2014
Southern Ground Hornbill
Bucorvus leadbeateri

PAAZA African Preservation Programme
Husbandry Manual

Photo: T Rehse

PAAZA
Pan-AFRICAN ASSOCIATION of ZOOS and AQUARIA

Editor: Tracy Rehse
National Zoological
Gardens of South Africa

Publication number: PP90/3-14

Table of Contents

Introduction

This is the second edition of the Southern Ground Hornbill (*Bucorvus leadbeateri*) husbandry manual produced under the auspices of the Pan African Association of Zoos and Aquaria (PAAZA). It has been created by a variety of conservation professionals, with experience in both the captive as well as the *in situ* environments, giving a well-rounded approach to Southern Ground Hornbill Husbandry.

The African Preservation Programmes (APP's) of PAAZA are multi-institutional zoo based conservation programmes that involved both an *ex-situ* as well as an *in-situ* element. The Husbandry Manual for the species is a vital component of these programmes, describing current methods of best practice for captive management. This is a living document and is to be updated as and when new information, ideas or challenges come to light.

Acknowledgements

This document is a collaboration of many different people and institutions involved with Southern Ground Hornbill conservation on the African continent. Most are still actively involved in this effort within the PAAZA region, some have moved facilities or even continents since the first draft of this document was produced, but all have given valuable input into the captive husbandry of this species.

I would just like to thank all of those who have contributed their knowledge, expertise, wisdom and blood, sweat and tears to produce a comprehensive manual to guide, and hopefully inspire, others who wish to take part in the conservation of these enigmatic birds.

National Zoological Gardens of South Africa
Mabula Ground Hornbill Conservation and Research Project
Boscia Birds
Loskop Dam Nature Reserve
Umgeni River Bird Park
Montecasino Bird Gardens
Johannesburg City Parks and Zoo

Chapter 1: Natural history

Ann Turner*, Alan Kemp*, Dee De Waal*, Nick Theron*, Ben Botlhole*, Gillian Theron*, Delecia Gunn** and Lara Jordan***.

* Mabula Ground Hornbill Conservation and Research Project

** Loskop Dam Nature Reserve

*** Johannesburg City Parks and Zoo

1. Indigenous folklore

The ground hornbill is also known as a 'Thunder' or 'Rain' bird and they were held in awe by many of the Xhosa-speaking Pondos of the Transkei area. People regarded them as being in league with the witch doctors that were said to use them to further their nefarious works. During times of crippling drought people believed it was perfectly feasible to harness the powers of this bird in order to bring rain. The unfortunate bird would be caught, a rock was tied to its neck and it was hurled into the water. Copious rains were guaranteed to follow this operation within a very short time (Nevill 1984).

2. Distribution

The Southern Ground Hornbill *Bucorvus leadbeateri* was formally distributed throughout Africa south of the Equator, including Rwanda; Burundi; S Kenya; north to Eldoret and Turkwell R; SE DRC; Tanzania (accidental to Zanzibar); Angola; Zambia; Malawi; N Namibia; N and E Botswana; Zimbabwe; Mozambique; N and E South Africa in Transvaal; Natal; and E cape Provinces (Kemp 1995, Eskom Red Data book).

However is has disappeared from several parts of its former range, maybe as much as 70% in South Africa and Zimbabwe. The core concentrations in South Africa lie in the extensive conservation areas of the Kruger National Park (KNP) and adjacent private reserves (Tarboton 1987 in Kemp 2000), the conservation and farming areas of northern and midland KwaZulu-Natal (Cyrus & Robson 1980; Knight 1990 in Kemp 2000), and the rural areas of the Eastern Cape (Vernon 1986). It occurred at low densities in Swaziland and a gap in the range is becoming apparent, separating the population in northern KwaZulu-Natal and southern KNP (ASABI; 708-709 in Kemp 2000).

Historical records indicate a much (at least 50%) wider distribution in Gauteng, North West, Limpopo and Mpumalanga Provinces, having been in the Magaliesberg near Hartebeesport and Pretoria and at the Limpopo-Marico confluence during 1842, at Loskop, Nylsvlei and Northam in the 1940's, and Haenertsberg, Pilgrims Rest and Hanglip up to the 1970's. It was recorded near Durban's Umlaas River in KwaZulu-Natal in 1840. It decreased in the grasslands of the Eastern Cape between 1900-1970. The overall range has decreased less, and no major declines have been reported since the early 1980's (Kemp 2000) although there are now concerns for northern KZN, Swaziland and southern Mpumalanga.

3. Threats

The Southern Ground Hornbill feeds over a wide range of savannah, grassland and farming habitats. Its primary threat is loss of habitat. This affects both quality of foraging habitats and loss of suitable breeding sites through human exploitation of trees, with firewood being removed and perhaps reducing the number of available nest sites (Johnson *et al*. 1998 in BBC Wildlife May 1996). The hornbills need a tree with a cavity with an internal diameter of at least 40cm. The aptly named leadwood is the most frequently used and long-lasting tree site in South Africa, but also the softer-wooded fig, ebony, marula and, where it occurs, the mighty boabab. Conservation of these key tree species is as important as caring for the hornbills themselves. Over-utilization of savannas, leading to loss of ground cover and/or encroachment of woody bushes, and afforestation of grasslands both lead to reduction in the quality and area of foraging habitat available to the hornbills.

Groups have also been eliminated by indirect poisoning during campaigns against livestock-predators and rabies-carriers, to which their systematic terrestrial foraging makes them prone. Secondary trapping and snaring is also a probable cause for the same reasons. Unfortunately they are persecuted in developed areas, where their aggressive territoriality leads to attacks on and shattering of their reflection in window panes often leading to the bird being destroyed (Kemp 2000).

Another reason for its decline are body parts used for traditional practices associated with rain-making, mainly during drought. It has emerged as the animal species of most conservation concern from traditional medicinal use in South Africa (Maner *et al*. 1997 in Kemp 2000). Electrocution on power lines and the trade in the exotic bird industries often to supply zoos, are also thought to have an impact (pers comms Anne Turner).

Southern Ground Hornbill are also limited by availability of food. Their slow-breeding rates, (groups fledging one chick every nine years on average in South Africa) their delayed maturity and low adult mortality, around two percent per annum, make them susceptible to persecution and slow to recover from its effects. Together, this causes them to be rendered Vulnerable at least (Kemp 2000).

Chapter 2: Demographic analysis

Tracy Rehse
National Zoological Gardens of South Africa

The demographic analysis is derived from data from birds of southern African origin, which form the core of the captive management programme.

1. Summary

	Total	Males	Females
Life Table Summary (years)			
r	-0.030 <> -0.005 <> 0.016	-0.027 <> -0.002 <> 0.019	-0.046 <> -0.009 <> 0.020
λ	0.970 <> 0.995 <> 1.016	0.974 <> 0.998 <> 1.019	0.955 <> 0.991 <> 1.020
T	17.9 years	17.7 years	18.2 years
Ro	0.883	0.861	0.904
Mortality			
30 Day Mortality	0.28 (N=100)	0.30 (N=49)	0.27 (N=51)
0 Age Class Mortality	0.45 (N=77)	0.47 (N=37)	0.44 (N=40)
Avg. Pre-Repro Mortality	0.14 (N=50)	0.12 (N=24)	0.16 (N=26)
Avg. Repro Mortality	0.05 (N=18)	0.04 (N=10)	0.06 (N=8)
Avg. Post-Repro Mortality	0.19 (N=1)	0.00 (N=0)	0.25 (N=1)
Survival (years)			
Lx = 0.50	3.1	2.8	3.4
Lx = 0.25	18.9	24.1	13.7
Lx = 0.10	∞	∞	28.3
Lx = 0.05	∞	∞	28.6
Lx = 0.01	∞	∞	28.9
Life Expectancy	∞	∞	10.8
Oldest Currently Living	27.3 (ID:16)	27.3 (ID:16)	27.2 (ID:19)
Oldest Recorded	28.0	27.3	28.0
Reproduction (years)			
Earliest	6	9	6
Latest	26	26	24
Average Mx	0.2 (N=18)	0.1 (N=10)	0.2 (N=8)

2. Age Parameters Report

Ages at death for animals surviving to at least 30 days

	25th %tile	Median	75th %tile	Maximum	N
Males:	5M,5D	2Y,6M,20D	7Y,8M,23D	~24Y	27
Females:	10M,2D	4Y,1M,26D	11Y,7M,7D	~28Y	32
Unknown sex:	1M,11D	4M,2D	8M,24D	~16Y	19

Ten oldest males:

8 Wild hatched Died at PRETORIA/900397 at age of ~24Y 'HOUDINI'
In captivity for ~23Y

28 Wild hatched Died at PRETORIA/903779 at age of ~22Y,7M 'ODZI 91'

10 Wild hatched Died at B G BOTSW/NONE at age of ~16Y 'BOT 1'
In captivity for ~11Y

56 Wild hatched Died at MABULAGHP/NONE at age of ~15Y 'HOGAN'
In captivity for 10Y,2M,21D

T03 Unk hatch type Died at RHINOLION/NONE at age of Unknown '3 MARK'
In captivity for ~0D

54 Wild hatched Died at HAENERTSB/905273 at age of ~10Y,1M,10D 'KUMANE 2'

161 Wild hatched Died at QUEENS PK/NONE at age of ~9Y
In captivity for ~2Y

13 Wild hatched Died at KRAAIFONT/930095 at age of ~9Y 'GRAVELOT'
In captivity for 4Y,6M,2D

62 Wild hatched Died at BESTER/_____ at age of ~7Y
In captivity for ~4Y

58 Wild hatched Died at HAECHETZ/NONE at age of 6Y,10M,29D 'CHICK 1/98'

Ten oldest females:

12 Wild hatched Died at PRETORIA/902554 at age of ~28Y 'PENDUGA'
In captivity for ~26Y

27 Wild hatched Died at KRAAIFONT/081011 at age of ~19Y,8M

22 Wild hatched Died at BOSHOFF C/NONE at age of ~19Y 'UMGENI'
In captivity for ~16Y,10M

76 Wild hatched Died at LOSKOP NR/NONE at age of 14Y,10M,0D 'DUDU'

4 Wild hatched Died at PRETORIA/904907 at age of ~13Y
In captivity for ~6Y

73 Wild hatched Died at MABULA/NONE at age of 12Y,10M,9D 'KINGFISHER'

3 Wild hatched Died at PRETORIA/904906 at age of ~12Y
In captivity for ~3Y

160 Wild hatched Died at QUEENS PK/NONE at age of ~11Y
In captivity for ~4Y

40 Wild hatched Died at PRETORIA/904196 at age of ~11Y,7M,7D 'BATELEUR 93/94'

9 Wild hatched Died at PRETORIA/904910 at age of Unknown
In captivity for ~5Y,7M

Ten oldest unknown sex:

2 Wild hatched Died at PRETORIA/904904 at age of ~16Y
In captivity for ~13Y
1 Wild hatched Died at PRETORIA/904903 at age of ~16Y
In captivity for ~12Y
7 Wild hatched Died at PRETORIA/904909 at age of Unknown
In captivity for ~10Y
6 Wild hatched Died at PRETORIA/904908 at age of Unknown
In captivity for ~10Y
5 Wild hatched Died at PRETORIA/904905 at age of ~10Y
In captivity for ~5Y
T01 Wild hatched Died at VORSTER B/NONE at age of ~8Y
In captivity for ~8Y
23 Wild hatched Died at BLANTYRE/NONE at age of Unknown
In captivity for ~2Y
144 Wild hatched Died at PRETORIA/910820 at age of Unknown
In captivity for 2Y,6M,16D
148 Wild hatched Died at PRETORIA/910824 at age of Unknown
In captivity for 11M,2D
147 Wild hatched Died at PRETORIA/910823 at age of Unknown
In captivity for 5M,2D

Note that median ages are for dead animals only and are NOT average lifespans.

Ages for animals surviving to present

	25th %tile	Median	75th %tile	Maximum	N
Males:	2Y,3M,17D	5Y,10M,20D	18Y,3M,15D	27Y,2M,27D	42
Females:	2Y,2M,18D	4Y,2M,25D	7Y,5M,29D	~27Y,2M,22D	36
Unknown sex:	3M,14D	5M,16D	1Y,6M,25D	~12Y	16

Ten oldest living males:

16 Wild hatched At UMGENI PK/935 at age of 27Y,2M,27D 'MARALYN'
T64 Captive hatched At SWAZILAND/NONE at age of ~24Y
49 Wild hatched At LOSKOP HP/NONE at age of ~24Y 'RAMOND'
In captivity for ~19Y,5M,5D
29 Wild hatched At PRETORIA/903780 at age of ~23Y,2M 'CHIREDZI'
30 Wild hatched At TRNSV SNK/03181 at age of 22Y,4M,27D 'HUGO'
33 Wild hatched At LORY PARK/0034 at age of 22Y,2M,15D 'ELVIS'
34 Wild hatched At TRNSV SNK/03179 at age of 22Y,2M,13D 'DEREK'
61 Wild hatched At BESTER/_____ at age of ~19Y
In captivity for ~16Y
50 Wild hatched At LOSKOP HP/NONE at age of ~18Y,4M 'MALELANE'
51 Wild hatched At MOHOLOHOL/NONE at age of ~18Y,4M,10D 'METSI 2'

Ten oldest living females:

19 Wild hatched At LOSKOP HP/NONE at age of ~27Y,2M,22D 'KRUGER'
31 Wild hatched At TRNSV SNK/03182 at age of 22Y,4M,11D 'PRISCILLA'
35 Wild hatched At TRNSV SNK/03180 at age of 22Y,2M,10D 'TSUWANE'
38 Wild hatched At LOSKOP NR/NONE at age of 21Y,2M,18D 'MONDZU RIV.93'
64 Wild hatched At BESTER/_____ at age of ~19Y
In captivity for ~16Y
55 Wild hatched At JOHANSBRG/5891 at age of 18Y,2M,18D 'STANGENE'
T85 Unk hatch type At HOUT BAY/NONE at age of ~14Y
93 Wild hatched At DURBAN ZO/1220 at age of ~11Y,9M
152 Wild hatched At RHINOLION/NONE at age of ~11Y
In captivity for ~9Y
86 Captive hatched At MADIKWEGR/NONE at age of 7Y,5M,29D 'NKOSI'

Ten oldest living unknown sex:

T02 Wild hatched At VERHEEM S/NONE at age of ~12Y
In captivity for ~12Y
T46 Captive hatched At SWAZILAND/NONE at age of ~3Y,6M,10D 'EYASI'
T45 Captive hatched At SWAZILAND/NONE at age of 3Y,6M,10D 'NDEGE'
T86 Captive hatched At VERHEEM S/NONE at age of 1Y,7M,2D 'SELOUS'
T87 Captive hatched At VERHEEM S/NONE at age of 1Y,6M,25D 'MAYAI'
T105 Captive hatched At HOUT BAY/NONE at age of 1Y,2M,28D
T103 Captive hatched At LOSKOP HP/NONE at age of 7M,10D 'MTITO'
T104 Captive hatched At LOSKOP HP/NONE at age of 7M,4D 'SUPAI'
T93 Wild hatched At LOSKOP HP/NONE at age of 3M,27D 'NELSON'
T97 Wild hatched At LOSKOP HP/NONE at age of 3M,26D 'ADDGAR 2013'

Note that median ages are for living animals only and are NOT average lifespans.

