AN EXPERIMENTAL CROPPING SCHEME OF HIPPOPOTAMI IN THE LETABA RIVER OF THE KRUGER NATIONAL PARK

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The annual census of hippopotami in all the permanent rivers of the Kruger National Park since 1956, has divulged a definite tendency in the population growth curve of each residential hippo population.

As a result of poaching, disease (anthrax, etc.), mortal combat amongst bulls, and punitive destruction of hippo damaging the boundary fences, population fluctuations in the boundary rivers such as the Crocodile and, particularly, the Levubu, were not prominent and the numbers remained relatively static during the past nine years.

The picture changes, however, in respect of the hippo populations of the Sabi, Olifants and Letaba rivers. Despite slight fluctuations here, as a result of varying climatological conditions, there has been a definite and consistent rise in the population growth curve. The position in the Sabi river is still satisfactory, but during the past few years the rapid increase of hippo in the Letaba and Olifants rivers, has become cause for some concern.

The dangers of a population explosion in both these rivers were accentuated by the severe drought experienced in the Kruger National Park since 1962. The Letaba river stopped flowing altogether during the winter months and the Olifants reached its lowest ebb in living memory. Pools suitable for hippo habitation became limited and this resulted in excessive crowding of hippopotami in the remaining pools to the extent of becoming unhealthy. This, quite naturally, resulted in vicious fights amongst the animals as well as extreme trampling and over-utilisation of the surrounding grazing grounds.

These conditions were more in evidence along the Letaba than along the Olifants as a result of a better distribution of permanent water-holes suitable for hippo habitation in the latter river. Owing to the absence of grazing in the river bed itself, hippos from the Olifants river tend to graze

far inland, consequently serious trampling of the riverbanks, mainly covered by quick grass (*Cynodon dactylon*), has not yet reached excessive proportions.

Reeds and rushes being plentiful in the Letaba river, the hippos here feed on or near the riverbanks. This in turn causes serious trampling and inevitable soil erosion on the steeper banks, especially around the established herd habitats.

In 1963 the hippo population of each of these two rivers had exceeded 1,000, and it was obvious that the critical level in the population curve had been reached. The danger of habitat destruction through overpopulation was now becoming very real.

Estimating the carrying capacity of the riverine grazing for hippo is a ticklish problem, particularly in view of intense competition with other herbivora during the winter.

Basic data needed to determine the reproductive potential and carrying capacity was not available. This included information on sex ratios, herd composition, percentage of cows that calve annually, time-lapse between births, natural mortality amongst young and adults, feeding affinities and daily food consumption.

To obtain this information it was recommended to our Board that 100 hippos be culled according to the randomised sampling method.

This cropping campaign commenced on 25th May, and was successfully terminated on 20th August, 1964.

TECHNIQUES EMPLOYED

Owing to variations in population-pressure and grazing potential, it was decided to limit this campaign to the section of the Letaba river west of the confluence with the Nwanedzi spruit.

All institutions that could possibly benefit from the results obtained from the cropping scheme were approached and their co-operation was solicited. Both the Zoology Department of the Pretoria University and research personnel of the Veterinary Department, Onderstepoort, reacted favourably to this request.

The Zoologists were mainly interested in skeletal and histological material, whereas the veterinarians, and in particular Major McCully, Miss A. Verster and Mr. S. P. Kruger, were mainly concerned with pathological and parasitological aspects, blood serum analysis and the collecting of ecto- and endo-parasites.

Two young hippos were preserved "in toto" and removed to Onderstepoort for anatomical studies.

Use was made of the randomised sampling method in order to obtain a statistically acceptable representation of the age structure of the hippo population.

A wheel, mounted on a horizontal plane, with a bisectional pointer was used. The first hippo to emerge in line with the indicator after the wheel had been spun, was destroyed. In the event of this particular animal submerging before it could be shot, firing was withheld until it emerged again.

Most of the animals were shot in the water, although a few dozing out on the sandbanks were also destroyed. Extreme care was taken not to disturb the animals excessively and operations were continually alternated from one hippo pool to the next, without the destruction of too many animals in any one particular locality.

Animals were destroyed by shooting them through the brain with a heavy caliber rifle (.375 Holland and Holland), and death was instantaneous. The animal sank to the bottom almost immediately. Within a period varying from thirty minutes to a few hours, the bloated carcass rose to the surface with its feet upwards. Immediately after the carcass became visible, a rope was attached to it from an aluminium boat. It was then retrieved by African labourers, who hauled it onto the river-bank, and moved it to a suitable site for flensing.

Each part of the animal, as it was cut off, was weighed on a portable spring balance. The stomach was weighed with and without contents, and a sample of the ingested food material was preserved for differential analysis of food plants and for determination of moisture content.

To ascertain the rate of digestion, fifty percent of the animals were shot early in the morning and the others late in the afternoon. The difference in weight of the stomach contents of comparable animals of the two different groups was subsequently utilised in calculating the rate of digestion. From this figure the total food consumption over a 24 hour period could be derived.

The carcasses of females were carefully examined and all reproduction data was noted on a special form compiled for this purpose. The Senior State Veterinarian from Skukuza, his Technical Assistant and Major McCully performed complete autopsies on all animals. All ecto- and endo-parasites were collected.

The veterinary aspects of their findings will form the basis of a series of papers now in preparation.

After detailed examination, the carcasses were removed to a central camp, which had been established for this purpose. Here the hides were cut into strips for the making of whips and riding crops. The meat, bones, etc. were boiled to comply with veterinary regulations and subsequently transported to consumers outside the Park.

Rangers J. de Kock and D. Ackerman took charge of the actual shooting operations, the retrieving, flensing and preparing of the by-products and with the aid of their African labourers, this was accomplished with remarkable efficiency.

Detailed returns of all data on each hippo were periodically despatched to Skukuza, where these were checked, analysed and filed by the research personnel.

RESULTS.

A. PRODUCTIVITY, AGE STRUCTURE AND REPRODUCTIVE POTENTIAL OF POPULATION.

Fifty-two bulls and fifty-two cows, totalling 104 hippopotami, were destroyed in that part of the Letaba river, west of the Nwanedzi mouth. This indicates a basic sex ratio of 1 : 1.

