elephants sampled during culling operations that provided the observations in this paper. The region, five clan designations (in parentheses), approximate central coordinates of clan locations, sample sizes and date sampled.

Biome	Clan	Location	Sample size	Date
Murchison Falls National Park/North	Murchison North (MFPN)	2° 24′N 31° 42″E	1197	March 1965–June 1967
Murchison Falls National Park/South	Murchison South (MFPS)	2° 10′N 31° 50′E	798	November 1965–May 1967
Nyika Kenya	Tsavo Koito (TSO)	3° 00′S 38° 42′E	298	August 1966
Nyika Tanzania	Mkomazi East (MKE)	4° 22′ S 38° 35′E	299	March 1968
Nyika Tanzania	Mkomazi Central (MKC)	4° 09′S 38° 14′E	295	August–September 1969
Total			**2887**	

Table 2. Occurrence of uterine or peri-uterine cysts

Clan	Cysts	Total
MFPN Murchison Falls/NP North	GMU 88, GMU 144, GMU 409, GMU 526, GMU 1115, GMU 1123, GMU 1154	7
Murchison Falls NP/South	GMU 235, GMU 324, GMU 337, GMU 1418, GMU 1484, GMU 1752, GMU 1875	7
Tsavo Koito	WLS 48, WLS 70, WLS 81, WLS 87, WLS 96, WLS 103, WLS 127, WLS 181, WLS 182, WLS 184, WLS 188, WLS 198, WLS 213, WLS 231, WLS 233, WLS 266	16
Mkomazi East	WLS 74, WLS 192	2
Mkomazi Central	WLS 335, WLS 466, WLS 474, WLS 476	4
Total		**36**

Table 3. Cases (11) of wholly or partially retained placentae long after parturition as judged from the age of calf at heel.

Area	Serial number and retained placenta	Total
Murchison Falls NP/North	GMU 479, GMU 602, GMU 1243, GMU 1382	4
Murchison Falls NP/South	GMU 1740, GMU 1839, GMU 1904	3
Tsavo Koito	0	0
Mkomazi East	MKE 8, MKE 22, MKE 64, MKE 168.	4
Mkomazi Central	0	0
Total		**11**

Table 4. Cases in which the uteri showed evidence of abortion or contained a dead foetus.

Area	Serial number abortions or dead foetus	Total
Murchison Falls NP/North	GMU 602	1
Murchison Falls NP/South	GMU 266, GMU 332, GMU 1740, GMU 1878, GMU 1890	5
Tsavo Koito	nil	0
Mkomazi East	MKE 39, MKE 168, MKE 192	3
Mkomazi Central	nil	0
Total		**9**

Table Note: The evidence of abortion was recorded on the field data sheets held in the Parker archive held in the University of Florida.

Results

Female uterine pathology

Cysts: The occurrence of uterine or peri-uterine cysts is presented Table 2.

Retained placentae: Table 3 lists females who had wholly or partially retained placentae.

Uterine involution: In GMU 27, GMU 88 and GMU ?, the uteri had not fully involuted postpartum, preventing further conception.

Foetal mortality and abortions: Table 4 presents cases of apparent abortions or the presence of a decomposing foetus.

Blocked uterine cornua: Placental implantation scar tissue completely sealed the lumen of one uterine cornu in MFPN 188, 190, 1084 and MFPS 1762—preventing further conception in the affected cornu.

Uterine diverticulae: In GMU 415, the right cornu had a diverticulum, and a drawing was made on the back of the data sheet. In TSO 223, initially thought to be a diverticulum off the uterus with a structure with approximately 20 cm in diameter within the broad ligament uterus was initially thought to be a diverticulum. On dissection, however, it was found to be an independent body lined with endometrial mucosa.

Sepsis: GMU 602 presented with endometritis, vaginitis, distended vulva with thickened tissue, and a left cornu containing brown fluid and placental remains. The female had recently given birth; her left ovary regressed, but no calf was present, she was lactating but her mammae were very small. GMU 125 had recently given birth but had sepsis around the implantation site. In MKC 323, the vulva and surrounding tissues showed extensive sepsis.

Calcareous bodies: In GMU 207, there were two calcareous bodies in right cornu.

Fibroma: GMU 1484 had a fibroma in the wall of the uterus, plus multiple cysts on both ovaries.