3. Male life table

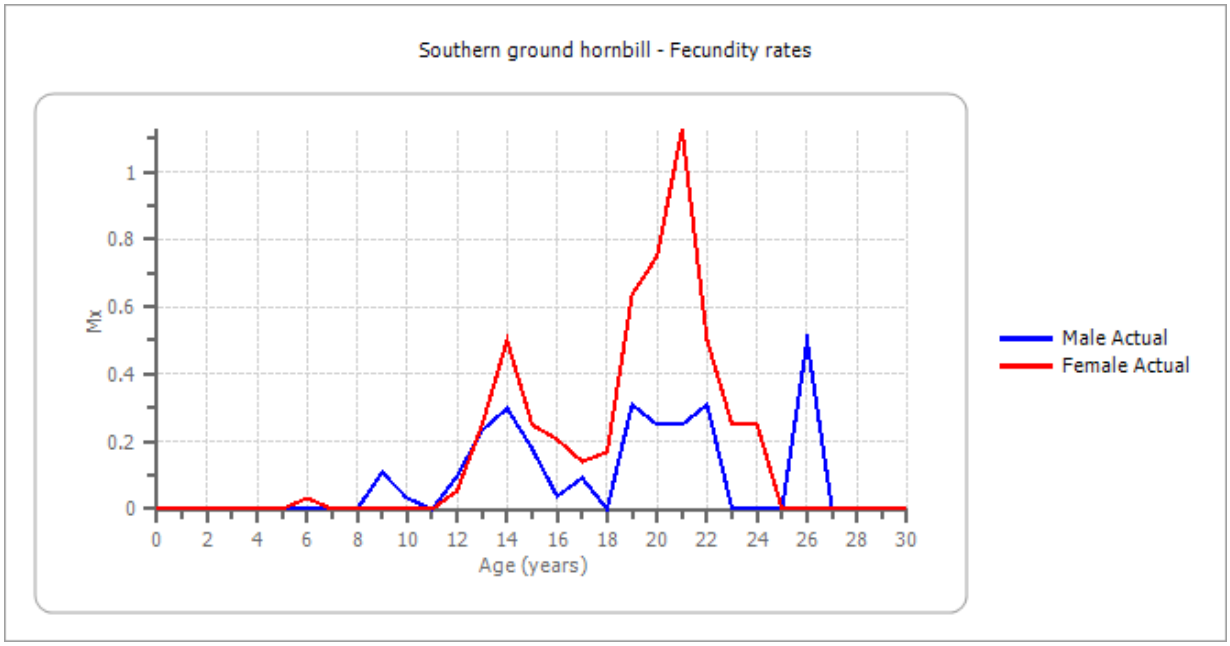
Age (years)	Px	Mid Px	Qx	Risk Qx	Lx	Mid Lx	Mx	Risk Mx	Ex	Vx
0	0.53	0.69	0.47	36.8	1.00	0.77	0.000	36.8	---	1.31
1	1.00	0.96	0.00	30.9	0.53	0.53	0.000	30.9	---	1.87
2	0.93	0.94	0.07	25.4	0.53	0.51	0.000	25.4	---	1.92
3	0.95	0.95	0.05	19.6	0.49	0.48	0.000	19.6	---	2.03
4	0.95	0.97	0.05	18.5	0.47	0.45	0.000	18.5	---	2.13
5	1.00	1.00	0.00	21.0	0.44	0.44	0.000	21.0	---	2.17
6	1.00	1.00	0.00	21.1	0.44	0.44	0.000	21.1	---	2.15
7	1.00	1.00	0.00	19.9	0.44	0.44	0.000	19.9	---	2.14
8	1.00	0.97	0.00	19.5	0.44	0.44	0.000	19.5	---	2.12
9	0.95	0.97	0.05	19.4	0.44	0.43	0.108	19.4	---	2.16
10	1.00	0.98	0.00	17.5	0.42	0.42	0.030	17.5	---	2.09
11	0.97	0.98	0.03	16.3	0.42	0.41	0.000	16.3	---	2.07
12	1.00	1.00	0.00	15.5	0.40	0.40	0.096	15.5	---	2.09
13	1.00	1.00	0.00	15.0	0.40	0.40	0.233	15.0	---	1.98
14	1.00	0.97	0.00	15.0	0.40	0.40	0.300	15.0	---	1.73
15	0.93	0.89	0.07	14.7	0.40	0.39	0.179	14.7	---	1.47
16	0.85	0.92	0.15	12.3	0.38	0.35	0.040	12.3	---	1.43
17	1.00	1.00	0.00	11.0	0.32	0.32	0.091	11.0	---	1.50
18	1.00	1.00	0.00	9.6	0.32	0.32	0.000	9.6	---	1.40
19	1.00	1.00	0.00	8.0	0.32	0.32	0.313	8.0	---	1.39
20	1.00	1.00	0.00	8.0	0.32	0.32	0.250	8.0	---	1.07
21	1.00	0.90	0.00	8.0	0.32	0.32	0.250	8.0	---	0.81
22	0.80	0.89	0.20	6.1	0.32	0.29	0.313	6.1	---	0.62
23	1.00	0.83	0.00	3.7	0.26	0.26	0.000	3.7	---	0.34
24	0.67	0.80	0.33	2.0	0.26	0.21	0.000	2.0	---	0.41
25	1.00	1.00	0.00	1.0	0.17	0.17	0.000	1.0	---	0.50
26	1.00	1.00	0.00	1.0	0.17	0.17	0.500	1.0	---	0.50
27	1.00	1.00	0.00	1.0	0.17	0.17	0.000	1.0	---	0.00
28	1.00	1.00	0.00	0.0	0.17	0.17	0.000	0.0	---	0.00
29	1.00	1.00	0.00	0.0	0.17	0.17	0.000	0.0	---	0.00
30	1.00	1.00	0.00	0.0	0.17	0.17	0.000	0.0	---	0.00

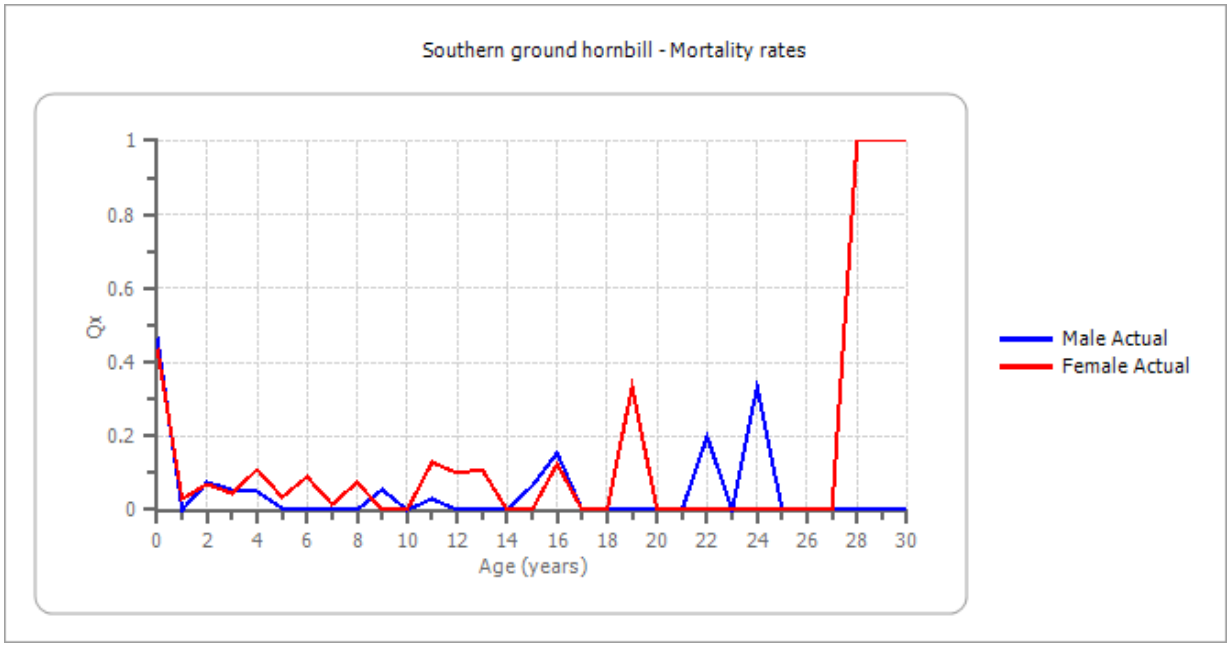
P_x = survival
Q_x = mortality
L_x = cumulative survivorship
M_x = fecundity
E_x = life expectancy (not calculable with current data)
V_x = expected future reproduction
Risk Q_x and M_x = number of individuals that have lived during the age class

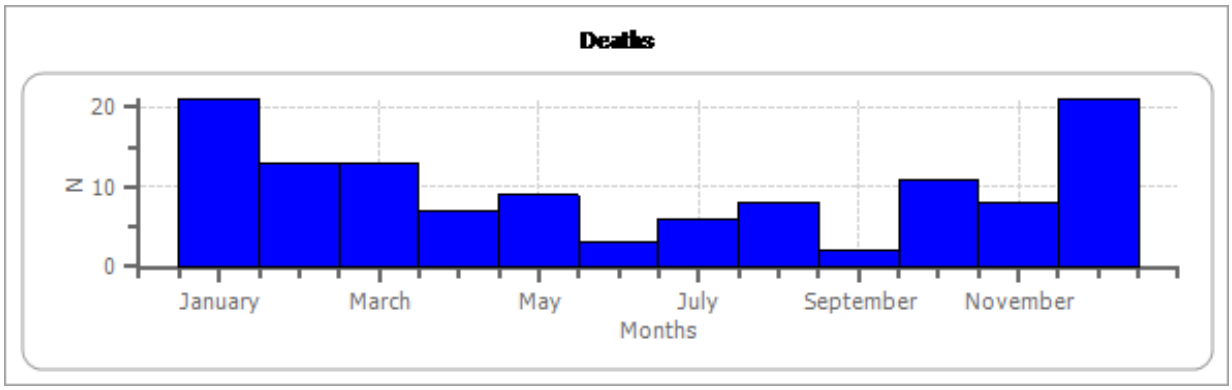
4. Female life table

Age (years)	Px	Mid Px	Qx	Risk Qx	Lx	Mid Lx	Mx	Risk Mx	Ex	Vx
0	0.56	0.71	0.44	40.5	1.00	0.78	0.000	40.5	10.82	1.28
1	0.97	0.95	0.03	31.9	0.56	0.55	0.000	31.9	13.83	1.79
2	0.93	0.94	0.07	25.9	0.55	0.53	0.000	25.9	13.49	1.87
3	0.95	0.92	0.05	22.0	0.51	0.50	0.000	22.0	13.26	1.98
4	0.89	0.93	0.11	18.9	0.49	0.46	0.000	18.9	13.27	2.13
5	0.96	0.94	0.04	16.9	0.43	0.43	0.000	16.9	13.25	2.29
6	0.91	0.95	0.09	15.7	0.42	0.40	0.034	15.7	13.06	2.42
7	0.98	0.96	0.02	13.4	0.38	0.38	0.000	13.4	12.74	2.51
8	0.93	0.96	0.07	11.5	0.37	0.36	0.000	11.5	12.27	2.61
9	1.00	1.00	0.00	11.5	0.35	0.35	0.000	11.5	11.72	2.70
10	1.00	0.94	0.00	11.5	0.35	0.35	0.000	11.5	10.72	2.68
11	0.87	0.88	0.13	11.3	0.35	0.32	0.000	11.3	10.39	2.85
12	0.90	0.89	0.10	9.8	0.30	0.29	0.056	9.8	10.62	3.21
13	0.89	0.94	0.11	8.7	0.27	0.26	0.250	8.7	10.76	3.51
14	1.00	1.00	0.00	8.0	0.24	0.24	0.500	8.0	10.38	3.44
15	1.00	0.94	0.00	8.0	0.24	0.24	0.250	8.0	9.38	2.93
16	0.88	0.93	0.13	7.3	0.24	0.23	0.205	7.3	8.93	2.84
17	1.00	1.00	0.00	7.0	0.21	0.21	0.143	7.0	8.50	2.81
18	1.00	0.83	0.00	6.4	0.21	0.21	0.167	6.4	7.50	2.65
19	0.67	0.80	0.33	4.8	0.21	0.18	0.633	4.8	7.80	2.96
20	1.00	1.00	0.00	4.0	0.14	0.14	0.750	4.0	8.50	2.90
21	1.00	1.00	0.00	4.0	0.14	0.14	1.125	4.0	7.50	2.13
22	1.00	1.00	0.00	2.6	0.14	0.14	0.500	2.6	6.50	1.00
23	1.00	1.00	0.00	2.0	0.14	0.14	0.250	2.0	5.50	0.50
24	1.00	1.00	0.00	2.0	0.14	0.14	0.250	2.0	4.50	0.25
25	1.00	1.00	0.00	2.0	0.14	0.14	0.000	2.0	3.50	0.00
26	1.00	1.00	0.00	2.0	0.14	0.14	0.000	2.0	2.50	0.00
27	1.00	0.50	0.00	1.3	0.14	0.14	0.000	1.3	1.50	0.00
28	0.00	0.00	1.00	0.0	0.14	0.07	0.000	0.0	1.00	0.00
29	0.00	0.00	1.00	0.0	0.00	0.00	0.000	0.0	0.00	0.00
30	0.00	0.00	1.00	0.0	0.00	0.00	0.000	0.0	0.00	0.00

P_x = survival
Q_x = mortality
L_x = cumulative survivorship
M_x = fecundity
E_x = life expectancy
V_x = expected future reproduction
Risk Q_x and M_x = number of individuals that have lived during the age class


Southern ground hornbill - Fecundity rates
Mx
0
0.2
0.4
0.6
0.8
1
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Age (years)
Male Actual
Female Actual


Southern ground hornbill - Mortality rates
Qx
0
0.2
0.4
0.6
0.8
1
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Age (years)
Male Actual
Female Actual


Deaths
N
0
10
20
January
March
May
July
September
November
Months

5. Reproductive Parameters Report

Incubation period set to 40 days, ~1.3 months.
Ages are as of egg-laying for dams, as of insemination for sires.