Sixty-eight were adults, twenty-seven immature animals and nine young calves.

Measurements and weights obtained for each individual suggest a definite correlation between age and weight groups. Amongst the sub-adults, four definite weight classes were determined, which suggests the possibility of four age groups.

A still-born calf weighed only 53 lbs., whereas another very small calf weighed 118 lbs.

A female calf born at the National Zoological Gardens, Pretoria, weighed 94 lbs. and a male calf of the Overton Park Zoo weighed 65 lbs. On the other hand the heaviest foetus found in a total of 169 adult cows destroyed in the Queen Elizabeth Naiotnal Park in Uganda, weighed 137 lbs. A newborn calf in he same area weighed 118 lbs.

The female calf born in the National Zoological Gardens in Pretoria, weighed 300 lbs. at 6 months and during the last four months showed a constant weight increase of ± 1.2 — 1.3 lbs. per day. This calf was hand reared.

Calves suckled by their mothers put on weight much faster during the first six months. (cf. the young male which was reared by its mother in Overton Park and weighed 235 lbs. at 10 weeks, which indicates a weight increase of more than 2 lbs. per day).

If we accept that the average weight at birth is 70 lbs., then it will appear that hippo calves in the natural state, can weigh as much as 600 lbs. a six months, i.e. an average weight increase of 2.9 lbs. per day.

"Year old" calves (6-18 months) would fall in the 600-1,200 lb. class and would grow at an average rate of 1.7 lbs. per day.

The 1,200-1,700 lb. class would include the "two year olds" (18-30 months), and the 1,700-2,100 lb. class the "three year olds" (30-42 months). This is indicative of a weight increase of 1.4 lbs. per day for the first group and 1.1 lbs. per day for the second group.

It would appear that hippos become sexually mature in their third year and calve in their fourth. It was significant in this respect that the youngest cow suckling a calf, weighed 2,196 lbs. (cf. also Jarvis & Morris (1960) who provide data that hippo become sexually active at three years). The gestation period is $7\frac{1}{2}$ to 8 months and pregnant 'three year old'

heifers will drop their calves during their fourth year.

The reproductive organs of a 2,100 lb. female and the testes of a 2,000 lb. male showed that they were already sexually active and this was confirmed by histological examination.

The classification of 104 hippos into age groups resulted in 9 individuals being allocated to each of the 0-6 months (calves of the present season) group, 6-18 months ("one year old"), 18-30 months ("two year old"), and 30-42 months ("three year old") groups. When correlated with the number of cows still in lactation (i.e. 20 adult cows with active mammary glands), the number of suckling calves destroyed during this cropping campaign was far too low. The actual figure should have read 12 out of a total of 107 (see Table below). Sixty-eight hippos were classified as adults and constituted the 2,100-4,000+ lbs. weight class. The heaviest adult bull weighed 4,412 lbs. and the heaviest adult cow 3,696 lbs.

The table below provides a compleie analysis of the age structure and the correlation between age and weight classes of the hippo population in the Letaba river.

Twenty of the thirty-six adult cows destroyed were in lactation, two were pregnant and the balance were neither lactating nor in calf. The mammae of both the pregnant females were inactive. Whenever a lactating cow was shot, it was repeatedly noticed that there were no very young calves in the particular herd. Unlike most other herbivora, it was obvious that hippos suckle their young for an extended period, and in fact even irregularly after the calf commences grazing. Calves born during the previous season were still periodically suckling. Weaning takes place over a long period, and the mammary glands of the mothers only gradually return to the inactive state. It is also apparent that lactating cows are sexually inactive (particularly during the earlier period of lactation).

Despite the relatively short gestation period of eight months, there are numerous indications that hippos calve only once every three years, and not every second year, as is commonly believed. The calves are suckled for more than a year and weaning is gradual. Lang (1962), on the other hand, states that Liberian dwarf hippos *(Choeropsis liberiensis)* in captivity calve every second year.

The National Zoological Gardens, Pretoria, supplied confirmation of the long suckling period. The female calf born in 1964 received one gallon of milk three times per day until the age of 7 months. The milk was then gradually decreased to two bottles per day prior to weaning, but she virtually stopped growing and the milk supply had to be increased. At 10 months, she only weighed 356 lbs., compared to the Overton Park bull calf that weighed 365 lbs. at two-and-a-half months.

At 10 months the calf at the National Zoological Gardens was capable of eating meal and green Kikuyu grass, but its dentition had not developed sufficiently to cope with dry lucerne hay.

It would therefore appear that hippos calve only every third year, and

COMPARISON OF AGE WITH WEIGHT CLASSES OF 104 HIPPOPOTAMI DESTROYED IN THE LETABA RIVER BETWEEN 25.5.1964 — 20.8.1964

MALES (TOTAL 52)

Calves of the present season (0-6 months) *70(53)-600 lbs.*	*'One year olds'* (6-18 months) *600-1,200 lbs.*	*'Two year olds'* (18-30 months) *1,200-1,700 lbs.*	*'Three year olds'* (30-42 months) *1,700-2,100 lbs.*
53 lbs.	780 lbs.	1,364 lbs.	1,765 lbs.
118 lbs.	848 lbs.	1,390 lbs.	1,860 lbs.
466 lbs.	857 lbs.	1,676 lbs.	1,888 lbs.
492 lbs.	956 lbs.		1,904 lbs.
592 lbs.	1,144 lbs.		1,906 lbs.
	1,200 lbs.		2,008 lbs.
Number: 5*	*Number:* 6	*Number:* 3	*Number:* 6
Average weight: 344 lbs.	*Average weight:* 964 lbs.	*Average weight:* 1,477 lbs.	*Average weight:* 1,888 lbs.
Average weight: (♂ and ♀) 395 lbs.	*Average weight:* (♂ and ♀) 1,027 lbs.	*Average weight:* (♂ and ♀) 1,509 lbs.	*Average weight:* (♂ and ♀) 1,903 lbs.

* This figure should be 6-cf. 20 adult lactating cows with 6 suckling male calves and 6 suckling female calves of the present season. The balance of suckling calves are older calves of the previous season, which are still suckling periodically. Examination of the gonads indicate that males in the 2,000 lb. group are commencing sexual activity.