Placental scars: As described by Laws (1967), scars across the uterine cornua mark implantation sites and provide an index of a female's reproductive history. Assuming a minimum calving interval of four years commencing at 10 years of age, a female elephant could have produced a maximum of three calves by the age of 22 and four by the age of 26. GMU 1525, aged 26; GMU 1526, aged 22; and GMU 1527, aged 26, had eight, ten and six placental scars, respectively. Together, this represents 13 more implantation scars than the maximum number of full-term births expected under the assumed four-year calving intervals indicating that some pregnancies were not carried to full term.

Male reproductive pathology

Male reproductive physiology was described by Laws et al. (1975). As reported at the time, fresh sperm were expressed from the vas deferens before fixation in alcohol, examined by microscope in the field and subjectively categorized into three classes: none, few or abundant. These categories were used to assign males to the reproductive states of immature, pubertal or mature. These field records were later confirmed through laboratory examinations of the fixed, stained slides. Before fixation, sperm motility was assessed before and after the addition of seminal fluid extracted from a seminal vesicle.

Seminal fluid: Seminal fluid was most commonly straw-coloured but varied from gin-clear to dark brown with the latter being more viscous.

Sperm motility: In the vas deferens, the majority of sperm were quiescent until a drop of seminal fluid was added to the microscope slide. Following its addition, 'all' became motile. In two cases, GMU 51 and GMU 85, many were motile before seminal fluid was added. Motility declined with increasing time post-mortem, but some remained motile six hours later. Elephant GMU 48, aged 23 years, had abundant non-motile sperm that were not activated by its seminal fluid, which was brown, and viscous. Many of the sperm from GMU 1394, aged 49 years, were deformed with bent tails. GMU 1546, aged 48.5 years, had no sperm, and his seminal fluid was dark brown.

Parasites

Where parasites were seen and recognised, their

Table 5. The table below presents exceptions in which slides contained few sperm at ages where abundant sperm would have been expected. (All 11 cases were adults.) Except for GMU 1443, which was with females and their young, all were in male-only units.

Clan	Serial number	Age years	Herd number	Males only	With Females	Few Sperm	No Sperm
Murchison North	GMU48	23	7	X		X	
Murchison South	GMU1402	48	198	X		X	
Murchison South	GMU1403	31	199a	X		X	
Murchison South	GMU1406	34	199b	X		X	
Murchison South	GMU1411	51	201	X		X	
Murchison South	GMU1443	38	296		X	X	
Murchison South	GMU1466	40	204b	X		X	
Murchison South	GMU1486	35	209	X		X	
Murchison South	GMU1546	48.5	217	X		X	
Murchison South	GMU1552	52	217	X			X
Tsavo Koito	TSO277	29	27	X		X	
Total	**11**		**11**	**10**	**1**	**10**	**1**

presence was noted, but they were not specifically searched for as part of the routine data collection.

The elephant stomach bot fly: *Cobboldia loxodontis* lays small rafts of eggs on tusks near their point of emergence, through the gingiva and inside the mouth alongside the molars, indicating that the flies sometimes successfully enter the buccal cavity. Eggs were noted on tusks of GMU 125, GMU 304, and TSO 5, but larvae were ubiquitous in every stomach examined, except small, unweaned calves.

Warble flies: Probably those of *Ruttenia loxodontis* Rodhain (1927). Larvae were found in the upper flank skins of some elephants (ranging in number from 2 to >50) but only in a small area of MFPN close to the Ayago River. These classical 'warbles' had respiratory openings through the epidermis. Larvae were observed emerging from GMU 45 and GMU 136, presumably to pupate externally.

Black flies: *Simulium damnosum* were abundant around elephants in the same area as the warble flies, close to the Ayago River in MFNP, but, oddly not in the vicinity of the Nile (into which the Ayago flows), where the water is fast flowing over rocks suitable for the larvae.

Stable flies: *Stomoxys*? were recorded in MFPS on elephants GMU 201 (as well as around its dung) and TSO 66.)