Dam data

7 reported dams, with 21.23.25 (69) offspring (not including 14 offspring of unknown dams)

Youngest dams at first reproduction:
99 at UMGENI PK had baby T106 at age 6Y,8M,22D 'KOTOKOTO'
73 at MABULA had baby T12 at age 8Y,9M,22D 'KINGFISHER'
35 at UMGENI PK had baby 75 at age 12Y,7M,23D 'TSUWANE'
T85 at HOUT BAY had baby T105 at age ~12Y
64 at LOSKOP HP had baby T22 at age ~13Y
31 at UMGENI PK had baby 83 at age 14Y,1M,17D 'PRISCILLA'
19 at LOSKOP HP had baby 94 at age ~17Y,9M,15D 'KRUGER'

Oldest dams at first reproduction:
19 at LOSKOP HP had baby 94 at age ~17Y,9M,15D 'KRUGER'
31 at UMGENI PK had baby 83 at age 14Y,1M,17D 'PRISCILLA'
64 at LOSKOP HP had baby T22 at age ~13Y
T85 at HOUT BAY had baby T105 at age ~12Y
35 at UMGENI PK had baby 75 at age 12Y,7M,23D 'TSUWANE'
73 at MABULA had baby T12 at age 8Y,9M,22D 'KINGFISHER'
99 at UMGENI PK had baby T106 at age 6Y,8M,22D 'KOTOKOTO'

Oldest dams to have reproduced:
19 at had baby T107 at age ~26Y,9M,16D 'KRUGER'
19 at LOSKOP HP had baby T57 at age ~24Y,7M,4D 'KRUGER'
19 at LOSKOP HP had baby T44 at age ~23Y,6M,27D 'KRUGER'
19 at LOSKOP HP had baby T27 at age ~22Y,8M,19D 'KRUGER'
31 at TRNSV SNK had baby T92 at age 22Y,0M,1D 'PRISCILLA'
31 at TRNSV SNK had baby T91 at age 21Y,11M,26D 'PRISCILLA'
35 at TRNSV SNK had baby T96 at age 21Y,10M,13D 'TSUWANE'
31 at TRNSV SNK had baby T90 at age 21Y,10M,5D 'PRISCILLA'
31 at TRNSV SNK had baby T89 at age 21Y,10M,1D 'PRISCILLA'
19 at LOSKOP HP had baby T26 at age ~21Y,9M,6D 'KRUGER'

FEMALES	Median	Average	N
Age at first reproduction:	~13Y	12Y,4M,5D	7
During all reproduction:	~17Y,9M,20D	17Y,7M,7D	67
Age at last reproduction:	21Y,10M,13D	17Y,4M,17D	7

Shortest interclutch intervals

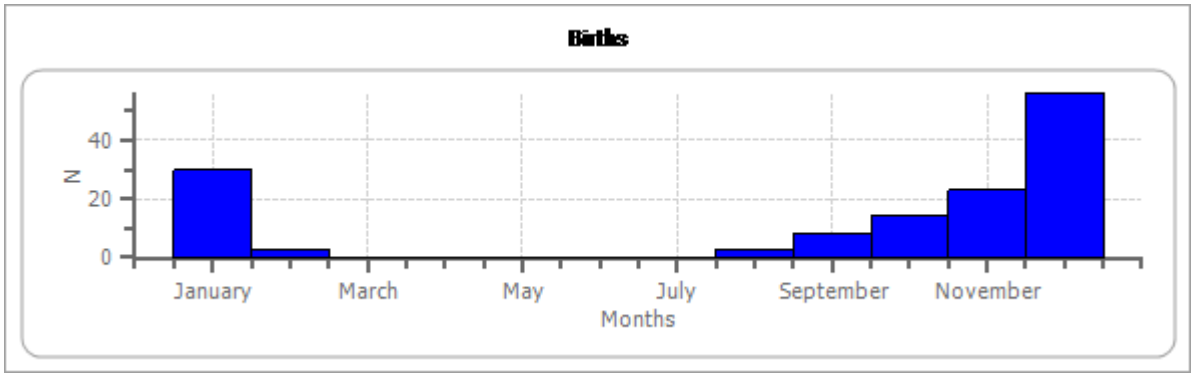
Dam	Interval	Offspring
64	7 days between	T86 & T87
35	11 days between	85 & 87
35	21 days between	87 & 90
35	30 days between	77 & 79
31	31 days between	84 & 88
35	43 days between	79 & 81
31	55 days between	T89 & T91
31	61 days between	T88 & T89
31	199 days between	T73 & T88
31	209 days between	83 & 84
31	276 days between	T50 & T66
35	295 days between	81 & 85

Hatch seasonality

(clutches to known dams)

January:	4	9%
February:	2	4%
March:	0	0%
April:	0	0%
May:	0	0%
June:	0	0%
July:	1	2%
August:	4	9%
September:	9	20%
October:	12	26%
November:	7	15%
December:	7	15%

[Clutches with a hatchdate estimate of 'Y' not included.]



Viability:

Rearing:	Lived > 1 year	Died < 1 year	Died < 30 days	DInShell & Dead Embryo
Parent (16)	9 56%	0 0%	7 44%	0 0%
Hand (50)	30 60%	12 24%	8 16%	0 0%
None (1)	0 0%	0 0%	0 0%	1 100%
Unknown (2)	2 100%	0 0%	0 0%	0 0%
TOTALS	41 59%	12 17%	15 22%	1 1%

First hatches to dams at an average age of ~12Y,4M,5D
71.4% lived >1 year 0.0% died <1 year 28.6% died <30 days
N = 5 N = 0 N = 2

Subsequent hatches to dams at an average age of ~18Y,1M,12D
59.0% lived >1 year 19.7% died <1 year 21.3% died <30 days
N = 36 N = 12 N = 13

Clutch size

Clutch size	N	
1	23	50%
2	23	50%

46 total clutches, mean size is 1.5
Clutches hatch within 6 days of the first hatching
Dams for largest clutches: 64

Clutch size viability:

Clutch size:	Lived > 1 year	Died < 1 year	Died < 30 days	DInShell & Dead Embryo
2	24 52%	9 20%	13 28%	0 0%
1	17 74%	3 13%	2 9%	1 4%

Sire data

7 reported sires, with 21.23.25 (69) offspring

Youngest sires at first reproduction:
50 at LOSKOP HP had baby 94 at age ~8Y, 9M 'MALELANE'

34 at UMGENI PK had baby 75 at age 12Y, 6M,16D 'DEREK'
65 at MABULA had baby T12 at age ~12Y 'STORM'
T84 at HOUT BAY had baby T105 at age ~12Y
61 at LOSKOP HP had baby T22 at age ~13Y
30 at UMGENI PK had baby 83 at age 14Y,0M,23D 'HUGO'
16 at UMGENI PK had baby T106 at age 26Y,5M,8D 'MARALYN'

Oldest sires at first reproduction:
16 at UMGENI PK had baby T106 at age 26Y,5M,8D 'MARALYN'
30 at UMGENI PK had baby 83 at age 14Y,0M,23D 'HUGO'
61 at LOSKOP HP had baby T22 at age ~13Y
T84 at HOUT BAY had baby T105 at age ~12Y
65 at MABULA had baby T12 at age ~12Y 'STORM'
34 at UMGENI PK had baby 75 at age 12Y,6M,16D 'DEREK'
50 at LOSKOP HP had baby 94 at age ~8Y,9M 'MALELANE'

Oldest sires to have reproduced:
16 at UMGENI PK had baby T106 at age 26Y,5M,8D 'MARALYN'
30 at TRNSV SNK had baby T92 at age 21Y,11M,8D 'HUGO'
30 at TRNSV SNK had baby T91 at age 21Y,11M,2D 'HUGO'
30 at TRNSV SNK had baby T90 at age 21Y,9M,12D 'HUGO'
30 at TRNSV SNK had baby T89 at age 21Y,9M,8D 'HUGO'
34 at TRNSV SNK had baby T96 at age 21Y,9M,7D 'DEREK'
30 at TRNSV SNK had baby T88 at age 21Y,7M,8D 'HUGO'
30 at TRNSV SNK had baby T73 at age 21Y,0M,22D 'HUGO'
30 at TRNSV SNK had baby T72 at age 20Y,10M,21D 'HUGO'
30 at TRNSV SNK had baby T69 at age 20Y,10M,18D 'HUGO'

MALES	Median	Average	N
Age at first reproduction:	~13Y	14Y,4M,17D	7
During all reproduction:	~15Y	16Y,0M,27D	67
Age at last reproduction:	21Y,9M,7D	19Y,4M,29D	7

6. References

Rehse, T.P. 2014. 2014 PAAZA regional studbook for the Southern Ground Hornbill (*Bucorvus leadbeateri*), 8th Edition. PAAZA publication number PP89/2-14

Chapter 3: Housing and Enclosure Design

Ann Turner*, Alan Kemp*, Dee De Waal*, Nick Theron*, Ben Botlhole*, Gillian Theron*, Delecia Gunn** and Lara Jordan***.

* Mabula Ground Hornbill Conservation and Research Project

** Loskop Dam Nature Reserve

*** Johannesburg City Parks and Zoo

1. Enclosure design

The enclosure should be large enough for the birds to fly into high branches. Their wingspan is 1.5 meters and they require sufficient distance for flying up and landing. A good sized enclosure is 15 meters by 13 meters by 6 meters high. Wire should be chain link 2" by 2". The roof should be lined with soft netting so they do not hurt themselves if they fly up.

The enclosures should have natural substrate and grass, long grass is the most natural environment as they forage and dig in it. They choose to be in the sun generally, but in the warmer climates especially they will need some shade. They will often have a midday sleep in the heat of the day, on the ground, but roost high in trees at night around 2.5 to3.0 meters high. They tend to perch towards the ends of branches and will perch in a different place each night given the option.

It is probable that a 'mist system' will encourage them to breed. The South African summer rains start around October with the main rains coming in December and January, this would lead to a natural explosion in the food supply e.g. frogs and insects, followed by a general build up in other animal numbers. A small sand pit of fine sand may be used for sand bathing or sun bathing.

If the enclosure has short and long grass and bushy areas with some trees it will allow plenty of variation for shade and sun. They will often use the shade in the heat of the day. Good strong level branching is ideal for this species with bark which they will endeavour to break off. Branching that has a variety of thickness and heights are advantageous especially if you have young birds in your group. Branching with forks will enable them to use these areas to break large food items such as rats. They will jam the item into a corner and then will use their beaks to break the food up. They have also been seen using tools to break up food items.

Installing a mister into an enclosure will serve a number of uses. Softening the ground with water gives them the opportunity to dig up the ground afterwards. As mentioned before it may also be a useful tool to stimulate breeding. They have also been seen bathing and sometimes drinking from the misters. It may be useful in hotter climes to have it running on the nest boxes to help prevent the chicks suffering from dehydration.

Building a pond into the enclosure will encourage amphibians and insects to the enclosure forming natural entertainment. The birds also play in the pools. It will increase moisture to

the enclosure, which in the drier climates is advantageous. An ultra-violet light can also be suspended in the enclosure and switched on at night to attract insects that can be found the next day.

2. Nest box design

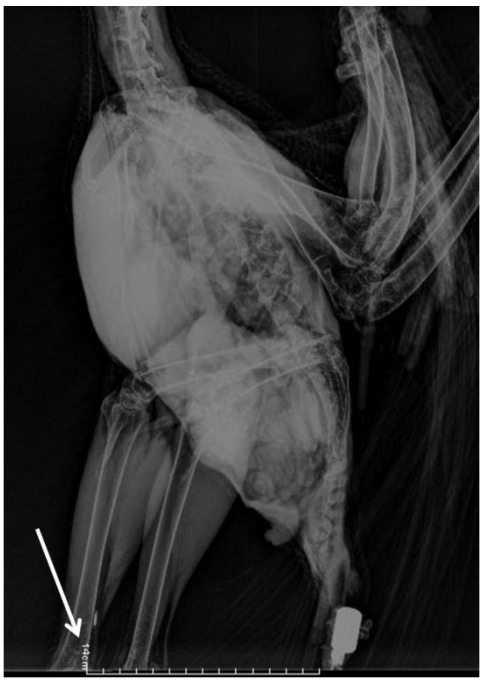
Nest box designs are varied but can be equally successful. The nests should be as high as possible with branches outside the nest allowing the male to feed the female on the nest or to feed chicks. In hot climates it may be necessary to have shading over the nest box to prevent chick dehydration and or a mister that can run over the nest box. Air circulation holes should be put at the back of the box, and drainage holes in the base. A nest camera in the box is invaluable to aid husbandry of rearing birds and also for research purposes.

Chapter 4: Animal Management

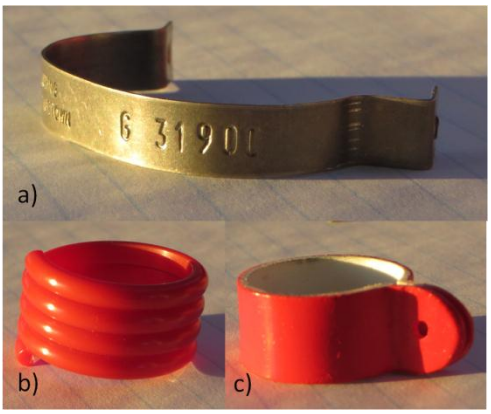
Lucy Kemp
Mabula Ground Hornbill Conservation and Research Project

1. Identification Methods

In a small collection it is possible to recognise individual Southern Ground-Hornbills, using identifiable features such as extent of age or sex colouration or pattern of feather 'side-burns'. For successful intensive management of a Southern Ground-Hornbill captive population it is essential however that all individuals be readily and accurately identifiable. This then links all other data with the individual identification recorded in the studbook and it is recommended that both micro-chips and rings be used simultaneously.