ADULT MALES

2,100-3,000 lbs.		*3,000-4,000 lbs.*		*Over 4,000 lbs.*
2,144 lbs.	2,954 lbs.	3,815 lbs.	3,814 lbs.	4,412 lbs.
2,447 lbs.	2,620 lbs.	3,934 lbs.	3,824 lbs.	4,280 lbs.
2,862 lbs.	2,820 lbs.	3,434 lbs.	3,570 lbs.	4,196 lbs.
2,498 lbs.	2,948 lbs.	3,754 lbs.	3,248 lbs.	4,104 lbs.
2,844 lbs.	2,678 lbs.	3,398 lbs.	3,364 lbs.	4,112 lbs.
2,952 lbs.	2,832 lbs.	3,516 lbs.		4,022 lbs.
2,880 lbs.	2,612 lbs.			
2,372 lbs.				
Number: 15		*Number:* 11		*Number:* 6

Total Adult Males: 32: Average weight of Adult Males: 3,290 lbs. Weight of heaviest Male: 4,412 lbs.

COWS (TOTAL 52)

Calves of the present season (0-6 months) *70-600 lbs.*	*Average weight:* 462 lbs. *'One year olds'* (6-18 months) *600-1,200 lbs.*	*Average weight:* 1,153 lbs. *'Two year olds'* (18-30 months) *1,200-1,700 lbs.*	*Average weight:* 1,525 lbs. *'Three year olds'* (30-42 months) *1,700-2,100 lbs.*
336 lbs.	1,098 lbs.	1,412 lbs.	1,780 lbs.
376 lbs.	1,162 lbs.	1,484 lbs.	1,924 lbs.
544 lbs.	1,200 lbs.	1,500 lbs.	2,092 lbs.
590 lbs.		1,572 lbs.	
		1,588 lbs.	
		1,596 lbs.	
Number: 4*	*Number:* 3	*Number:* 6	*Number:* 3
Average weight: 462 lbs.	*Average weight:* 1,153 lbs.	*Average weight:* 1,525 lbs.	*Average weight:* 1,932 lbs.

* This figure should be 6, i.e. half the number of suckling calves. Cf. number of adult cows in lactation=20 (+4). Twelve of the lactating cows are suckling calves of the present season and the balance, calves of the previous season.

ADULT COWS

2,100-3,000 lbs.		*3,000-3,500 lbs.*		*Over 3,500 lbs.*
2,196* lbs.	2,222 lbs.	3,000 lbs.	3,310 lbs.	3, 696 lbs.
2,468	2,498*	3,205*	3,010	
2,778*	2,904*	3,265	3,034*	
2,728*	2,276	3,252*	3,085*	
2,890	2,594*	3,010	3,292*	
2,740*	2,908 D	3,128*	3,040	
2,976*	2,872*	3,154*	3,064*	
2,960 D	2,668*	3,176+	3,352*	
2,546	2,974*			
2,716				
Number: 19		*Number:* 16		*Number:* 1

Total Adult females: 36. *Average weight of Adult Cows:* 2,920 lbs. Weight of heaviest cow: 3,696 lbs.

* Number of adult females in lactation: 20.

D Number of adult females in calf: 2.

Number of pregnant adult females in lactation: 0.

Number of adult females neither lactating nor in calf: 14.

Youngest lactating female: 2,196 lbs.

Average weight of all females: 2,408.5 lbs.

Average weight of all males: 2,471.6 lbs.

Average weight of all males and females: 2,440.0 lbs.

+ Both macroscopic and microscopic examination of the uterus and ovaries of this animal indicated that she had never calved and was sterile.

SUMMARY OF AGE STRUCTURE OF MALE POPULATION

Age Group	Number	Percentage of total	Percentage of total minus present season's calves
* Present season's calves	5+1=6	11.3%	—
'One year old' calves (6-18 months)	6	11.3%	12.8%
'Two year old' calves (18-30 months)	3	5.7%	6.4%
'Three year old' calves (30-42 months)	6	11.3%	12.8%
† Adult males	32	60.4%	68.0%
Total	53	100.0%	100.0%

* Half the number of suckling calves (i.e. 12).

† Fewer adult males compared to adult females indicates higher mortality amongst adult males (fights).

SUMMARY OF AGE STRUCTURE OF FEMALE POPULATION

Age Group	Number	Percentage of Total	Percentage of Total minus present season's calves
* Present season's calves	4+2=6	11.1%	—
'One year old' calves (6-18 months)	3	5.6%	6.3%
'Two year old' calves (18-30 months)	6	11.1%	12.5%
'Three year old' calves (30-42 months)	3	5.6%	6.3%
Adult cows	36*	66.7%	75.0%
Total	54	100.1%	100.1%

* 20 Females in lactation. (12 Females were suckling calves of the Present season. The balance were suckling the previous season's calves.)

Basic sex ratio of 104 hippos=52 males: 52 females, i.e. 1 : 1.

SUMMARY OF AGE STRUCTURE OF ENTIRE HIPPO POPULATION (MALE AND FEMALE)

	Number	Percentage of Total	Percentage of Total minus present season's calves
* Present season's calves	12	11.2%	—
'One year old' calves (6-18 months)	9	8.4%	9.5%
'Two year old' calves (18-30 months)	9	8.4%	9.5%
'Three year old' calves (30-42 months)	9	8.4%	9.5%
Adult animals	68	63.6%	71.5%
Total	107	100.0%	100.0%

MORPHOMETRICS OF IMMATURE MALES (Total 20)