Tracheal nematodes: A *Mammomonogamus* helminth (species not identified) was recorded. Females 10–15 mm long with attached males were first found in clusters ~4 cm wide, extending around the entire tracheal circumference just before the bronchial bifurcation in GMU 164, GMU 196, GMU 200, GMU 278, GMU 279, GMU 287, GMU 296 and GMU 297. Thereafter, the tracheae of many elephants in MFPS were examined. All except the youngest unweaned calves had dense clusters of these parasites, always at the same location, with ulceration around the attachment sites. The clusters were sufficiently dense that they must have impeded air intake. The nematodes were also found in MFPN when specifically searched for. None were found in TSO, MKE or MKC.

Unidentified Nematodes: Elephant GMU 235 had a cyst near the pyloric sphincter containing many small nematodes.

Table 6. Presence or absence of large nematodes (up to 20 cm in length), in the bile ducts of a sample of 24 elephants, arranged in ascending order of age. Red indicates absence; black present. The nematode species was not identified.

Clan	Age	Sex	Herd number	Serial number	Age	Sex	Herd number	Serial number	Age	Sex	Herd number
MKE162	0.1	F	17	MKE181	8	M	18	MKE174	12	M	18
MKE165	0.1	M	17	MKE191	8	M	19	MKE183	13	M	18
MKE184	1	M	18	MKE198	8	M	19	MKE199	15	F	19
MKE217	1	F	21	MKE206	8	F	20	MKE168	16	F	18
MKE175	2	F	18	MKE155	8.5	M	17	MKE159	17	M	17
MKE173	2.5	M	18	MKE156	10	F	17	MKE216	31	F	21
MKE197	3.5	M	19	MKE172	11	M	18	MKE178	32	F	18
MKE207	5	M	20	MKE179	11	F	18	MKE180	43	F	18

Hookworms: Hookworms of an unidentified species were fortuitously found in the mucosa of the small intestine of elephant TSO 20.

Bile duct nematodes: In MKE, veterinarian, Jack Debbie searched the bile ducts of 24 elephants for nematodes; these results are presented in Table 6.

Tapeworms: No mature tapeworms were recorded. The only cysticercus sac found in elephant tissue was embedded in the masseter of elephant MKC 403. Given the amount of muscle that was cut and collected during the elephant culls, and the familiarity of the contractor's staff with tapeworm cysts in both domestic and wild bovids, the low incidence in elephants was surprising, even though tapeworm cysts were not specifically searched for.

Ixodida: Ticks of several species were present on most elephants. However, infestations were recorded on the field data sheets only when they were heavy; this occurred in two herds: GMU herd 89 and MKE herd 8.

Dentition

Uneven molar eruption: Because the maxilla was not systematically studied, the observations were incidental. In TSO 47, the molar emerging at the back of the maxilla had only four lamellae in wear, whereas the opposing molar in the lower jaw had five. In TSO 55, the molars on both sides of the upper jaw had one lamella in use, whereas the corresponding lower jaw molar had two lamellae in use on one side and three on the other. These observations suggest the Laws' ageing key, which is based on lower jaws, should not be applied to upper jaw dentition without confirmation.

Caries: In the left upper M6, GMU 1395 had four carious lesions exposing pulp above. There was no obvious swelling or alteration of the maxillary bone comparable to the mandibular abscesses reported by Laws (1966) and Parker (2017), suggesting a different aetiology for these maxillary caries.

Molar anomalies: In the right lower ramus of GMU 433 the lamellae lay horizontally rather than vertically, and there were no opposing molars in the upper jaw.

Tusk anomaly: In situ, the right tusk of GMU 68 appeared normal, although it was broken close to the lip. When extracted from the alveolus, it separated into seven tusklets of similar dimensions, each with its own pulp cavity. In cross-section, the tusklets collectively resembled the segments in an orange radiating out from a central point. Their outer surface occupied approximately the same degree of arc of the alveolar circumference. (I recall seeing photos of a similar tusk from the then Belgian Congo in the *Field* magazine, possibly around 1952).

Miscellanea

Internal abscess: The spleen of elephant GMU 128 had multiple abscesses, the largest measuring 12.7 cm in diameter. The spleens of GMU 241 and GMU 244 from the same herd had similar abscesses to GMU 128. TSO 61 had an abscess in the left temporal gland.

Superficial external abscesses: Discounting sepsis associated with fresh snare trauma (see below), only two superficial abscesses of unidentified origin were observed: one on the ankle of GMU 1535 and the other on one ear of MKC 462.