Micro-chips: The main form of identification for captive Southern Ground-Hornbill is a microchip. The microchip may be placed subcutaneously in the dorsal midline at the base of the neck or intramuscularly in the left pectoral muscles positioned subcutaneously between the shoulder blades. However, there are reports of microchips migrating beneath the skin (see x-ray) when placed subcutaneously. Care should thus be taken to scan the entire bird if the chip does not register at the implant site. Microchip failure rate is 1 to 2 chips per 100 000 so the chance of a chip failure is essentially zero. Failure may result though due to the microchip not being inserted correctly, which if amongst feathers may happen. If the microchip is injected it may come out shortly afterwards via the wound canal. It is important to inject downwards (away from the head) so that the wound canal points upwards, thereby allowing gravity to assist in keeping the chip initially in place, then massage the wound canal (thumb and forefinger) to assist in the initial closing and ensure that the chip is not pulled out with the removal of the needle. Microchip codes are also registered on the PAAZA studbook.



Rings:
The South African Bird Ringing Unit's (SAFRING) engraved stainless steel rings (see image a) are used for identification and registration within the national population and are registered both with SAFRING and the PAAZA studbook. The rings are size G with an internal diameter of 26mm. Rings must be put below the tarsometatarsal joint. Males should be banded on the right, females on the left and ringing should be postponed until sexing results are available. Young

birds should be banded as close to fledging age as possible to minimise handling and stress prior to their acceptance into a 'natal' group.

Coloured rings can also be used for temporary or permanent identification. Plastic spiral rings (see image b) have however been shown to cause injury and so plastic rings should have a fastening mechanism strong enough to withstand the bill strength of a hornbill (see image c). Placement of colour rings and metal bands should also be recorded on the studbook.

Patagial tags: Wing tags have been used experimentally, however it was felt that the birds found them uncomfortable, which was expressed by the birds holding the wings out at an awkward angle. The risk of excessive interference from handling by other birds in the group leading to a tear in the patagium is great.

One of the early trials at Mabula (photo N Theron)

2. Sexing

DNA sexing: The use of blood, plucked feather and egg-shell swab samples, have been used successfully to sex genetically both developing chicks and adults. For management of placements of young birds within the captive and reintroduction populations it is helpful to sex the birds at three weeks of age when drawing blood is not a risk/stressful. This enables birds being moved to appropriate groups at fledging (three months of age) to ease acceptance into their new 'natal' groups. It is also the quickest, as it can be done as soon as a hornbill acquires its first real feathers or is large enough to spare a drop of blood at three weeks of age.

The National Zoological Gardens will DNA-sex captive birds that are part of the APP at no cost. Due to lab caseloads this may take time and the Molecular Diagnostic Laboratory (MDS) will do reliable sexing for minimal cost.

Molecular Diagnostic Laboratory
Tel: +27 (31) 267 7000
Fax: +27 (31) 267 7005
Email: mds@mdsafrica.net
Physical Address: 6 Ribston Place, Westville, 3629, Durban, KZN, South Africa
Postal Address: Private Bag X20, Westville, 3630, Durban, KZN, South Africa

Surgical sexing: As this is an invasive procedure it should only be conducted on clinically healthy birds. Non-invasive methods such as DNA sexing should be used if sexing is the only outcome required, but sound record keeping should ensure all captive birds can be aged

and endoscopy should only be used to ensure there are no abnormalities that might affect breeding. Gonads and surrounding organs can be visually observed for any evidence of disease. Evaluation of gonads can only be done in sexually matured birds and should ideally be done once breeding pairs are established. It is important when managing pairings within a captive population to ensure that both mates are sexually viable. This ensures time is not wasted holding non-viable breeding birds in a breeding position, essential in a species as slow-breeding as the Southern Ground-Hornbill.

Sexual dimorphism: Adults are sexually dimorphic but there is evidence of males exhibiting female colouration so is not a fully reliable method of sexing. See below.

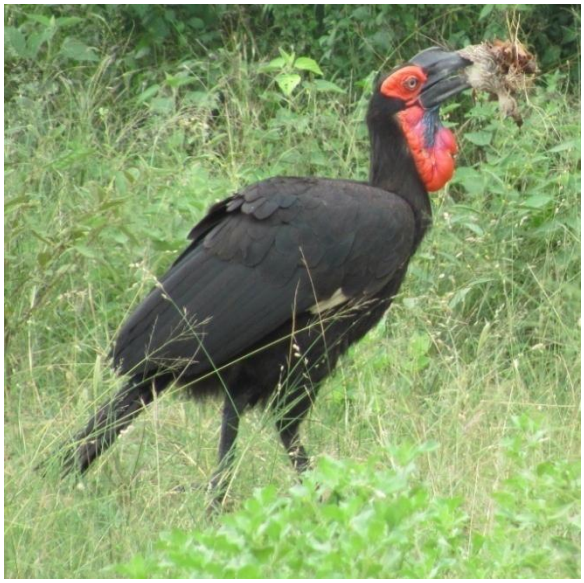
3. Morphology and sex determination

The birds are **sexually dimorphic** after three to four years (see aging chart below). Rate of colouring differs between individuals and sexes, which may be due to levels of suppression by more dominant birds in the group. Males exhibit entirely red facial skin whilst female have varying amounts of violet-blue within the red throat pouch below the bill. However there are a small number of males exhibiting female colouration within the captive population and individuals have also been identified in the wild population. It is unknown what the reason for this is or whether it has any effect on breeding behaviours or success though anecdotal evidence of 'blue' males carrying nesting material suggest it does not.

Males are equal to, or up to 17% heavier, than females in mass. Wing length of males is 1 to 21 % greater and bill length 8 to 30% greater than in females. Male casques are subtly deeper and longer than female casques, which can assist in determination of blue-throated males.

As there is so much variation recorded hornbill managers should note the age at which sexual and ageing dimorphisms develop to allow for better long-term analysis and so contribute to the growing body of

knowledge on the species. The kit below is just a guideline.



A blue male in the wild population in the Kruger National Park carrying nesting material and food to a nest (photo M. Rossouw).

4. Maturation and longevity

Southern Ground-Hornbills are long-lived but average life expectancy is unknown. It is not possible to age Southern Ground-Hornbills in the wild after five years of age so no data are available for longevity in the wild populations. To date the oldest captive birds within the EAZA captive populations is at least 33 years old (came to captivity as an adult) and the oldest individual in the AZA collection is a male that is of minimum age 49 and still breeding. A 34 year old female is still laying viable eggs. It is unknown whether at this stage whether either sex reach a stage of reproductive senescence.

5. Moult

Moult of all hornbill species is quite variable but little studied, especially in larger species. As a larger hornbill species the Southern Ground-Hornbill have a more prolonged or continuous moult, although details of feather sequence and timing are unrecorded. Females do not simultaneously moult their flight and tail feathers during the breeding season as all other hornbill species do. Hornbills regulate their moult according to their nutritional status and other factors, and can moult feathers quite selectively. The hormonal and nutritional regulation of moult is not well understood in hornbills, and deserves further study. A disturbed moult might indicate a hormonal, environmental or nutritional problem, or a combination of these.

6. Restraint

Southern Ground-Hornbills should not be pinioned. The length and breadth of their secondary feathers still allows them to fly even when pinioned. They should be kept fully winged in large enclosures. Tendonectomy is also not recommended as this is a permanent disfiguration and to be avoided.

7. Capture, handling and transport

A range of capture techniques can be used which are dependent on the individual bird and whether they are tame. Tame birds can be caught up without any need for specific capture equipment. Less tame individuals will require the use of nets or towels to corner and catch the birds. Birds can be trained using positive reinforcement and association to feed in a place where capture can be facilitated, either in a trap or a more confined space of the aviary. To-date this has been done using a whistle to signal every feeding time and an association with a red bowl carrying the food. This has also worked effectively for the management of birds in the reintroduction programme after release.

Specifically designed traps have also been used to trap wild birds for research purposes and these have been made available to the several institutions when birds have escaped from their enclosures.

Restraining of birds is consistent across collections, the bird's body is held under one arm and the hand of that arm restrains the feet. The other hand gently restrains the beak without blocking the nostrils. Covering the bird's eyes is highly advisable as it reduces the stress levels and consequently reduces negative associations with capture.

Alternatively the bird may be carefully held chest down on the floor by applying gentle pressure on its back and keeping the wings together with one hand, whilst the other hand holds the beak. A similar procedure can be used for ringing the birds by gentling laying the bird on one side so that access to both legs is possible.

Birds younger than thirty days should be held with their wings at their sides and they are best grasped at the tops of their thighs.

Crates are used for local transportation of birds, one per bird. They may be made from wood or the commercially available plastic pet transportation crates or 'sky kennels' have been used. However, when using sky kennels with a metal gate it is has been reported that the latch can accidentally opened due to the movement of the bird. The plastic crates are easier to clean and disinfect and may be more resistant than wooden crates to bill "shaving" activities. Large slits or other openings should be covered with mesh so that the hornbills cannot manipulate the crate or bite. Suggested approximate crate size is 0.80 x 0.55 x 0.58 m to ensure the bird feels secure. If the rate is larger they can shift around too much. No perch should be used as the bird is safer on the bottom and can lie down if necessary. Non-slip shower matting over a towel or newspaper is a useful substrate.

Taping of the long wing and tail feathers with gummed paper helps to prevent feather abrasion and breakage. To reduce stress in transit the crate should be dark but with sufficient ventilation and care taken to ensure the crate is not exposed to a draft (on the back of a vehicle) or too hot (left in the sun). Excessive wind flow will lead to dehydration and increased stress. If unstressed the birds usually just lie down for the duration of the transit. Some birds take a while to stand again and should just be left quietly to make their way out of the crate.

For international transportation on commercial air lines IATA guidelines for crate specifications and transport procedures must be followed.A hornbill should have sufficient time to become used to the crate before shipment. If transport time will be longer than a couple of hours it should be ascertained that birds are drinking and eating in the crate before transportation.

8. Quarantine Procedures

When birds are moved to a new collection they should ideally be kept separate from other birds for at least 30days (see veterinary protocols Chapter 11). Health checks should be carried out on the birds prior to travel and observations made to ensure that they are not unduly stressed by the transit, the new environment, are ill due to stress-induced immuno-compromisation and that they carry no parasites.

Standard quarantine procedures (e.g. use of foot bath, care of animals by keepers not in contact with other birds in the collection, easily cleaned walls and floors) should be applied when working with hornbills. The transport and quarantine periods are inherently stressful to birds however there are a number of actions that can minimize the stress. It should be noted that quarantine is not suitable for birds that are intended for the reintroduction programme as it is counterproductive to rearing wild, well–socialised individuals:

- An adequately sized enclosure, allowing the birds to exercise by flying to perches at the opposite end of the enclosure, should be provided. The enclosure should be large enough to allow the hornbill to comfortably extend its wings fully which for Southern Ground-Hornbills is about 1.5m.
- Perches should preferably be mounted horizontally above human height. If enclosures are not large, perches for ground hornbills should be closer to the ground. The circumference of quarantine perches should be approximately 1/3 larger than the hornbill's foot closed around the perch. Perches should not be hard or slippery.
- Food should not be offered more than 30 cm off the ground and preferably accessed from outside the cage.
- The diet provided at the hornbill's previous institution should initially be provided and then other items can be given in addition to these but any dietary changes should be gradually made.
- Quarantine areas usually lack natural furniture as it is too difficult to keep sterile but providing a short length of knotted rope attached to the aviary roof above a

favourite perch can be used by the hornbills to clean the inside of their bills to mimic the snags on natural perching that would fulfil this purpose in a display aviary.

Hornbills should generally be held separately during quarantine. Possible exceptions might be family groups or pairs with a long-term pair bond. However, even these situations require supervision as the quarantine situation may evoke aggression. Hornbills should not be held adjacent to other hornbills or individuals of other species with which aggression is observed unless a solid wall can used to separate the animals. Enclosure boundaries should be able to withstand a hornbill's assaults, and should not promote bill damage.

9. References

Kemp A. C. 1995. The hornbills, *Bucerotiformes*. Oxford: Oxford University Press.

Galama W., King C. and K. Brouwer. 2002 EAZA Hornbill Management and Husbandry Guidelines. The EAZA Hornbill TAG, National Foundation for Research in Zoological Gardens.

Chapter 5: Behaviour and Social Organization

Lucy Kemp & Sophie Neller
Mabula Ground Hornbill Conservation and Research Project

It is important to understand how these birds are 'hard-wired' to behave to understand if one is looking at normal behaviour that the birds exhibit in the wild or unnatural behaviour due to some imbalance in their captive setting. The following information is extracted from the scientific literature, mostly from the work by Alan and Meg Kemp (Kemp 1995; Kemp & Kemp 1975; Kemp 1988; Kemp & Kemp 1980) who spent days and sometime weeks following wild groups through both the dry and the wet seasons, but also Gary Knight who worked in KwaZulu-Natal, Nick Theron who worked in the Limpopo River Valley *(Theron et al*. 2013)and the FitzPatrick work in the Associated Private Nature Reserves (Wilson & Hockey 2013). The text boxes then highlight key aspects of this behaviour that need to be catered for in a captive environment.

1. Social organisation

Southern Ground-Hornbills (hereafter SGH) are resident, group-territorial, and live in cooperatively breeding groups of 2-11 birds. All members of a group co-ordinate their activities and remain close together throughout the day. Groups maintain exclusive territories at a density of about 100km² in South Africa. The average group size is 3.5 and only 2% of the population is solitary. Group composition is variable, but there is always only one dominant pair of adults that undertake breeding. There is usually only one adult female, often more than one adult male, and usually one or more juveniles of different ages. Most lone birds are adult females as the alpha-male will often reject them from the group at around 1-2 years of age. Once this occurs, females will often inhabit small territories in between that of neighbouring groups, and wait for a breeding vacancy to arise. The females are extremely vulnerable to predation during this period and so have been known to form coalitions with other females in order to improve their chance of survival. The adult sex ratio is 1.4 males per female, with juveniles forming about 20% of the population.

- If aviary space allows rather keep a normal group structure: alpha male and female and young male helpers. This is the best sort of enrichment (normal social interactions) and these youngsters then learn the right behaviours to enable them to be successful breeders when they reach maturity.
- Groups in neighbouring aviaries may exhibit stress during the breeding season due to their fiercely territorial nature, which may lead to unnatural/undesirable behaviours. In the wild nests may be within hearing distance but are never within sight.
- Young females should be removed at 5-9 months before social aggression becomes dangerous. This depends on when the breeding female of the group kicks back into breeding season – often earlier in the captive situation when breeding is less dependent on food availability.

2. Daily activity

Walking: Groups spend an average of 70% of their daylight hours walking, and may cover up to 11km in one day. Walking is a stiff rolling gait, with a stride of 20-30 cm and with only the tips of the fore and hind toes touching the substrate. Hopping is used as an alternative when in trees or crossing over rocks. Walking decreases towards midday, when groups spend time resting, and increases again later.