Date destroyed	Weight	Estimated weight at birth	Length (Head to base of tail)	Weight increase since birth	Estimated average weight increase per day	Age Month + Days (months) = Months	Month of Birth	Circumference of Chest	Shoulder height	Length of lower canine
2.7.64	53 lbs.	53 lbs.	3 ft. 0 inch	—	—	— + — = 0.5	July	2 ft. 1 inch	1 ft. 5 inch	—
23.7.64	118	70	4 2½	48 lbs.	2.9 lbs.	— + 16.6 (0.5) = 0.5	July	3 5	2 0	—
3.8.64	466	70	5 6	396	2.9	— + 137 (4.6) = 4.6	March	5 2	3 0	—
29.6.64	492	70	5 6½	422	2.9	— + 146 (4.9) = 4.9	February	4 10½	2 3½	½ inch
16.7.64	592	70	6 1	522	2.9	— + 180 (6.0) = 6.0	January	5 0	3 0	¼
				Over 600 lbs.)						
19.8.64	780	70	6 11	180	1.7	6 + 106 (3.5) = 9.5	November	5 10	3 2	1
23.6.64	848	70	6 10	248	1.7	6 + 146 (4.9) = 10.9	July	5 11	2 11½	2½
2.7.64	857	70	6 10	257	1.7	6 + 151 (5.0) = 11.0	End July	5 5	3 4	0¼
16.7.64	956	70	7 2	356	1.7	6 + 209 (6.9) = 12.9	June	6 5	3 5	3
9.7.64	1144	70	7 9	544	1.7	6 + 320 (10.7) = 16.7	February	6 6½	3 6	4
25.5.64	1200	70	7 3	600	1.7	6 + 353 (11.8) = 17.8	December	6 6	3 8	1½
				(Over 1200 lbs.)						
16.7.64	1364	70	8 0	164	1.4	18 + 117 (3.9) = 21.9	September	6 10½	3 3	5½
27.7.64	1390	70	7 9	190	1.4	18 + 136 (4.5) = 22.5	September	6 7½	3 2	4¾
12.8.64	1676	70	8 6	476	1.4	18 + 340 (11.3) = 29.3	March	7 7½	3 4	5½
				(Over 1700 lbs.)						
12.8.64	1765	70	8 8	65	1.1	30 + 59 (2.0) = 32.0	December	7 5	4 5	5½
30.7.64	1860	70	8 3	160	1.1	30 + 145 (4.8) = 34.8	August	7 8	3 10	5½
7.7.64	1888	70	8 6	188	1.1	30 + 171 (5.7) = 35.7	July	8 0½	3 10	5½
23.6.64	1904	70	8 7	204	1.1	30 + 185 (6.2) = 36.2	June	7 5	4 0	5
28.7.64	1906	70	8 9	206	1.1	30 + 187 (6.2) = 36.2	July	7 8	4 0	5
12.8.64	2008	70	9 3	308	1.1	30 + 280 (9.3) = 39.3	May	7 8	4 7	5½

0-6 Months

70(53)-600 lbs. — 530 lbs. Weight increase 2.9 lbs. per day.

18-30 Months

1,200-1,700 lbs. — 500 lbs. Weight increase 1.4 lbs. per day.

618 Months

600-1,200 lbs. — 600 lbs. Weight increase 1.7 lbs. per day.

30-42 Months

1,700-2,100 lbs. — 400 lbs. Weight increase 1.1 lb . per day.

MORPHOMETRICS OF IMMATURE FEMALES (Total 16)

Date destroyed	Weight	Estimated weight at birth*	Length (Head to base of tail)	Weight increase since birth	Estimated average weight increase per day	Age Month + Days (months) = Months	Month of Birth	Circumference of Chest	Shoulder Height	Length of Lower Canine	Percentage of Total
7.7.64	336 lbs.	70 lbs.	4 ft. 11½ inch	266 lbs.	2.9	— + 92 (3.2) = 3.2	April	4 ft. 2 inches	2 ft. 5 inches	—	
7.7.64	376	70	4 10	306	2.9	— + 106 (3.5) = 3.5	March	4 0	2 7½	—	
28.7.64	544	70	5 10	474	2.9	— + 163 (5.4) = 5.4	February	5 1	2 8	¼ inch	25.0%
25.6.64	590	70	5 8	520	2.9	— + 179 (6.0) = 6.0	December	5 2	2 9	¼	
				(Over 600 lbs.)							
22.7.64	1098	70	7 0	498	1.7	6 + 293 (9.8) = 15.8	March	6 9½	3 9½	1½	
17.8.64	1162	70	7 5	562	1.7	6 + 331 (11.0) = 17.0	March	6 5	3 9	2½	19.0%
+11.8.64	1200	70	9 1 (Very lean)	600	1.7	6 + 353 (11.8) = 17.8	February	7 8	4 6	4	
				(Over 1200 lbs.)							
5.8.64	1412	70	7 4	212	1.4	18 + 151 (5.0) = 23.0	September	7 5	4 0	2½	
16.7.64	1484	70	7 2½	284	1.4	18 + 203 (6.8) = 24.8	June	7 1¾	4 1	2½	
=20.8.64	1500	70	8 4	300	1.4	18 + 214 (7.1) = 25.1	July	7 6	3 9	4	37.0%
18.6.64	1572	70	7 5½	372	1.4	18 + 266 (8.9) = 26.9	March	7 4	4 0	3¼	
=4.8.64	1588	70	8 4	388	1.4	18 + 277 (9.2) = 27.2	May	7 0	4 3½	4	
30.7.64	1596	70	7 8	396	1.4	18 + 283 (9.4) = 27.4	April	7 3	4 0	2	
				(Over 1700 lbs.)							
18.6,64	1780	70	8 3	80	1.1	30 + 73 (2.4) = 32.4	September	7 5	4 3½	3¼	
18.8.64	1924	70	9 1½	224	1.1	30 + 204 (6.8) = 36.8	July	7 10	3 11	4¼	19.0%
13.7.64	2092	70	9 2	392	1.1	30 + 356 (11.9) = 41.9	February	7 6	4 8	4½	

0-6 months

70-600 lbs. — 530 lbs. Weight increase 2.9 lbs. per day.

6-18 months

600-1,200 lbs. — 600 lbs. Weight increase 1.7 lbs. per day.

18-30 Months

1,200-1,700 lbs. — 500 lbs. Weight increase 1.4 lbs. per day.

20-42 months

1,700-2,100 lbs. — 400 lbs. Weight increase 1.1 lbs. per day.

* Average of three known birthweights, i.e. 94 lbs., 65 lbs. and 53 lbs.

\+ Apparently a very lean 'three year old'.