Osteoporosis: Estimating elephant age required lifting and handling several thousand lower jaws, which gave me a tactile, albeit subjective sense of jaw weight relative to size. Strikingly, the lower jaws of very old females, particularly those retaining only small remnants of M6 molars, seemed much lighter for their size, and the bone appeared much less dense, suggesting clinical osteoporosis. These observations indicate that marked age-related loss of mandibular bone density may occur in elderly female elephants.

Malignant tumours: No obvious evidence of malignant neoplasia was observed.

Benign tumours: GMU 611 had hyperplastic growths and cysts throughout the entire length of reproductive tract. In GMU 1472, both temporal glands showed chronic bacterial infection. GMU 1484 had a fibroma measuring 3 × 2.5 cm in the uterine wall. TSO 33 had a well-circumscribed fibrous tumour in the right adrenal medulla measuring 1.0 × 1.5 × 2 cm. TSO 126 had a benign neoplasm 6 × 2.54 × 1.3 cm found floating free in the abdomen (Keith McCullagh pers. comm. 2021).

Hematuria: GMU1561 had blood-stained urine. The cause was undetermined, but the finding was not attributable to cull trauma.

Gall stones: No gall stones were recorded in MFPN, TSO, MKE or MKC. In MFPS, however, GMU207, had a single gall stone weighing 425 g; GMU 369 had several large stones, the largest weighing 4,060 g; and in GMU 1613 had stones present but these were not weighed.

Mastitis: The mammae of all pubertal and adult females were examined, and lactation was assessed by determining whether milk or any other exudate could be expressed. No cases of mastitis were reported from MFPN, TSO, MKE or MKC. However, in MFPS, it was observed in GMU 1706, GMU 1736, GMU 1741, GMU 1935 and GMU 1959.

Enteritis and hepatitis: Elephant GMU 573 was very thin, scouring, with marked inflammation throughout the abdominal cavity and viscera. In TSO 29, the mucosa of the large intestine was inflamed, accompanied by slight hepatitis. TSO 32 had mild inflammation of the caecum. TSO 113, the small intestine was lightly inflamed; and part of the large intestinal mucosa appeared necrotic. Samples were collected from both sites.

Warts: GMU 146 and GMU 259 both exhibited lesions described in the field as "warts", although they may not have been warts *sensu stricto*. The condition occurred in patches on upper back, slightly anterior to the pelvis, and on the head, anterior to the occiput; each patch was approximately 3,000 cm^2 in extent. Normal elephant epidermis appears as papillae of ~1 mm in height. In these "warty" patches, the papillae were up to 30 mm, with mud and soil deeply embedded between them. Other elephants showed the same condition, but it was not entered on the field data sheets.

Healed bone fractures: Two elephants, GMU 1400 and TSO 59, had previously sustained complete breaks at the distal end of a femur. In both cases, the fractures had healed with malalignment. GMU 1400 was in poor condition: both tusks were broken, and it had a recent festering snare wound around the previously broken right hind leg. TSO 59 appeared otherwise reasonably healthy.

Swelling no cause identified: GMU 509 had a markedly swollen left foreleg. There was no sepsis or oedema, but fibrous tissue was thickened throughout.

Table 7. Evidence of snare wounds in MFPN. The average age of snared animals was 24.0 years. GMU 693 is not included in the table—this 32-year-old had a deep, narrow groove halfway along the dorsal surface of one tusk, a lesion that could only have been caused by a wire cable.

Serial number	Age	Sex	trunk	leg	Notes
48	23	M	1		
70	30	M	1		
85	18	M	1		
96	15	M	1		
105	29	M		1	Left front healed
118	13	F	1		
150	32	M		1	Right front healed
164	39	F	1	1	Rear leg
169	10	F	1		15-20 cm missing
194	28	M	1		
438	23	F			
505	32	F		1	Healed
955	25	F	1		
1215	33	M		1	Left hind festering
1293	27	M		1	Right front healed
1395	45	M		1	Right front healed
1400	18	M		1	Festering
Total	**17**		**9**	**8**	

No snare wounds were recorded from MNPS, TSO, MKE or MKC.