- Aviary floor space should be clear and open to allow for them to walk as much as possible of their available space.

Vocalisation: Adults proclaim their territory and detect trespassers daily, primarily by calling at dawn. The calling begins before leaving their roosting site, usually just before the first light, and can last 2-50 minutes. The call is a deep, resonant, 4-note booming or 'hoohoohoo-hoo' and alternates between two pitches. Normally the alpha-male will call at the lower pitch and the female at the higher, however either sex can call at either pitch and two females have been known to call both pitches in order to maintain a 'group identity'. When calling, the hornbill tips down the bill, arches the neck and slightly inflates the pouch with each contraction, which in flight causes the bird to stall with each note. A deep soft call of two notes 'u-hu' is given by group members when they cannot see one of the group or by an individual unable to locate its group.

Immatures make a soft nasal bray when begging for food, often repeatedly as they walk with the group. The call increases in volume as an individual carrying food approaches, and sometimes the head and neck feathers are raised at this stage. Small chicks utter soft peeping notes when requesting food in the nest.

The breeding female will make a harsh nasal bray when accepting food from other individuals; it is similar to the begging call of immatures but is a harsher sound and often continues for long periods.

When frightened, a high pitched grating squawk is vocalised and repeated, whereas the alarm call is a deep hu if an individual is suddenly startled; this may be an involuntary exclamation.

Avoid playback of any calls, especially the booming contact/advertising calls, as these tend to over-stimulate and stress the individual birds according to their status and sex.

Feeding, Foraging, Hunting: Virtually all food is obtained from the ground and therefore most of the day is spent on the ground, where foraging is the main activity. The large bill over 30 cm long acts as a very strong pickaxe, and also as a powerful pair of forceps for handling dangerous or distasteful items such as snakes, scorpions or hairy caterpillars. SGHs will eat anything they can overpower, up to the size of hares, squirrels, large tortoises, and snakes. The majority of food items are simply picked up from the ground or low vegetation; however digging is especially prevalent during the dry season when resources are less

abundant. Feeding is opportunistic, and groups have been known to scavenge from carcasses.

When hunting large, fast or dangerous prey items, individuals band together, however the item will eventually only be consumed by one individual. They have been reported to distract large snakes either with wing quills outspread or by covering them with grass.

All individuals will forage, however immatures will be supplementary fed by other individuals in the group, without incurring aggression, until they are at least two years old and will learn hunting and foraging techniques by observing the elders in the group.

Food exchange or refusal is also used as a form of dominance expression, so having desirable food items (natural prey, larger than normal) available may facilitate social expression. As breeding condition/season approaches, males and sometimes helpers carry items to courtship feed the alpha female, especially larger more natural items, so these may also be offered to help assess/encourage/teach breeding activity.

- Allow them to catch some of their own food (crickets, meal worms etc.) to allow them to develop their hunting skills. This is also a good form of enrichment.
- They eat an extremely varied diet in the wild (see chapter on diet) and it is good to vary the diet as much as logistically possible.
- They are faunivorous rather than carnivorous and so eat the whole animal rather just the meat. This means their digestive systems are geared for fur, scales, exoskeletons and small bones.
- Offer a few natural items of different sizes, especially in spring.

Roosting: Just before dark, the group will fly up into a single tree, or several neighbouring ones to roost, this is not a fixed site but simply wherever they end the day's walk. As it becomes dark they move out onto the very tips of the branches, and may often fly quietly to more distant trees, finally lying down in the peripheral branches. There they often squat down across the branch, tucking the head deeply between the shoulders so that the bill points upwards. They usually remain in this position, until dawn, but they may wake and call on moonlit nights without standing up. Descent to the ground and calling has been reported on moonlit nights.

- They like to roost high and preferably on more open perches than densely foliaged one.
- Perch thickness should be about a 1/3 larger than the hornbills foot closed around the perch – smaller and larger than this may cause foot damage, injury due to imbalance and may affect posture.
- Try to make the roost area as free of artificial light pollution as possible.

Flying: Although the majority of the time budget is spent walking, flying is utilised when moving from roosts, moving along territorial boundaries, moving to feeding areas, crossing unsuitable habitat or pursuing intruders. The flight is strong with deep beats of the broad

wings and with little gliding. The flight is stable, allowing calling in flight, carrying of large food masses in the bill, and low stalling speeds during aerial combat. They are capable of a flight speed of approximately 30 km/hr and can cover a distance of 5km during chasing. Flight is usually within 30m of the ground but can rise to 300m for long distances or territorial pursuits.

- Ensure aviaries have sufficient space that they can fly up high to perch and there is space to fly between perches. This maintains muscle strength, allows subordinate birds to move away from dominant birds if necessary and provide a 'jungle-gym' for play.

Playing: SGHs are very playful, especially immatures, and excess time after foraging will often be filled with such activities. Lone play often involves running, short flights into trees and back to the ground, tossing objects about in the bill, or pursuing other birds. Social play often involves pestering and having mock fights with adults, having running chases, jumping off banks onto each other's' backs, or having tug-of-wars with pieces of stick, however bill-wrestling is the most common form of play contact.

- Ensure there is some loose vegetation available in the aviary (branches, sticks, bark) for them to play with and enough birds that these important social interactions can happen.

3. Maintenance behaviours

Bathing – Sun, Dust, Leaf: When not foraging, SGHs may sunbathe by lying flat on ground with wings outspread, tail fanned and head lolling to one side, sometimes being groomed by other group-members. This behaviour is thought to benefit feather maintenance by driving parasites out from the plumage and assisting the preen oil to spread. Sunbathing lasts for around 2 minutes and is often followed by vigorous head scratching and preening. Dust-bathing is also used as a maintenance behaviour, where individuals will lower themselves close to the ground and wriggle their bodies to disperse substrate over and between the feathers; this is followed by shaking and preening.

After rainfall, individuals will be seen bathing in wet foliage, during which they will flop around in the foliage with wings spread and move from one spray to the next, to moisten the feathers and will follow this with preening.

- Ensure the aviary gets enough direct sunlight and if possible provision a 'sand pit' with fine sand to allow for dust-bathing. A sprinkler system to mimic rain brings much excitement to the aviary and allows for feather maintenance.

Heat-loss: SGHs, being entirely black in colouration, are highly sensitive to heat, and at peak times of the day will obtain a heat-loss posture to regulate their body temperature. The first posture shown is often the opening of the bill whilst holding the wings away from the body, until the bird moves into the shade. Once in the shade the wing coverts are erected, the

wrists opened while turning into the wind to expose the bare underwing, and the bill is kept open. When there is little wind, individuals may fly to branches in the shade as opposed to remaining on the ground. Overheating begins when the temperature reaches about 26°C.

- Ensure the aviary has enough dense shade for the birds to retreat to on very hot days.

Preening & allo-preening: Individuals will spend time tidying and cleaning their feathers with their bill, to ensure their plumage condition is kept high. Alternatively allo-preening, where one member of the group preens another, most commonly a juvenile and an adult, is used to maintain social structure and bonds. Allo-preening is also performed during courtship, by the alpha-male on the alpha-female, prior to copulation.

4. Breeding behaviour

Courtship behaviour

Breeding is only commenced at the beginning of the rains, and continues as necessary if the food supply remains high during the wet season. Courtship begins with a combination of allo-preening and courtship-feeding, where the male will crouch by the nest with his bill raised, usually with a food item in the bill and uttering a squeaky call, possibly soliciting the female to enter. [Detail more of courtship feeding first, the most frequent, persistent and obvious courtship that leads directly into breeding once egg laying has occurred. Copulation sometimes follows which always occurs on a branch where the male can bring his tail under the female after preening her hard on the head and neck and forcing her to crouch. The male then steps on her back, holds her nape in his bill, and squats on her back while copulating. Afterwards, the female may stand for a few minutes with her head and neck feathers fluffed out.

- If necessary use a sprinkler system to mimic the start of the rains.
- Ensure they have enough perches for copulation to occur on – they cannot copulate successfully on the ground.
- Offer as much natural food and of different sizes as possible to facilitate courtship feeding.

Nest-Lining: A deep lining of dry leaves is brought in bundles to the nest by the males before and during the nesting cycle, always with a food item included in the bundle. The dominant female sits in the nest during a visit, sometimes emerging briefly and returning, but spends long periods hammering at the lining of the cavity with her bill. The males catch a food item and then gather dry grass and leaves in the bill without relinquishing the food. They deposit this load in the nest, where the female sorts through and picks out the food to eat, then depending on how full the nest is, she will either arrange or toss out the lining material.

- Ensure there is enough leaf and grass litter available daily for the male to collect and present to the female to line the nest. This may take weeks.
- Provide small natural food items for inclusion with the lining

Helping: Only the dominant female will incubate the two eggs, laid 3-5 days apart, and is fed on the nest by most group-members, primarily by adult males but including sometimes other adult females and 2-year-old and older juveniles. Food is usually delivered to the nest as many items held in the bill tip, unless there is a single large item, or a small item is found close to the nest. Items are collected by placing those already caught on the ground while securing additional prey. The alpha-male and helper males will feed the female through incubation and, once hatched, the chick also until it fledges at 3 months old. The second-hatched chick will be ignored, should the first chick appear fit and healthy. Food is dropped on the nest-floor and either consumed by the female, or fed by the female to the chick, until the latter can see to feed itself from about 3 weeks old.

- Ensure the supply of small enough food items throughout the day for the male and helpers to collect to provision the female and the chick.

During this period, the female may leave the nest for up to 45 minutes once the chick is 10 days old to defecate, preen, dust-bathe and occasionally to catch some food for herself. By 30 days old, the chick is normally left totally alone except for visits to dump food. The group will usually visit the nest at dawn, and the incubating female will also emerge to call with them. The group will then visit the female on average 3-4 more times per day with food. By 30 days old, the chick can be left totally alone, though the female will return regularly with the group to feed it.

Once fledged, the juvenile will continue to be fed by all group-members, following them around with incessant begging. Although the chick can feed itself after six months or a year, it may still be given food when at least 2 years old if it solicits an adult. Juveniles of two years old do not assist with feeding at the beginning of the next season, but learn to do so during their second summer.

5. Aggression

Dominance: A dominant bird will assert its authority over other individuals in the group using complex interactions involving the giving and withholding of food. Often, the alpha-male will retain a food item in his bill and walk around holding it raised in the air as the height of dominance, as if 'parading' it, and ignore the begging call of juveniles in the group.

During agonistic encounters, threat is shown by raising the bill as high as 70° above the horizontal and so exposing the naked throat skin. As the intensity of the threat increases the bill is lowered and the aggressor advances with the bill slightly open and directed at the opponent. This leads to pursuit if the opponent moves away, or to bill-grappling if it does

not. This may lead to chasing and bill-grappling in flight, as often occurred during territorial encounters.

Territoriality: When groups meet on a territory boundary, sometimes the hornbills will peck hard at solid objects, especially those producing a loud sound such as a dry log. At its most vigorous the wings will be jerked open with each peck, producing a flash of white primaries.

When in a foreign territory, birds will become alert, look up and about frequently when feeding, and fly back to their territory if encountering their neighbours. The resident group will pursue any intruders, which characteristically involves high aerial chases, but once the intruders have returned to their territory will either perch quietly or will call at their repulsers. Juveniles take no part in territorial defense until at least four years old, but may risk predation when left behind during pursuits.

6. References

Kemp, A. 1995. Bird Families of the World. In *The Hornbills Bucerotiformes: Bird Families of the World* (1st ed., pp. 94–99). Oxford: Oxford University Press.

Kemp, A.C. 1988. The behavioural ecology of the Southern Ground Hornbill: are competitive offspring at a premium? In *Proceedings of International 100 Deutscheornitologen-Gesselschaft Meeting Current topics in avian biology* (pp. 267–271). Bonn.

Kemp, A.C., & Kemp, M. I. 1975. Studying the basic biology of the Southern Ground Hornbill. *Bulletin of the African Bird Club*, *March*, 6–7.

Kemp, A.C., & Kemp, M. I. 1980. The Biology of the Southern Ground Hornbill Bucorvus leadbeatri (Vigors) (Aves: Bucerotidae). *Annals of the Transvaal Museum*, *32*(February), 65–100.

Theron, N., Jansen, R., Grobler, P., Kotze, A. 2013. The home range of a recently established group of Southern ground-hornbill (*Bucorvus leadbeateri*) in the Limpopo Valley, South Africa. *Koedoe*, *55*(1), 1–8.

Wilson, G., & Hockey, P. A. R. 2013. Causes of variable reproductive performance by Southern Ground-hornbill Bucorvus leadbeateri and implications for management. Ibis 155: 476–484.

Chapter 6: Nutrition

Tracy Rehse
National Zoological Gardens of South Africa

Hornbills are carnivorous birds and can be fed on a variety of meats from day-old chicks, mice and rats of all ages, game meat, chicken, snake, game birds, boiled eggs grass hoppers and mealworms are reported to work well. However the fattier meats such as beef should be kept as a smaller proportion of their diets.

A number of diet sheets have kindly been provided by PAAZA members for comparison.

Umgeni River Bird Park diet sheet

Southern Ground Hornbills								
			Morning (1 bowl)			Afternoon (1 bowl)		Total
Chicken (whole chicks)			30			30		60
Meat			120g			120g		240g
Dog Biscuit/mince/raff Mix			100g			100g+		200+

Boscia Birds

Daily:

Day old chicks
Mice
Nutribird Hornbill Pellets
Hard-boiled egg

Additional:

Diced Fruit
Hissing cockroaches
Giant mealworms
Grasshoppers

Johannesburg City Parks and Zoo (NPC)

City Parks House
40 De Korte Street
Braamfontein

P O Box 2824
Johannesburg
2000

Tel +27(0) 11 712 6600
Fax +27(0) 11 403 4495
www.jhbcityparks.com

Johannesburg City Parks and Zoo diet sheet

Common Name: Ground Hornbill

Species: *Bucorvus leadbeateri*

Enclosure: BRAVO 016

Estimated weight: Diet calculated on 5Kg average weight

Information: Ground Hornbills need to meet their water requirements through food intake. They have protein requirements of approximately 28% and high calcium requirements. The average energy requirements were calculated at 1200KJ / bird /day.

History: There are currently 5 birds in the enclosure The main feed will meet their nutritional requirements and the enrichment items are offered to meet the behavioural needs.