= Probably also lean 'three year olds'.

of the 20 lactating cows that were destroyed, only 12 could possibly have been suckling calves born during the preceeding breeding season, i.e. calves less than 6 months old. The remaining 8 possibly still periodically suckled older calves or were in the process of returning to the non-lactating state. A further 4 adult cows had probably weaned their calves of the previous season and would only mate again during the following year. The remaining 12 non-lactating cows (out of a total of 36 destroyed) would possibly only mate during the mating season of 1964 and calve in 1965. Two were already pregnant and carried very young embryos.

The postulation of a time lapse of three years between hippo calves also agrees with the findings of Bere (1959) in the Queeen Elizabeth Park, Uganda. Forty-one percent of a total of 169 adult hippo cows destroyed there were lactaiing and 22 percent were pregnant. Another 5 percent were pregnant but with evidence also of active mammary glands. The sex ratio of foetuses was 45 males: 47 females, with 8 of uncertain sex.

The number of calves born in any one season, when correlated with the number of one year-, two year- and three year old calves, indicates a mortality rate of 16.6% amongst the very young calves. Five out of every six newborn calves survive the first critical year. This is a realistic mortality rate, and is further evidence in favour of the supposition that hippos calve every third year. Should they calve every second year, the mortality amongst the young calves would have to be 50% to substantiate the present findings. This is decidedly not the case. After the first year the life expectancy of calves is high, and natural mortality is negligible.

Of the 68 adults, 32 were bulls and 36 cows. This indicates a slightly higher mortality for adult males than females. Fighting for territorial rights or during the mating season, could generally be responsible for this higher mortality rate.

Life expectancy of hippos in their natural state may be 40 years. The maximum age attained by a hippo in captivity was $41\frac{1}{2}$ years. This was a female in the Jardin des Plantes, Paris. (Bigalke, 1939).

Reproduction data gained from the 36 adult cows during the cropping scheme, indicates that hippos have a fairly well defined breeding season, which coincides with the most favourable grazing period. In the Letaba river calving commences in December and continues to the end of July, with a peak period from the middle of March to the middle of June. (In the more southern rivers young calves are regularly recorded in November). A gestation period of 8 months (210-250 days, average 237.4 $\pm$ 1-2 days. Kenneth & Ritchie (1953)), would specify a mating season lasting from April to the end of November, with a peak period from the middle of July to the middle of October. This has been confirmed by repeated field observations during the culling period. (cf. Histogram below).

These phenomena find no mention anywhere in the literature but are factual features of the present study. Hippos in captivity breed throughout the year and there is no indication of a breeding season. (Zuckerman, 1953; Brand, 1963).

A further 10 adult hippo cows were destroyed during October and November and data obtained from these confirms the earlier findings. Two of the three destroyed during October were lactating and the third was neither lactating nor pregnant. Similarly 6 of the 7 destroyed during November were in lactation and the seventh was dry. One of the lactating cows had a ± 3 inch embryo.

It would be advisable to conduct future control measures also during the summer and autumn months, i.e. from October to the end of May, in order to obtain more detailed and complete reproduction data.

With the known rate of growth as a basis, it is interesting to note that by reducing their weight in terms of months and days, the majority of young animals destroyed, appeared to have been born during the period from December to the end of July. (See tables above).

Assuming that a female hippo gives birth to female and male offspring alternately, and if we accept that females attain puberty at three years of age, and subsequently calve every third year, one couple would theoretically be responsible for a progeny of 38 (representing six generations) over 20 years, provided the first calf is a female. In the event of it being a male, the figure would be 24. This, however, would be purely theoretical, and mortality figures are not even considered.

With the facts at our disposal, a life table of a group of 57 female hippos in 1964, shows that they will multiply to a total of 484 in 1984. (See table). By using a life table the nett annual recruitment may be calculated with ease, and, consequently the annual culling figure for all age groups (if the total population is to remain static). An equal number of males will also have to be destroyed.

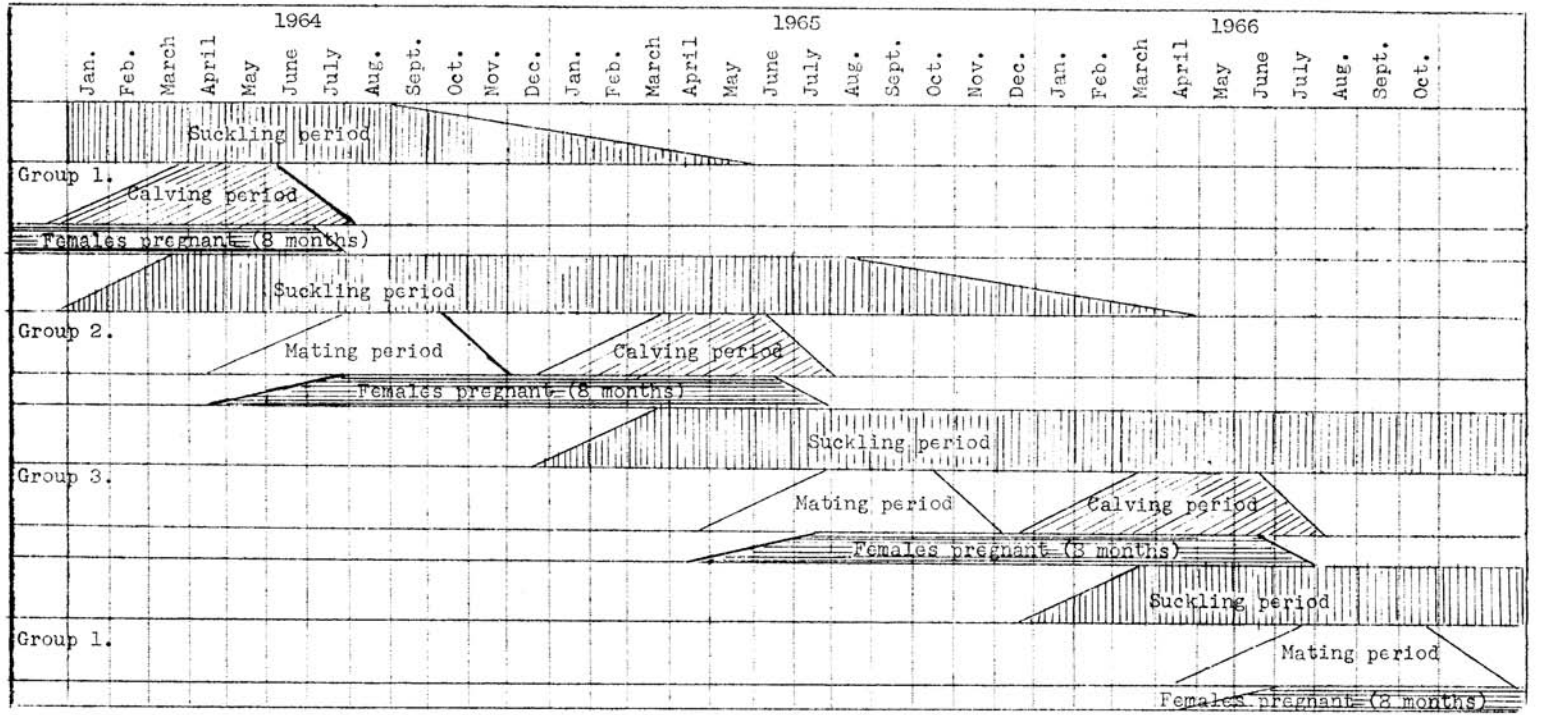
B. GRAZING HABITS, FOOD AFFINITIES AND DAILY CONSUMPTION.