Geophagia: Soil was present among the stomach contents of many elephants examined. It is unclear whether this material had been deliberately ingested or consumed incidentally when grasses and other plants were pulled from the ground and ingested, complete with attached roots. GMU 117 had a small stone, 4 cm in diameter, in the small intestine, while GMU 198 had large quartz pebbles in the stomach.

External trauma

Evidence of external trauma was inferred from the presence of fresh wounds, scars and amputations.

External abscesses: Only two local abscesses of unidentified origin were recorded: one on an ankle of GMU 1535 and the other on one of MKC 462's ears.

Snare wounds: Snare wounds were recorded in 17 (1.4%) of the 1,200 elephants culled in MFPN. These injuries consisted of partial or complete trunk amputations, or wounds around the carpal or tarsal joints, as shown in Table 7.

Predator attacks: In MFPS 22, trauma wounds attributed to hyaena are presented in Table 8.

Bullet wounds: No bullet wounds were found in elephants from MFPN or TSO. One case was recorded from MFPS, one from MKE and three from MKC.

Deformed feet: I have seen five cases among approximately 3,500 elephant forefeet in which the nails of both forefeet were similarly overgrown. Each nail had extended radially outward and upward for approximately 20 cm around the foot, forming a rough, inverted crown of keratin.

Table 8. The incidence of wounds inflicted by spotted hyaena in MFNP. Average age of elephants with scars 7.4 y.

Serial number	Age	Sex	Trunk	Tail	Trunk + Tail	Notes
341	4	m		1		no tail
345	1	m		1		no tail
347	3	f	1			wound trunk
1433	20	m	1			no tail
1472	14	m		1		half tail
1518	0.5	f		1		no tail fresh scar
1588	12	f		1		no tail
1606	28	m		1		no tail no scar
1673	5.5	m			1	no tail, 46 cm trunk, hole in left nostril
1709	1	m	1			recent scar: missing ~13 cm of trunk
1715	8	m		1		half tail old scar seen
1773	7	f		1		no tail
1818	2.5	f			1	no trunk no tail
1867	5	f		1		only 15 cm tail left
1867	5	r	1			only 15 of trunk left
1879	0.5	f		1		no tail no trunk
1940	16	m		1		no tail
1977	13	m		1		no tail
1873	6.5	m			1	no tail, trunk 48 cm, 3 holes in left nostril
1988	10	m		1		no tail
1988	10	m		1		no tail
Total	**22**		**4**	**14**	**3**	**21**

Discussion

Combined, the data on female and male reproduction provide further insight into elephant biology. Compiled from field notes, these observations are too incomplete to support firm conclusions, but they are sufficiently consistent to suggest possible patterns. The presence of cysts, retained placentae, abortions, blocked uterine cornua, sepsis and placental scar evidence indicates that reproductive pathology may have contributed to shaping population profiles.

The cysts filled with clear fluid appeared, subjectively to be benign. However, the largest cyst in the left ovarian lateral ligament of GMU 1752, contained nine litres of fluid. Another, attached to the atrophied right ovary of an MKC elephant, was filled with brown fluid; with its contents, it weighed with 1,146 g and measured 16 × 12 × 11 cm. Emptied of fluid, the cyst membranes weighed 126 g. These two cases challenge the assumption that such cysts were necessarily benign. Only cellular analysis could have established their aetiology, but this was not possible under field conditions. Nevertheless, and while moot, the physical presence of such cysts, particularly the large specimens, could have affected reproductive performance. When the data in Table 2 are considered in relation to the total number of female herds culled, their occurrence varied among areas. The proportions of female herds with recorded cases, were 4.3% in MFPN, 3.5% in MFPS, 61.5% in TSO, 11.5% in MKE and 10.7%. in MKC.

Uterine distention in advanced pregnancies made placental scars difficult to detect. Consequently, scars were not counted in all females of reproductive age. Nevertheless, the culls yielded 816 samples in which there were 1,537 placental scars: 786 in the right cornu and 750 in the left, with one exception in the lower uterus below the junction of the two cornua.

When fully developed, the placental attachment scar covered most of the circumference of the tubular cornual wall. In the four cases cited above, this scar tissue completely occluded the internal lumen circumference, precluding further conceptions in that cornu.