Revised Diet: Insects every morning for enrichment

	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat/sun**
Main feed	750g meat chunks With 4 measures felivit 40 mice	1,5 Kg Chicks	750g meat chunks With 4 measures felivit 40 mice	5 small whole chickens (2cut into smaller pieces)	40 mice or rat pups 30 chicks	1,5 Kg Chicks
	150g H16 pellets	4 measures felivit	150g H16 pellets	4 measures felivit	150g H16 pellets	4 measures felivit
Enrichment	5 boiled eggs	Insects Grapes	3 apples cut into quarters	Insects	5 boiled eggs	1 paw paw cut into large pieces
Afternoon feed	1,5 Kg chicks 3 measures felivit	1,5 Kg chicks 3 measures felivit	1Kg chicks 3 measures felivit	1,5 Kg chicks 3 measures felivit	1,5 Kg chicks 3 measures felivit	1,5 Kg chicks 2 measures felivit

Please Note! This diet is specific for the animals at the Johannesburg Zoo and is not a prescribed diet for any other animals / institution outside of the Johannesburg Zoo.

Montecasino Bird Gardens diet sheet

Common Name	Southern Ground Hornbill
Scientific Name	Bucorvus leadbeateri

Feeding Actions

Morning - 09H00

DIET DESCRIPTION (PER BIRD)	AMOUNT
De-yoked Day old Chicks	5
H16 (Specialised Hornbill Pellet) or Good Quality Dog Pellets (Soaked)	50g (Dry Weight)
Fruit – Apple/Watermelon/Grapes	40g
Ox-heart (or Venison)	75g
Whole Boiled Egg (**Mon,Wed & Fri**)	½
Crickets/mealworms (Enrichment)	

*Fresh water to be supplied daily

Afternoon- 15H00

DIET DESCRIPTION (PER BIRD)	AMOUNT
De-yoked Day old Chicks	8
Mice (Mon, Wed & Fri)	2
BREEDING SEASON(August-January):	
Mice (Everyday)	2
Crickets/ mealworms (**Tues, Thurs & Sun**)	3/3

Mondays	Calcium & Insect Pate	1 tsp each
Tuesdays	Beefee & Mirra Cote	1 tsp /5ml
Wednesdays	Calcium & Insect Pate	1 tsp each
Thursdays	Beefee & Mirra Cote	1 tsp /5ml
Fridays	Calcium & Insect Pate	1 tsp each

National Zoological Gardens of South Africa diet sheet

Species Diet Sheet

Southern ground hornbill
Bucorvus leadbeateri

LogOn: 01.10.2007
Average Weight: 4 (kg)

AM

FoodItem	Preparation	FFCode	Times	Quantity	Units	UpDate
Calcium supplement (ICD)	Powder	D	AM	5.00	g	13.08.2013
Chicken	Boiled	D	AM	0.10	kg	13.08.2013
Day old chicks	Whole	D	AM	6.00	Each	01.10.2007
Egg	Boiled	D	AM	1.00	Each	01.10.2007
Mouse	Whole	Mo,We, Fr	AM	3.00	Each	13.08.2013

Comments: Insects should be fed weekly when available.

Signed: Dr Ian Espie
Veterinarian/Nutritionist **Curator/Conservator** **Date**

13.08.2013 This diet sheet was reviewed by **IE** on **13.08.2013**

Chapter 7: Environmental Enrichment

Ann Turner*, Alan Kemp*, Dee De Waal*, Nick Theron*, Ben Botlhole*, Gillian Theron*, Delecia Gunn** and Lara Jordan***.

* Mabula Ground Hornbill Conservation and Research Project

** Loskop Dam Nature Reserve

*** Johannesburg City Parks and Zoo

1. Enrichment

These birds are very intelligent so it is advisable to build enrichment ideas into their enclosures and food structure.

As with carnivorous mammals, it is a successful technique to hide food around the enclosure. Feeding three or four times a day is advisable to help occupy their time. Feeding whole carcasses when available is a great enrichment e.g. game birds or pheasants.

A pile of leaves or hay, into which you can put meal worms/crickets/frogs etc. keeps them naturally busy for hours. Also hiding live food in Rhino or Elephant dung and placing it in the enclosure is a natural foraging behaviour where they hunt dung beetles in the wild.

Alternatively putting mealworms in a 2 litre coke bottle will have them throwing the bottle around to retrieve the mealworms. Or similarly placing a heavy rock in the bottom of a bucket so they cannot tip the bucket and putting in leaves and mealworms will keep them entertained.

Throwing a cardboard box into an enclosure will also keep the birds entertained as they enjoy breaking it up.

Chapter 8: Reproduction

Ann Turner*, Alan Kemp*, Dee De Waal*, Nick Theron*, Ben Botlhole*, Gillian Theron*, Delecia Gunn** & Lara Jordan***

* Mabula Ground Hornbill Conservation and Research Project

** Loskop Dam Nature Reserve

*** Johannesburg City Parks and Zoo

1. Pairing

Sub-speciation of the Southern Ground hornbill has not been defined at the moment; so it is unclear whether variation exists across the species' range. This could have repercussions on breeding and pairing in captive populations, and confirmation of this issue is important for future recommendations. In the absence of this information it is deemed prudent to maintain at least Southern African and East African stocks separately.

Females may need to be 10 years old before reaching sexual maturity in captivity, and males about 7-8 years old. Putting a young pair together will help the bonding process.

2. Parent Rearing

If the female is interested in breeding she is likely to spend an increased amount of time in the nest box, banging the inside (a protein rich diet can be given to the female at this time). These hornbills do not mud up the entrance hole. This early breeding behaviour has been seen in females around the age of five well before maturity. The wild the nest is lined with grass with leaves on top. The parents can be seen taking new leaves and a food item to the nest box throughout the breeding season; this is likely to enable the box to be kept clean. Therefore adding leaves to the enclosure enables the parents to maintain a clean nest box. It is thought that fresh leaves especially damp leaves will increase humidity in the nest. In the event of a particularly hot season it is advisable to put damp leaves in the enclosure for the parents to utilise. In captivity a mixture of wood chip and hay has also been used successfully.

In our wild and captive experience of parent rearing, these hornbills will never rear both chicks no matter how much food you give them and how many helpers they have. Therefore it is prudent to remove the second chick and hand rear.

The diet for the enclosure whilst rearing chicks has been successful with the following regime. Feed every two hours from day 1, chopping up the food, and skinning and removing egg yolk and bones. Add small crickets and mealworms if available. Increase the size of the food as the chick gets older. At around two months start introducing skin back into the diet. Eventually start adding bones, introducing foodstuff with soft bones and cartilage working up to whole day-old chicks.

3. Double Clutching

Double clutching for this species is in its infancy as far as knowing what effect it will have on the pair. Long lived intelligent birds such as Ground Hornbills need be given the opportunity to fail in the nest and 'learn from their mistakes'. Dummying the eggs has been attempted with little success as the adults did not accept them as real eggs (the quality of the dummy eggs may affect this). Repeated taking of eggs may lead to an over protective response such as, destroying their own eggs. Furthermore they are very slow breeders bearing in mind that they attempt to breed on average every 2-2.5 years, which is the same length of time that it takes a chick to be able to fend for itself. The first signs from multiple clutching in the same year are that successive eggs and therefore chicks become increasingly smaller and weaker and in turn this will also have a long-term effect on the female. Clearly then it is important to plan your breeding strategy with careful consideration to the hornbills natural breeding cycle. Double clutching may improve productivity although repeated multiple clutching should not be performed.

4. Incubation

In most cases the hornbills will hatch both eggs and then will totally ignore one chick. Thus it is unlikely that incubating eggs will be necessary unless double clutching. There is some incubation experience available; the Zoological Society of San Diego incubated at 37.2ºC with relative humidity at 58.5%, hatching at 36.9ºC relative humidity at 66%. Abrey (1993) used an Anderson Brown moving carpet incubator, incubated eggs at a dry bulb temperature of 37.5ºC and a relative humidity of 52%. The eggs were automatically turned twelve times per day.

Other combined experience from South Africa of the Mabula Ground Hornbill Research and Conservation Project in conjunction with the National Zoological Gardens, Umgeni River Bird Park cc. and Montecasino Bird Gardens discovered that a 65% relative humidity for incubation proved a little too humid and caused hatching difficulties. The temperature used for incubation was 37.2ºC and relative humidity 45%-65% and weight loss was 14-15%.

Chapter 9: Hand-rearing & socialising protocol – 2014 / 2015

Ann Turner*, Alan Kemp*, Dee De Waal*, Nick Theron*, Ben Botlhole*, Gillian Theron*, Delecia Gunn** and Lara Jordan***.

* Mabula Ground Hornbill Conservation and Research Project

** Loskop Dam Nature Reserve

*** Johannesburg Zoological Gardens

This chapter is compiled by various hand-rearers from several institutions (see section 1. 8.) and is based on over 16 years of experience hand-rearing chicks harvested both from the wild and from captive-bred pairs. The chapter covers complete protocols for housing and feeding Southern Ground-Hornbill chicks and covers any problems that may arise. This is followed by a day-by-day table of what to expect and several hand-rearing records are included from a number of institutions that should act as a daily guideline for development and needs of the chicks from hatching to fledging.

1. The basics of rearing southern ground-hornbills chicks

a. Reasons for hand-raising southern ground-hornbills

You must have a clear understanding of the reasons why you're hand-raising the birds within your institution and what their intended futures will be. They could be for:

- "Show" or Ambassador birds;
- birds intended for captive breeding either to ensure the survival of the species or as a commercial endeavour,
- to encourage "double clutching" in captive breeding pairs or;
- simply because one has been unable to get the adult birds to rear their chicks in captivity
- "second" chicks from the wild have been harvested for rearing with a view to contribute to the conservation of the species through both captive breeding and reintroduction to the wild.

If the bird is destined for **reintroduction/release** then the method of release will be an important factor to consider (introduction to wild group/established tame group/with a shepherd/using conditioned response to noise, *etc*). The future of the bird will also influence what sort of socializing is required and regardless of the destiny of the bird the aim should always be for as healthy a bird as possible. Taking short-cuts will lead to an inferior-quality chick and this reduces it chances of being a successful release or captive breeder. It is very important to be well prepared; particularly if large numbers of chicks are to be reared at the same time as they are 'high maintenance birds to rear. It is vital to be committed to the entire process for the full three months it takes them to fledging age.

It is also important to know the natural history of the species when rearing any bird and this information is readily available. Relevant information is that the brooding female leaves the nest between day 15 – 20 and the fledging period is about 86 days. Nest cameras have captured more information and this is being analyzed to provide more insights that may enhance the rearing process.

To ensure successful rearing it is recommended to be in contact with someone who has already reared ground-hornbills successfully. It is worth a visit to several rearers to see how they set things up and to discuss any issues they have had to deal with. Prepare well in advance and do everything possible to not work with birds when you are stressed.

b. Imprinting, socialization and conditioning

Natural imprinting (i.e. on the same species) results in normal/ healthy/correct behaviour and is a combination of exposure to mainly visual and auditory stimuli. Different aspects of behaviour will be affected at different ages for each species (there is extensive information for humans and dogs but very little is known of the details of "mental development" stages in ground-hornbills).

When hand-rearing it is not just a matter of avoiding malimprinting (on humans), the chick must also learn its own species' communication and social cues to ensure it can be a successful breeder/provider/protector later in life and so the use of puppets and one-way mirrors has limited effect other than avoiding malimprinting. Birds that were reared using "ghosts" were found to respond to the silhouettes of people or even the shadows of people. A chick that is already human imprinted bird may still make an excellent parent/show bird, and could be used as a surrogate parent for chicks; this would resolve any future malimprinting problems.

It is important to note that imprinting is more marked in "hungry" chicks.

Rearing with a resident group of hornbills will expose the chicks to their own species and is certainly better than rearing in isolation. Where not possible a chick of another (but preferably similar) species might help. Where a chick must be hand-reared but "tameness" is to be avoided it will help to:

- get the chick exposed to ONLY one person to ensure that it does not approach "strange" people; or
- all rearers involved wear a specific costume; or
- the rearers work together to feed for the first 15 - 21 days; thereafter the workload can be shared into am and pm shifts with some overlap during the day: this mimics the natural system where only the female feeds the chick until day 15 - 21 when the rest of group start taking over the feeding responsibility. It has been shown when this is not the case the stress involved compromises the chick.

Where the chick is going to be kept tame in captivity or used as an ambassador bird it is important to get the chick used to the stimuli it will encounter throughout its life. This should happen from as early an age as possible. Release birds will also need to learn survival skills and develop good physical fitness/flight ability and this must be kept in mind. They would also need to be taught fear of predators (and maybe of humans too, depending on the threats they would be exposed to). Degree of imprinting is variable according to the rearing that has been done.

One should use the imprinting to advantage according to what one requires the bird for, however the malimprinting of SGH on humans should always be avoided as these birds are large, well-armed, potentially aggressive birds. There are several cases of increased aggression leading to injury when the birds reach sexual maturity, fuelled by hormonal changes. In the wild these birds would move away from humans but in captivity humans may become a target for the aggression. There may also be a reduction in breeding success, and social adaptation (aggression or fear towards or simple "misfit' behaviour) to other SGH, as found in other hornbill species.

It is recommended that chicks are reared only in facilities that can allow for the exposure to adult SGH throughout their development as described below.

Socialization to adults is done from the earliest possible stage. The chicks can hear the adults calling from day one (and likely even while still in the egg). When the group is calling the brooder lid should be opened to allow for this. The chicks are put in a secure cage or

"puppy pen" for sunlight and this is slowly positioned closer and closer to the adult enclosure. If there are any signs of stress the cage can be moved further away for a while and then gradually returned.[1]

Once the chick's eyes open the chick should have short visits to the adults. From day 15 they should spend the mornings and/or afternoons against the fence of the adults' enclosure. Once the chicks are standing they are kept in an enclosure next to the adults and once they can walk they are moved to an area adjoining the camp where they can learn to perch. At about fledging (day 86) they can be placed into the adult's aviary but must be monitored carefully for assimilation into the group, as SGH, like most social animals, will kill each other with alarming speed.

Allowing captive pairs to rear their own chicks

Allowing captive pairs to rear their own chicks allows for the ideal socialization of the chicks and is best for both rearing captive breeders and release birds. This has been achieved with much success by Mpumalanga Parks and Tourism at Loskop Reserve. A female, 'Kruger', was hand-reared at the National Zoological Gardens in Pretoria in the 1980's. Prior to moving the bird to Loskop (in Aug 2004) the female had laid eggs but had broken them on every occasion. The female had hospitalized a few people in other institutions and was moved to Loskop for pairing with a wild fledged 6 year old male. This pair immediately started breeding and by the 1st December 2004 the first chick hatched and was parent reared; the second chick was not reared. This pair has reared a chick every year for eight years showing the immense productivity available from breeding captive pairs. It is important to note that food preparation for parents rearing their own chicks is the same as for hand-rearing the birds (this is very labour intensive but vital – see the feeding section below for more details).