In view of the fact that hippos are nocturnal grazers, very little is known about their feeding habits. The available data was mainly derived from sporadic observations, and usually from the odd individual that one periodically finds grazing by day during cool weather. Field observations during the hours of darkness would be virtually impossible.

Under normal conditions, and with sufficient grazing available, hippos tend to remain close to the reed covered river beds and banks. Conditions during the time of the experiment, were abnormal, however, and it was found that hippos, as a result of the food shortage, grazed far inland — in fact, a matter of several miles.

Hippos, unlike other grazing animals (zebra, elephant and white rhino excepted), do not utilise their tongues to draw the grass over their incisors. Food plants, mainly grass, are clamped between the horizontal, horny ridges of the lips and are plucked with an upward sweep of the head. The animal has then to open its mouth again for the act of swallowing, and a certain amount of food is inevitably dropped in the process. In determining food consumption, as with elephants, a percentage of waste has to be considered.

DIVISION OF BREEDING SEASONS OF THREE GROUPS OF ADULT HIPPO FEMALES, DURING CONSECUTIVE YEARS.



Selective grazing is only possible in the case of homogeneous stands of such food plants as *Phragmites communis* and *Panicum maximum*, as the cavernous mouth of the hippo and its method of grazing in not conducive to selectivity. Bere (1959), however, finds hippos highly selective feeders in the Queen Elizabeth Park.

Stomach contents of 40 of the experimental animals were examined and with the exception of a negligible amount of leaves and twigs of dicotyledonous plants (probably accidently ingested), they were found to contain virtually only grass. Earlier observations indicated that a certain amount of dicotyledons was sometimes eaten, but this would be the exception rather than the rule. This is confirmed by Bere (1959), who states: "Stomach samples were saved from 122 specimens (hippos) and all were found to contain 100 per cent grass. There is no evidence of browse or of any forage being obtained from aquatic vegetation".

A complete list of species eaten by hippos will only be available after thorough microscopic investigation of stomach contents. From field observations however, the following list can be accepted as a guide:

Monocotyledons

*Chloris gayana, Panicum deustum, *Panicum maximum, *Phragmites communis, Themeda triandra, *Cynodon dactylon, Eriochloa* sp., *Loudetia filifolia, Hemarthria altissima, Cyperus sexangularis, *Cyperus* sp., *Typha capensis.*

Dicotyledons

Colophospermum mopane, Salix sp., *Nicotiana glauca, Euclea divinorum.*

* Staple food items.

During the experiment samples of stomach content of the first 40 animals were preserved for determination of moisture content, and for subsequent microscopic examination.

Directly after the total stomach contents were weighed, 450 gram samples were taken, made up of random collections from different parts of the food mass. These were preserved in 10% Formalin in glass jars and taken to the laboratory as soon as possible. Here the formalin and digestive juices were carefully washed out of the samples. Care was taken not to lose any of the material. The washed material was transferred to preweighed glass beakers and dried to a constant weight in a drying oven at 102°C. The accuracy of this method was confirmed by the fact that there was only a 10% variation in moisture content. Moisture contents ranged from 76%-86% with an average of 81.3%.

In a similar experiment in the Queen Elizabeth Park, it was assumed that the complete digestive process is completed in 24 hours. (cf. Bere (1959), who states that the total stomach content represents the total intake per day). In the present study it was attempted to calculate food intake without making use of assumptions, and it was therefore, decided to shoot approximately 50% of the experimental animals early in the morning and the rest in the late afternoon. In this way a definite figure, based on the difference

in weight of morning and afternoon stomach contents per unit of body weight, representing the loss or passage of food from the stomach to the rest of the alimentary tract, could be obtained. This difference in weight for the specified period was converted for a 24 hour period. This figure would then represent the amount eaten during the night to compensate the loss of food material from the stomach from one morning to the next. It was not always possible to adhere to this program, therefore 21 animals had to be ignored unfortunately, as they were shot either after 10 a.m. or before 3 p.m.

This method certainly provided valuable information as will be noted from the data below. (Fig. I and II). It soon became apparent that the experimental number was too small to differentiate between age or smaller weight groups. This, in any case, would only be of academic interest, as the difference in rate of digestion and total consumption between immature and mature animals is not of importance in this treatise. The general average figure is all that is needed.

The influence of temporary disturbane of the animals during the culling campaign could possibly have been a factor in confusing the general grazing pattern. It was noticed that where operations continued for some days in the same locality, some of the animals did not leave the water to graze at night. Consequently, stomach contents taken the following day did not provided the correct information. This could have been responsible for the great variation in the weight of stomach contents in the same weight class and group (morning and afternoon). Therefore animals shot on the second and subsequent days at a particular locality, were excluded from these calculations. When operations at a certain locality re-commenced within a week, no data from these animals was used. Nothing definite could be concluded from this theory in respect of individual variation, but the greater average excretion per animal does indicate some effect. (See Fig. II). Availability of food in a specific area must still be considered as the biggest single factor determining stomach content variation.