GMU 1706, GMU 1736, GMU 1741 were all members of the same herd (#237). The youngest animal in the herd, GMU 1748, was 2.5 years old and marginally, still suckling; the next youngest was 8 years old, well past suckling age. The fact that all three lactating females in the herd had mastitis suggests that GMU 1748 may have transferred the causative bacillus by taking milk from all three.

GMU 1525, aged 26 years; GMU 1526, aged 22 years; and GMU 1527, aged 26 years had eight, ten and six scars, respectively. Together, this was 13 more scars than the maximum expected with four-year calving intervals. This suggests that all three females had lost foetuses late enough in gestation for the placental scars to develop before aborting. That they were all members of the same herd suggests a possible shared cause. Placental scars also provide insight into reproductive activity in older females. Of the 816 uteri dissected, 66 were from females aged 50 years or older. Only two of these had a single scar, confirming just one recorded implantation. In contrast, GMU 1853 was 55 years, had 11 scars and mammae that were still exuding a clear fluid.

Table 5 presents 10 adult males in which sperm were subjectively fewer than expected, and one male, GMU 1552, aged 52 years, in which no sperm were recorded. All 11 elephants were culled between 13 February and 24 March 1967, suggesting a possible seasonal influence. However, males with abundant sperm were also recorded during the same period, weakening this interpretation.

Mammomonogamus nematodes were conspicuous in MFPS, where they caused ulceration and partially occluded the tracheal airway. They were therefore obviously not benign and must have contributed to poor health. Animal traders were reportedly reluctant to buy young elephants from Uganda, claiming they were always sickly and suffered high mortality (T. Carr-Hartley pers comm. 1965). This parasite may have contributed to such a perception. Its absence from TSO, MKE and MKC supports the possibility that infection was regional and perhaps associated with the higher humidity of Uganda.

The large nematodes collected by Debby from bile ducts of elephants in MKE were not identified to species. Subjectively, they appeared benign, however, their presence in every elephant examined except the two neonates suggests that, like *Cobboldia* larvae, they may be common in savannah elephants.

A widely held view among trophy hunters and conservation officials was that elephants with fractured limb bones would become immobile and die. This led to a standing policy of euthanasia, ostensibly "to put them out of their misery." The two cases of healed femurs are backed by a third case from Rwanda (Haigh et al. 1979), indicating that elephants can recover from a broken femur. This capacity may pertain to other major leg bones; in Kidepo NP in 1998, Parker and Root (unpublished report) observed a young female elephant approximately 2 m at the shoulder with a snare-amputated right foot running and keeping pace with its herd. The amputated limb was held clear of the ground and was not used for weight-bearing while the animal was in motion.

Regarding elephant stomach bot fly (*Cobboldia loxodontis*), egg cases were observed by the author on tusks from elephants across Africa while studying the ivory trade (Parker 1979). Subjectively, this fly appears to be a benign parasite hosted by virtually 'all' savannah elephants. Its taxonomic status appears unsettled: possible synonyms include *Cobboldia chrysidiformis* (Rodhain and Bequaert 1915) or *Platycobboldia*, and it has also been referred to in English as the green elephant stomach bot fly (Zumpt and Wetzel 1970).

Warble flies produced classical "warbles" with respiratory openings through the epidermis.

The TSO cases of enteritis were in elephants aged 0.75, 1.0, 0.75 and 11 years; all were therefore young animals. Very young calves are notoriously difficult to rear and are susceptible to enteritis. These cases suggest that capture trauma may aggravate a pre-existing condition rather than always being the primary cause.

Snares are nooses set across game tracks or wildlife paths or around bait and anchored to an immovable or heavy object. They are among the simplest traps and widely used in Africa. Suitable snaring sites occur where vegetation or topography funnels animals onto paths. Where vegetation is too open for paths to develop naturally, bush fences may be constructed from cut scrub, with snares (or pit traps) set at periodic intervals in gaps along the fence. Except when baited for carnivores, snares are ineffective in open grassland.

Since the colonial era, when metal wire or cable became abundantly available, these materials have become the preferred noose types. Although unlawful, snaring was widely practised in rural Uganda. Set primarily to secure antelope meat (now referred to as bushmeat), when industrial cable was used, they could hold animals as large as adult male buffalos, and certainly young elephants of comparable weight, which elephants attain at about 2 to 3 years of age.