[1] At Loskop: When the chicks are about 15 days they are put into a 'puppy pen' next to the aviary in which the adult birds are kept. This is done during the day from 10:00-18:00 starting at 10 minutes and gradually increasing the time, the bird gets accustomed to the outdoors (otherwise it gets intimidated by new environment). Enclose the chicks to protect them from predators. A puppy pen however does not allow the adults to feed the chick and so another plan needs to be made to allow interaction and feeding between adults and the chick. Monitor the chick if it shows stress and take it back to where it is comfortable and try again the next day. Once the birds start to stand they are transferred into a passage way/introduction camp which runs next to the aviary where they learn to walk and perch (the perches are only a few centimetres off the ground as the chick cannot fly well yet).

c. Hygiene

It is very important to keep the birds clean. After each feeding use a warm, moist piece of gauze to wipe away any food that may have collected on the beak, face, head or anywhere else on the chick. Dry them completely so they will not get chilled. Feathers will not grow in areas that are covered with dried-on food! Clean hands before each feed and place all utensils used for feeding in the sun after washing daily/ OR Milton is great for disinfecting syringes and plastic food dishes or other feeding utensils. For all metal instruments used Biocide, Virkon-S or Hibitane are good products to use. Read directions carefully when using the latter products. If instruments are left to long in disinfectant they may rust.

There is a huge difference between captive and natural situations and so general hygiene principles must apply. SGH chicks seem to be particularly susceptible to infections, particularly if there are any stress factors present. It is essential to keep the birds, bedding, feeding utensils and surroundings clean to prevent disease transmission/bacterial build up. Any food or dirt remaining on the feathers or bill can lead to an underlying bacterial/fungal growth that causes damage or discomfort for the chick. If any chemical disinfectants are used then be aware of what these are and what threats they may pose.

If the SGHs come from various sources or have been housed with different species there is a risk of disease. Prey/food species may also host disease; particularly if you are the origin is uncertified. Be aware of these in terms of the risk they may pose to the chicks. Prepare all food hygienically.
There is usually a lot of food wastage that may attract flies so ensure waste is removed from the site and disposed of regularly.

The system used at Loskop is to wash everything well. All utensils used to feed the chicks are put out in the sunlight to dry/disinfect. NO disinfectants/sterilizers/antiseptics are used for cleaning, but hygienic practices are followed with everything being kept clean at all times. To date no chicks have been lost to disease and no chicks have ever received antibiotics.

d. Food

Food quality and quantity

Food becomes important long before the first egg is even laid. If parent nutrition is not maximized during the courtship phase then eggs will be laid that may be small/underweight which will lead to chicks that are more difficult to rear.

Food quality and quantity are probably the most critical factors for rearing SGH chicks. One needs exceptional quality food, and **lots** of it! If you're planning to rear a few chicks **you will need to plan well in advance** to ensure an adequate supply of fresh, good quality food is available at the required time. SGH food must not be bought at the supermarket as this may be less fresh, full of hormones or worse salmonella and other potentially harmful bacteria. A common problem is running out of a proper selection of fresh healthy food and trying to get by with "shortcuts" or with only one type of food for several days. Give the greatest possible

variety of food types to ensure the most balanced diet possible, as one food type will compensates for any nutritional deficiencies in another. Although the species is carnivorous it does not eat JUST meat; do not remove the organ and beware of over supplementing. No supplements were used in the past and no bone problems were experienced (some rearers now use Beefee, Calsup and Protexin). If the diet is comprised of healthy fresh varied food supplements are not required and can lead to other nutritional imbalances. If Probiotics are to be used then Medvet Intestum is most highly recommended followed by Medvet Enteroplus if Intestum is not available. It must be remembered when choosing a pro-biotic that these are carnivorous/faunivorous birds with no crop.

Years of experience have shown that regardless of what other food items are chosen from the list below it is highly recommended that mice (pinkies/fuzzies etc – depending on age of chick) MUST be included in every feed or the birds will lose condition.

***it is very easy to become monogamous to your food choice – be careful of this and ensure variety at all times.

Food items used:
These birds are naturally faunivorous – eating entire animals – guts/exoskeletons/bones etc and this should be borne in mind when choosing food:

- Adult and baby mice ("pinkies" and "fuzzies", **skinned** and feet, tails and muzzles removed for the first week as it makes skinning easier);
- Rats and rat pups (convenient once the chick is a bit larger);
- Rabbits, use white meat and internal organs;
- Doves and pigeons (check carcass for any sign of disease!);
- Chicks, day old and reared for a few days to a few weeks (at around 7 days these are calcium-rich);
- Game birds;
- Flying ants (BUT **only one a day depending on size** – anymore will be too rich);
- Snake/Reptiles (remove heads if venomous);
- Silkworms;
- Mealworms, giant mealworms, crickets and flying ants;
- Aviplus or Pronutro
- Yolk of boiled egg;
- Assorted commercial meat is used as a last resort, in combination with the above;
- Red meat is best kept to an minimum – domestic meat is to be avoided due to the use of antibiotics in the commercial farming industry. Game meat is preferable.
- Dog food (or low iron pellets?) – these must be soaked and of good quality; and
- A variety of fruit such as grapes and paw paw/ papaya can also be given.

The quality of any animals raised to feed the chicks on **cannot** be compromised. They must be kept in good hygienic conditions and fed optimally to ensure the best possible quality feed. If they are nutritionally deficient this will be passed on to the chicks. Stress must be kept to a minimum as this will make them susceptible to disease which may be transmitted

to the SGH. You need to keep both a mouse colony and rear chicks and probably mealworms too to ensure there is no drop in the quality of the food[2].

Food preparation
Fresh or defrosted frozen food may be used for feeding the SGH chicks, although the freezing and thawing process may affect the nutrient quality of the food. This also has hygiene implications if not carried out properly. For very young chicks freshly killed food is preferable.

Food must be freshly killed before each feed, especially for young chicks and reused for no more than one feed. Day old chicks must be quickly frozen after slaughter (lay the chicks out on a flat surface to ensure quick cooling down of the carcasses as a bag of chicks is insulated by the down and carcasses will start decomposing). Defrost chicks on a tray overnight on newspaper, preferably in a refrigerator. Sometimes you may need to place the chicks in sun to warm them. Some may have started decomposing so select the food carefully! The food should be room temperature at feeding.

When captive adults have a chick in the nest all food must be prepared for them in the same way as you would prepare food for hand-rearing. This is a tremendously laborious process but remember in captivity these birds have no other way of accessing the correct food for their chicks and if you do not provide it they will respond to the chick's begging reflex by feeding whatever is available in the enclosure – like twigs or leaves – and this is dangerous for the chick.

Feeding
The following equipment is required for feeding hand-reared chicks.

- Tweezers (blunt end)
- Scissors - to cut the food
- Syringes - for administration of fluids
- Stainless steel bowl - to warm food
- Plates - for bird to self feed

All must be cleaned immediately after use and placed in the sun to dry.

Hold food items with blunt tweezers above the chicks head and allow it to grasp the food firmly. **Feeding** is **only** done when the chick is **actively begging** (lifting its head up and vocalizing) and has defecated since the last feed. This gives an indication that the bird is both strong and hungry and able to eat. If there is no active begging reflex then there is a possibility of aspiration or that the bird is in some way unable to deal with food, or is not ready for the next feed. If the chick is stressed due to being too hot or cool, "fright" factors, disease, etc., give it fluids until stabilized and then feed. If the ambient temperature is too

[2] *It has been discussed, due to adult birds macerating the chicks food by banging it in the soil, that soil might be considered for incorporation into the diet. Possible termite mound soil (gut pH) or vermicompost that would include probiotics, possibly diatomaceous earth would help with mineral supply.*

hot/cold then do not feed. Correct the temperature, allow the chick to stabilize and then feed it. Always ensure it has defecated and monitor the quality and quantity of the faeces before feeding. It can happen that the chick is defecating but insufficient amounts caused by a lack of fluids, which may be problematic later.

Feeding frequency should be done according to the daily recommendations (see Section 2 and 3). However each bird exhibits individual needs, particularly if it has been through a "stress period". It is best to adjust to the individual. If the chick does not respond with a good feeding response it should be left and tried again in an hour. Sometimes chicks will skip a meal but it is no reason for concern. It is beneficial to give the gut a break to empty out overnight (it also helps if the person rearing has had some sleep!).

If in crisis or rushed (meetings, family needs etc) give Ringer's Lactate for a feed and go back to feed the chick later. It is always better to skip a meal and have a slightly hungry bird than to make some other mistake (burn it /drop it/overfeed it/choke it) due to trying to feed in haste. However do not let this become the norm or the bird will become underweight and will develop behavioural and immunity problems.

How? The first time a newly hatched chick is fed should be in the evening to allow the gut adjustment time before the next feed and allow defecation. Chicks should then be fed from 5am (an early start allows for time crises during the day) or at least give Ringer's Lactate after weighing, if time is an issue.

The chick is taken out of brooder in a bowl for feeds and placed at a comfortable height to work with. Paper is changed after each feed to allow monitoring of faecal output (and to avoid heart failure in the rearers when mistaking blood from previous feed for something from the chicks!)

***Pinkies**: when feeding pinkies, remove feet/tail/muzzle (to facilitate skinning and ensure no small pieces of skin are left), leave guts and milk bag (stomach). If fresh pinkies are being used they should be freshly removed from their mothers and not stressed or starved or dehydrated before use! Frozen pinkies are difficult to skin as the skin breaks up when pressure is applied. Frozen pinkies are useful once skin and fur have been introduced into their diet.*

***Day old chicks**: Remove skin, yolk, wings, all feather-down, the feet and head. Use the liver and heart and chop/crush the chicks into smaller sections a meat cleaver is optimal. Cockerels that have been reared for a few days or a few weeks can provide bigger parcels of food and are therefore less laborious (they also don't have the yolk sac that needs to be removed). They can also be fed freshly killed (and fresh is critical for chicks in their first week).Ground Hornbill chicks are able to digest cartilage from a very early age, but impact on bone.*

e. Housing of ground hornbill chicks

Bowls

It is preferable to simply put the chick onto the prepared substrate on the brooder floor. If this is not possible then the bowls should be as shallow as possible. If a chick aspirates liquid this allows it to throw its throat forward and level with the floor, allowing the liquid to escape and thus reducing chance of aspiration. Ensure the bowls do not have sharp edges either as the chicks sometimes fall asleep with their necks over the edge and this can lead to aspiration or neck damage.

Face cloth

The chick is much more restful with a face cloth/flannel draped over its body. This simulates the pressure of the mother and calms them. Avoid feather dusters as the chicks get caught in them.

Brooders

Brooders should be secure and temperature and humidity controlled[3]. Whatever housing is used be sure you are familiar with it before the chicks arrive!

Temperature and Humidity

Controlling the temperature of their environment is important as SGH chicks remain featherless for an extended period. Temperature should be above 36°C for first week and not lower than 32°C. As the chick gets older it can tolerate greater temperature changes. Chicks must not be housed at high temperatures after days 15 – 20 as this is when the female leaves the nest for longer periods and chicks can regulate own temperature. She only returns to the nest at night.

SGHs breed in fairly warm/humid areas and so humidity must be kept high (65 – 88% seems to be optimal). Any loss in humidity must be compensated for; this is particularly critical in SGH as they normally only breed after the first rains. A dramatic improvement has been observed in the bird's skin after the first rains as they do not flake/peel. Whatever water is lost through the skin needs to be replaced in the diet. In addition a dish with water should be supplied to ensure the humidity remains high but this must be out of reach or have paper

[3] ***At Loskop*** *the position of the brooder is not moved once the chicks are in it. Passed experiacne has shown that it is not ideal to travel with the chicks.*
A water bath system is used with an aquarium heater. Temperature control can be a bit tricky and they have to be checked for leaks and functional thermostats at beginning of each season but they are silent, there is no light clicking on and off, there is no constant buzz of a fan and there is no constant flow of air leading to dehydration of the chick. A second thermometer is kept in the brooder to check the temperature and this is monitored at each feed in addition to observing the bird's comfort level. The humidity stops the skin peeling. Even in the brooders the effect of environmental humidity (arrival of rains) cannot be ignored and there is a noticeable difference with their eyes opening earlier and easier if the chick hatches once the rains have arrived.

towel/sponges in it. A plastic container filled with wet cotton wool/ sponges (as used at Johannesburg Zoo) with a perforated lid will provide a safe source of humidity.

It is important to not neglect **airflow**. This is important (as the brooders air can become very foul) but should not be extreme (fans can desiccate the chick and the noise may not be ideal).

Safety and stress

One should look at all possible aspects of safety:

- burns from heating lamps/coils being within reach of the bird;
- drowning/overheating;
- eating junk;
- attacking each other;
- predators, particularly once the chick is larger and is being housed outdoors - the enclosure should be predator proof.

Noise has been proven to play a role in stressing chicks and so do not house with other noisy species and rearers should avoid making any loud noises. Some background noise however may help to get them adjusted to their captive situation and disguise other noises. If they've been kept in total silence and there is suddenly an unexpected noise they will become stressed.

It is unquestionable that chronic stress will influence the chick metabolism, through the presence of cortisol, which influences bone formation and lowers their resistance to bacterial and other infections.

Keep only **ONE** chick per brooder as they show aggression towards each other and even if they cannot grab each other the other chick's presence may be stressful. These chicks exhibit a phenomenon known as passive siblicide as opposed to active siblicide in which the younger bird would have been actively attacked and killed.

The chicks will need to be kept warm with an infra-red lamp at one end of the tub once they have outgrown the brooder. The tub should be positioned so that the bird can adjust its distance to the lamp to maintain a comfortable temperature.

Sunshine and exercise

These are both critical for good physical and mental development. It is important to build their exposure to the sun up steadily. Put the birds in the sun briefly from day 2 (weather permitting) in dappled shade or early morning/late afternoon sunlight. Monitor the chick continually for comfort/stress/overheating. Birds show an appreciation for being put out in the sun. Chicks that have NOT been exposed to sunlight will spread out their wings and sunbathe immediately when given the chance and there's no good reason NOT to put the birds out in the sun.

From day one the chick must be encouraged to exercise as much as possible. It is a mistake to make life easy for the chick and plenty of movement must be part of what's expected from the chick. Remember to make the chick work for its food by moving around the bowl if

facing the wrong way. There is no harm in deliberately facing the chick in the wrong direction and asking it to turn around for food.