Data for each individaual animal concerned in this aspect are provided in Tables I and II. Weight of stomach content is subtracted from the total weight of the animal because the previously mentioned variation confused subsequent calculations. The same was also deemed necessary in the case of Table III. The basis for determining the rate of excretion per weight unit is therefore the total body weight (including the intestines and their contents) minus the stomach content.

It is a physiological fact that digestion is stimulated by food intake as well as physical activity. Nocturnal excretion, when the animals are grazing, would therefore be higher. Unfortunately, because of the absence of adequate data, assumptions have to be made. After thorough discussion and considering domestic animal habits, it was felt that in the hippo, the nocturnal tempo of excretion could not be more than 1.5x the diurnal rate (the inactive period). This assumption is brought into calculation in Table

FIG. I.

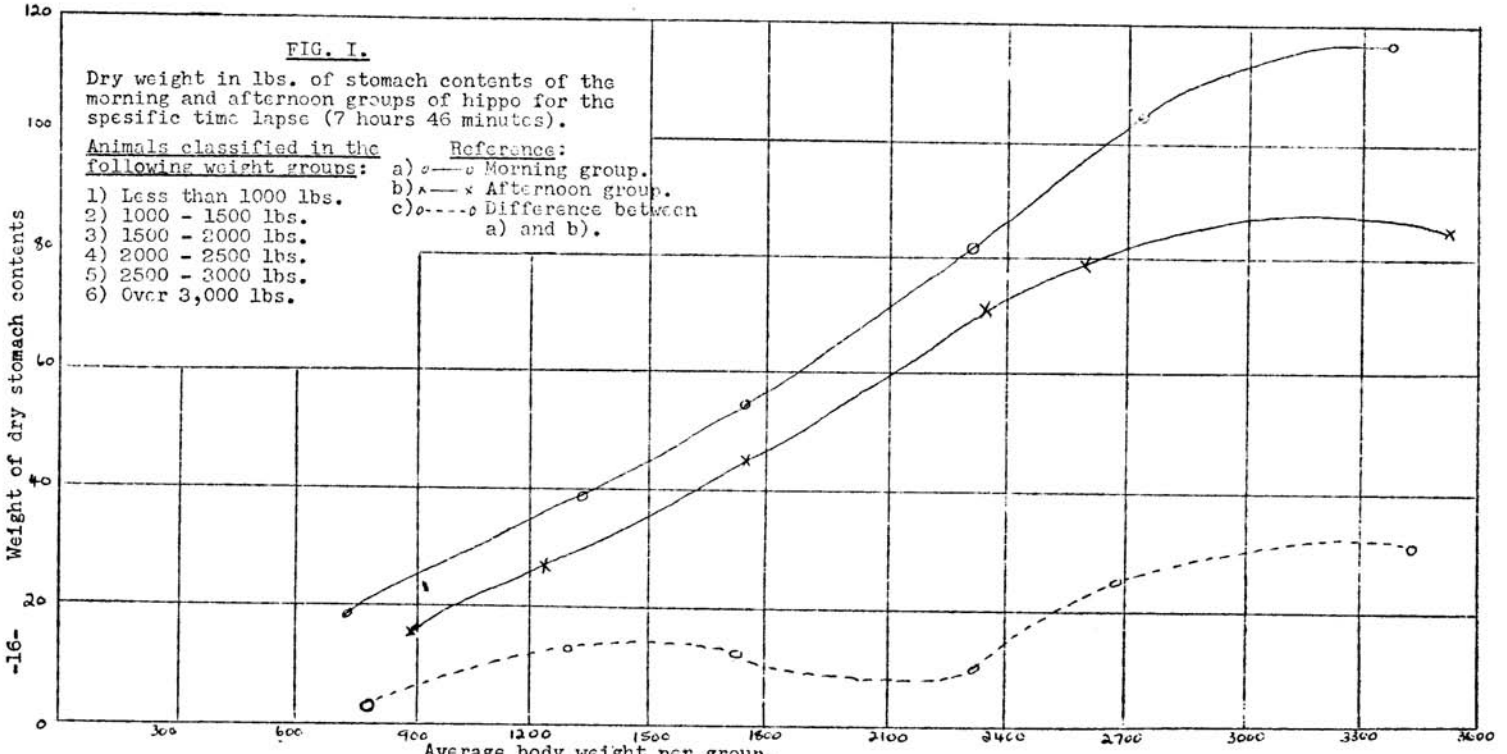
Dry weight in lbs. of stomach contents of the morning and afternoon groups of hippo for the spesific time lapse (7 hours 46 minutes).

Animals classified in the following weight groups:

1) Less than 1000 lbs.
2) 1000 - 1500 lbs.
3) 1500 - 2000 lbs.
4) 2000 - 2500 lbs.
5) 2500 - 3000 lbs.
6) Over 3,000 lbs.

Reference:

a) o—o Morning group.
b) ∧—× Afternoon group.
c) o----o Difference between a) and b).