Of the 17 snare wounds recorded, only two were fresh and festering; the remainder were well covered by scar tissue and may have been several years old. Snaring within MFPN was not reported by routine Park staff patrols nor by the culling teams, suggesting that elephants bearing snare wounds had acquired them, hitherto unreported, outside the Park. Six decades and more ago, this would probably have been in woodland beyond the Park's eastern boundary, where conditions were favourable for snaring. Since then, that area has been extensively cleared and densely settled, making it effectively unavailable to elephants.

The mean age of the snared elephants listed in Table 7 was 24 years, and none was younger than 13 years. This suggests two possibilities. First, the healed wounds may have been acquired when the elephants were younger, and by the time of the culls, MFPN elephants may no longer have been ranging outside the Park. Second, and more likely, the absence of young elephants with healed snare wounds may partly reflect higher mortality among younger calves and juveniles unable to break free. A comparable pattern was also noted by Haigh et al. (1979) in Rwanda, where more than 30% of elephants shot had similar snare wounds; in some cases the wounds had healed, but the retaining cable remained embedded as an internal bracelet.

The capacity of some elephants to survive and heal from severe snare injuries does not reduce the need for veterinary intervention in snared animals. It does, however, challenge policies of routine euthanasia based on the assumption that recovery was unlikely. In addition to the recorded snare wounds, a further six MFPN cases were attributed to failed predation (see below).

Only three cases of snare wounds were found in MFPS where the open grassland was unsuitable for their use. Again, as no actual snares were found in MFPS, it suggested that the three cases had been acquired outside the Park.

Evidence from MFPS presented in Table 8, suggests that tail loss and trunk amputation or damage resulted from attacks by predators. These injuries were attributed to the abundant spotted hyaenas (*Crocuta crocuta*). Had they been inflicted by lions, leopards or crocodiles, accompanying claw marks and/or characteristic bite wounds would have been expected. Their absence was consistent with hyaena hunting behaviour, in which animals typically bite and hold. The 16 cases of missing tails and five cases involving both tail/trunk injury together accounted for 21 (2.6%) of the 800 elephants culled in MFPS. Notably, the average age of elephants with presumed hyaena wounds was seven years. Because all wounds were well healed, they had clearly been inflicted when the animals were younger; indicating a period when young elephants were within reach of hyaenas attacking. Very young calves in small units comprising a female and her immature offspring would be vulnerable to a pack of hyaenas approaching from several directions. The number of healed cases indicates that some calves survived such attacks; it also suggests that hyaenas would not have used this strategy unless it was sometimes successful.

Although data on actual mortality from **both** snares and predation are lacking, the wounds attributed to both causes indicate that they probably contributed to the high juvenile mortality recorded in both MFPN and MFPS (Parker 2023).

No snare or arrow wounds were observed in the TSO, MKE or MKC culls. Despite familiarity with the ranges of the three clans between 1958 and 1966, both on the ground and from the air, I saw no bush fences. However, farther west in the same Nyika biome, such fences were present (Simon Trevor, pers. comm. 2026). Poisoned arrows had been used extensively across all three areas prior to the anti-

poaching campaigns of 1956/57, but the soft iron arrowheads would probably have dissolved over the 12 years between the onset of those campaigns and the culls of 1968 and 1969.

While cases of lions killing elephants in TSO are known, no evidence of such predation was found in the TSO, MKE and MKC cull carcasses.

The single bullet wound recorded in MKE contained an iron slug of the type fired by indigenous hunters from muzzle-loading guns. Two of the three MKC cases yielded 404 rifle bullets, a calibre that was standard issue to game scouts in both Tanzania and Kenya. It implied that either the elephants had been shot at while crop-raiding outside the Mkomasi Reserve, or had otherwise been shot illegally.

Although not an observation arising directly from the culls, the Results section notes that, in five of approximately 3,500 elephants examined, the outgrowth of toenails had deformed the forefeet. Similar overgrowth occasionally occurs in domestic animals when normal wear is insufficient, causing the hoof to grow to the extent that locomotion is impaired and the animal can no longer walk properly. Although elephants are not conventional ungulates, their toenails, like hooves (and fingernails), consist of continuously growing keratin that is normally maintained by wear. Because my observations were all post-mortem, the effect of the deformity on the elephant's gait could not be assessed.

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