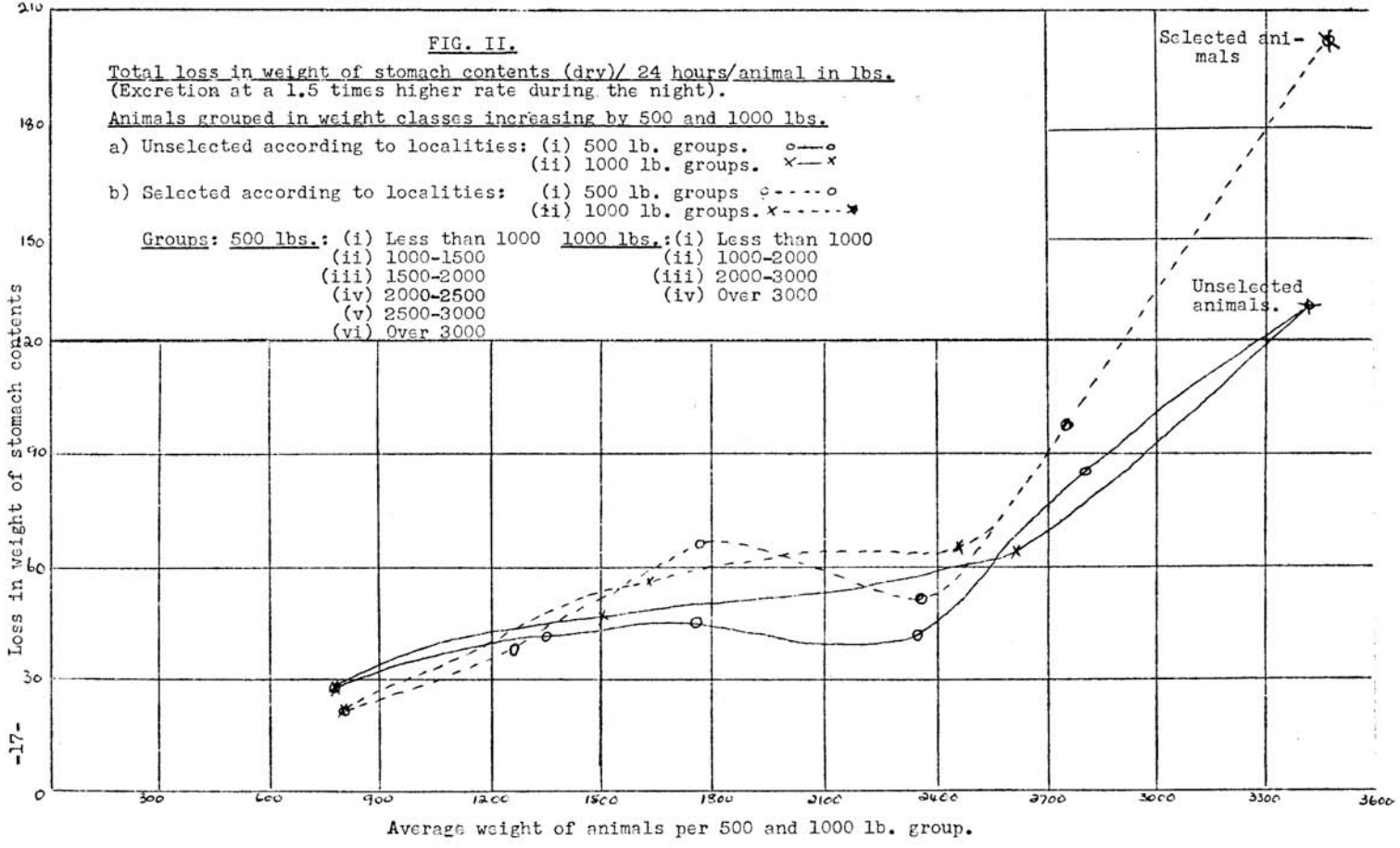


FIG. II.
Total loss in weight of stomach contents (dry)/ 24 hours/animal in lbs.
(Excretion at a 1.5 times higher rate during the night).
Animals grouped in weight classes increasing by 500 and 1000 lbs.
a) Unselected according to localities: (i) 500 lb. groups.
(ii) 1000 lb. groups.
b) Selected according to localities: (i) 500 lb. groups
(ii) 1000 lb. groups.
Groups: 500 lbs.: (i) Less than 1000
(ii) 1000-1500
(iii) 1500-2000
(iv) 2000-2500
(v) 2500-3000
(vi) Over 3000
1000 lbs.: (i) Less than 1000
(ii) 1000-2000
(iii) 2000-3000
(iv) Over 3000
Selected animals
Unselected animals.
Loss in weight of stomach contents
0
30
60
90
120
150
180
210
300
600
900
1200
1500
1800
2100
2400
2700
3000
3300
3600
Average weight of animals per 500 and 1000 lb. group.

TABLE I — BODYWEIGHT AND WEIGHT OF STOMACH CONTENTS (in lbs.) OF 52 HIPPOS SHOT BETWEEN 7.00 AND 10.00 a.m.

Time	Total weight	Bodyweight (Total weight less stomach contents)	Weight of wet stomacr contents	Weight of dry stomach contents
8.15	492	470	22	4.1
8.55	590	550	40	7.5
10.00	956	860	96	18.0
8.50	1200	936	264	49.4
9.00	1390	1204	186	34.8
8.30	1412	1228	184	34.4
8.00	1484	1320	164	30.7
9.00	1500	1326	174	32.5
7.10	1596	1348	248	46.4
9.45	1765	1451	314	58.7
9.45	1780	1560	220	41.1
8.55	1860	1596	264	49.4
8.05	1904	1600	304	56.8
8.25	1924	1680	244	45.6
8.30	2196	1688	508	95.0
8.55	2008	1730	278	52.0
8.50	2092	1782	310	58.0
8.45	2144	1908	236	44.1
8.30	2276	1960	316	59.1
8.30	2372	2004	368	68.8
8.45	2447	2075	372	69.6
8.30	2620	2180	440	82.3
8.30	2546	2194	352	65.8
8.15	2612	2272	340	63.6
9.00	2872	2288	584	109.2
9.05	2716	2306	410	76.7
9.10	2778	2318	460	86.0
9.35	2832	2340	492	92.0
9.30	2890	2386	504	94.2
8.55	2904	2420	484	90.5
9.30	2862	2430	432	80.8
9.05	2948	2458	490	91.6
8.30	2820	2460	360	67.3
8.30	3040	2500	540	101.0
8.10	3034	2540	494	92.4
8.25	3292	2572	720	134.6
10.00	3252	2620	632	118.2
8.20	3205	2880	525	98.2
8.35	3176	2760	416	77.8
8.00	3248	2764	484	90.5
8.35	3516	2800	716	133.9
8.30	3364	2864	500	93.5
8.20	3398	2910	488	91.3
8.45	3570	2950	620	115.9
9.30	3824	3244	580	108.5
9.45	3696	3248	448	83.8
10.00	3754	3274	480	89.8
8.15	3934	3304	630	117.8
8.45	4104	3344	760	142.1
9.00	4022	3426	596	111.5
7.40	4112	3476	636	118.9
8.20	4412	3596	816	152.6
Total	136,741	115,200	21,541	4,028.3
Average 8.46	2,630	2,215	414	77.5