Occasionally very yellow chicks are hatched and these benefit enormously with direct sunshine. If UV lighting is used it must be remembered that this is of higher intensity than natural sunlight and so should be treated accordingly.

Substrate

It is not normal for a chick to be on a flat surface in a wild nest; it can cause pressure sores and due to the birds feet slipping can cause splayed legs and retard the bird's development as it cannot support itself. The substrate[4] must be kept clean and changed regularly. Ensure that it cannot or will not be eaten (this should not happen if chick is well fed and not excessively bored) and cannot entangle the birds feet or neck. When the bird gets bigger it is moved onto fresh, green leaves (these also assist in raising the humidity) and eventually twigs. Initially house the chick in a bowl, into which it fits snugly, within the brooder. Sometimes chicks fall out of their bowls, get their heads stuck over the bowl or between the bowl and brooder, move up into a corner and may eventually tip themselves over, this is where it is necessary to be within earshot to hear the distress calls and be able to correct the situation. From the small bowls the chick progresses to a 2 lt plastic tub and then onto a larger area of the brooder. Increase the amount of space given to the chick gradually. Should the chick show signs of stress return it to what it is used to and try again in a few days. They should be kept on an absorbent and non-slip substrate. The chick eventually progresses to being kept on leaves in a thick layer.

According to the temperature and comfort level of the chick the brooder lid is gradually lifted allowing it to adjust to environmental temperature. Then the chick is moved into an open tub, which allows better ventilation, with a heating/Infra-Red lamp. The lamp should not be able to come in contact with the chick when in a standing position.

[4] *A non-slip layer is placed with a layer of tissue/kitchen roll and another non-slip layer of so that the bird's legs do not splay out (and the paper does not slip out from under bird). Paper has a rough (indented) pattern and it is further scrunched into a ball before being used and extra paper balls are placed to use up extra space in bowl when necessary. Keep a second bowl in the brooder, after each feed place bird in clean bowl; this way it is already warmed up and one can monitor faecal output at each meal. Peat moss/shredded paper/wood wool can be used but it must be covered by a non-slip surface and paper to ensure the chicks cannot eat the substrate.*

f. Observation and data

It is important to spend time observing the chick daily; preferably at each feed (see appendix 1 for a sample data sheet). The chick's behavior will give some indication of its state of health. Accurate records should be kept at each feed of **appetite**, **habitus e.g. vocal, getting up to be fed, shivering etc.,** and **faeces**.

This is important as you will need a reference as:

- you may run into problems and can then refer back to see what changes may have occurred;
- a handover from one person to the next doing the rearing;
- this is of great value to others in the future who may need to refer to this information.

- **Posture** will indicate if the chick is hot (lying flat with legs stretched out behind it) or cold (huddled up with wings and legs tucked in tightly).
- **Vocalization** may indicate that it is hungry, in pain or fearful, but might also be due to mal-imprinting which may cause the bird to vocalize excessively.
- **Weight** is one of the most critical indicators of the chick's progress. Weighing should be done every morning before the first feed. This should be recorded and compared to the "normal" growth curve (See appendix 2). If the chick falls behind the "normal" curve (due to disease or underfeeding) it should not be forced up to the normal growth curve, but allowed to follow a similar growth curve from present weight. In the case of extreme problem chicks they have simply been allowed to dictate their own food requirements (with an experienced rearer).
- **Body condition** should also be noted. This can be recorded by taking regular photographs of the chick, preferably against an object to give an idea of scale. The development growth and stages can be compared with other chicks.

The **feather development** of chicks is important as it affects not only flight but also temperature insulation, waterproofing, synthesis of Vitamin D and predator avoidance. It is vital to ensure feathers remain in peak condition - the chick should be able to preen and damage to feathers should be avoided. "Fret marks" (weak sections along the feather) are caused by stress factors at the time that section of feather was growing out. These marks make the feather susceptible to breakage and as each feather is supported by those alongside it if there is a weakness this may lead to a permanent situation of the new feathers breaking off. As SGH take a long time to moult this could have a negative effect, especially relevant in a bird intended for release.

g. Troubleshooting

Dehydration: SGH chicks are extremely susceptible to dehydration**,** as they would normally breed after the rains begin (hence the name 'rain birds'). Environmental humidity plays a role and chicks hatched after the first rains tend to develop better and without the problems of delayed opening of the eyes and peeling skin, which inhibits the eruption of the feathers. Clearly visible, puffed up s**ub-cutaneous airbags or neck pouches** indicate good hydration. If these are deflated against the throat it indicates a problem. Dehydration may lead to constipation/ impaction and even kidney damage and gout and brooders must be set up to minimize water loss. To correct for dehydration give oral fluids and increase the environmental humidity. If the chick appears dehydrated then REHYDRATE THE BIRD BEFORE FEEDING! Injections are to be avoided in dehydrated chicks as they cause extensive bruising and fluids should rather be replaced orally.

Impaction: This will be recognized if faecal output is monitored at all times. The faeces should be well formed not watery or pasty. There should be a deferent distinction between the uric acid and the faeces. The uric acid should be white while the faeces is dark in colour. The faecal may be green just after hatching but will change after a day or two. The colour of the faecal content may change depending on the diet. Some chicks are very active and it may happen that they smear the faeces around the bowl which may give the impression that the chick has diarrhea. Most chicks will defecate just after a feed or during the feed. Time spent waiting for the chick to defecate is not wasted.

Impaction may be caused by the wrong type of roughage/food consistency, gut stasis due to stress/temperature or may indicate general disease and dehydration. Giving fluids (Ringers Lactate Solution) to help clear the obstruction should be done first. If this does not work then administer *Duphalac.*[5]

Metabolic Bone Problems: This can occur due to the rapid rate of development of these birds. Combinations of diet/exercise/exposure to sunshine play a critical role in correct bone development. Problems seen include bent or fractured bones or complete lack of development of various skeletal structures. In some cases the birds seem healthy until a critical point is reached after which they rapidly develop multiple fractures and become unable to stand or experience difficulty breathing. Chronic stress, with accompanying high cortisol levels, will also affect bone density/metabolism and may have played a role in some chicks that developed bone problems but were fed the correct diet.

Aspiration of food/liquid may happen due to careless/hurried feeding or a bird that is not in a state to eat due to incorrect environmental temperature, weakness or disease. In addition

[5] *Duphalac dehydrates the bird further (by drawing fluid out of the body into the gut to help voiding of the gut) so it is advised to ensure the bird is well hydrated before treatment and fluid intake is increased to replace the loss. Duphalac syrup contains lactulose (4-0-B-D-galactopyranosyl-D-fructofuranose) 3,3g/ 5ml. 1-2ml given orally repeat after 2 hrs if no faeces seen.*

if a chick is left to get too hungry then it eats too fast, which may also cause this problem. If giving fluids bird must be able to swallow and a chick must **ONLY BE FED WHEN IT SHOWS AN ACTIVE BEGGING REFLEX**. Use earbuds/q-tips to remove excess fluid and ensure the chick is not in a bowl that is too high sided to allow it to assist in removing the food/fluid and check the chick every few minutes.

Growth problems: Growing too slowly or too fast can lead to problems and the growth chart really helps to give a guideline to what is normal. Underweight chicks may become excessively vocal and will eat inappropriate objects. An underweight chick has no reserves to fall back on should it be compromised through stress, cold or disease. If a chick goes quiet simply check its growth curve; it may simply be contented, not sick. Sandoz

Deformities: These may be congenital or environmental. Be aware of how you feed as holding the bird, especially during feeding, even gently, may physically damage the beak or head. Cases have been seen of chicks unable to stand or if able to stand and walk have deformed toe structures. This has been corrected if seen early enough by placing the legs in braces. The general thought is that if the chicks don't have enough space to move around in as they are growing the lack of exercise causes the toes to be deformed. It is important that from a very young age the chicks are given the space and opportunity to move around as much as possible. Chicks should not be "cared for" too well and not over crowded at any stage.

Quality of chicks: One needs to be aware that chances of success are affected by the actual quality of the egg/chick that you are start off with. Factors that influence the health of the chick to start with include: the diet of parents and early care and incubation; and for wild harvested chicks careful monitoring (keeping the egg warm and still if handled), a timely harvest (within two days) and careful transportation (monitoring for dehydration, temperature and humidity).

This protocol was compiled from over a decade of hand-rearing experience of ground-hornbill chicks.

If you would like to contact any of the rearers please find their contacts below*[i]

Name	Institution	Country	Email
Delecia Gunn*	Mpumalanga Tourism & Parks Agency	R.S.A.	delecia@loskop naturereserve.co.za
Elaine Bratt*	Johannesburg Zoo	R.S.A.	Elaine.Bratt@jhbzoo.org.za
Christine Giannone*	Seaworld Discovery Cove	U.S.A.	christineg0831@yahoo.com
Elaine Bratt*	Johannesburg Zoo	R.S.A.	elaine.bratt@jhbzoo.org.za
Joanne Fischer*	Montecasino Bird Gardens	R.S.A.	joanne@montebg.co.za
Minah Maloto*	Johannesburg Zoo	R.S.A.	Minah.Maloto@jhbzoo.org.za
Moya von Solms*	Montecasino Bird Gardens	R.S.A.	moya@montebg.co.za
Nollie Cilliers*	Boscia Birds	R.S.A.	nollie@plantae.co.za
Tinus Oberholtzer*	Boscia Birds	R.S.A.	tinus@plantae.co.za
Ann Turner	Mabula Ground Hornbill Project	U.K.	annturner2010@gmail.com
Dee de Waal	Mabula Ground Hornbill Project	R.S.A.	dee.dewaal@gmail.com
Donna Sweet	San Diego Zoo Safari Park	U.S.A.	DSweet@sandiegozoo.org
Jane Finch	Cricket St. Thomas	U.K.	peapod777@hotmail.com
Jacqui Rankin	National Zoological Gardens	R.S.A.	jacqui@nzg.ac.za
Hendri Coetzee	North West University	R.S.A.	hc.researchlogistics@gmail.com
Lara Jordan	Johannesburg Zoo	R.S.A.	lara.jordan@jhbzoo.org.za
Shaun Wilkinson	Montecasino Bird Gardens	R.S.A.	shaun@montebg.co.za

2. Generic guidelines for southern ground hornbill

Based on over a decade of experience (2003-2012)

Common Name: Southern Ground Hornbill

Scientific Name*: Bucorvus leadbeateri*

Incubation Period: 37-43 days

Nestling Phase: 86 days (12 weeks)

Abbreviations: RL = Ringer's Lactate; ºC = Degrees Celsius; SQ = sub-cutaneous

General:
When preparing food increase food chunk size as chick grows – with increased feathers/fur bits.
When giving liquids try and maintain full recommended amounts by giving small amounts and try and give make up for any dribbles.

DAY	BROODER/TEMP.	FREQ.	DIET	INTAKE	MISC
1	**35.0°C –36.0°C** **Drop 1ºC/day** **No talking when feeding chicks!** **Play background tape of natural sounds in rearing room.** **Place chick in large bowl to allow plenty of exercise. If the bowl is too small and the sides are too high should the chick need to vomit it may be restricted**	Wait hours post-hatch to feed. **If chick is cold, do not feed! Allow chick time to warm up in brooder for about 15-30 minutes before giving RL.** ** **some chicks**	**Ringers Lactate (RL) only.** **After retrieving chick from nest, give every 2 hrs 1ml RL until chick arrives at Center.** Upon hatching/arrival at center: - If giving a feeding response then ok to give warm oral fluids (1ml). - If not giving a feeding response, place chick in brooder for ~15-30 minutes then try again. May have to give SQ fluids if chick is extremely dehydrated and unresponsive. See troubleshooting section of protocol. **If chick is stable and not stressed then <u>weigh</u> before feeding!** 1-2 skinned day old pink mice last thing before	**1 ml every 2 hr**	Hatch blind, naked, w/ pink skin. Seal should be treated w/ Iodine/Betadine Egg tooth present. Asleep ~90% of time. **Monitor faecal output daily!** Chicks should faecal and pass urates after each feeding. Faeces are dark green and contain solids; urates are white.

	causing aspiration. Bowl made up with non-slip mat, paper towel, non-slip mat. At each feed turn the bedding so that the bottom is the (clean) top. The humidity must be high: 65%-88% will do the chicks no harm. If the brooder is dry the chick will peel severely which is not harmful to the chick however it is distressing for the rearers.	**need a little while in the mornings before they are ready to feed. Give ringers fist and then come back and feed in 30 minutes – day 1 – day 15.**	retiring. Chick will lift head, gape and chirp while giving a feeding response. Moisten pink mouse with RL and offer chick 1ml after feed. **Be careful of flooding throat**. When chicks get older they can demand more fluid. Feed with blunt end or plastic tweezers and 1ml syringe for fluids.		Begin sunning - 5 mins/day but not direct sun to ensure the chick is warm.
2	**35.0°C** Keep humidity high 60%-80%. Small tubs with water and/or sponges to prevent drowning.	**Every 2hr (7x day)**	Pinkie mice (newborn mouse); skinned, w/out legs and tail. Moisten pinkie w/ RL; if required supplements can be added daily. *(Use body weight as a guideline only – let chick dictate how much food it requires)	**20% of body weight***	Air sacs observed on shoulder - if chick is dehydrated air sacs will be deflated as will the skin on the throat Ensure chick is active - exercise is important – you must make the chick work for food
3	**34.0°C** If humidity is high then chick should not peel badly - avoid gels and only use oils for flaky skin as gels inhibit the growth of feathers.		Chick will lift head, gape and chirp while giving a feeding Give chick more RL if chick gives a drinking response or has a tantrum when syringe is removed. Chicks require large amounts of fluid - be careful not to over hydrate.	**25% of body weight**	Skin starts to change color (dark purple), but throat and mouth remain pink.
4	**33.0°C**	**Every 3hr (5x day)**	Whole skinned pinkies; no legs or tail Meal worms can be added but may be passed	**30% of body**	Start to see dry flaky skin.

			undigested. Flying ants are very useful as a source of food -they can be frozen and defrosted.	**weight**	Vocalizations may begin.
5	**32.0°C**		Consider varying diet w/in first week by adding more natural food items, such as frogs, lizards, snakes, etc. **(Meat only, no skin, bones, tail, or legs)** Natural food items fed to young chicks must be thoroughly cleaned of all debris and prepped accordingly! Good brand of dog food soaked in warm water can be introduced - ½ pellet to start increasing to 5-8 pellets later. **Be very cautious; watch for impaction!**	**35%of body weight**	SQ pinning visible. Ensure that tub holding chick is big enough - allow tub to grow with chick to ensure exercise.
7	**30.0°C**	**!! with eyes opening they can get easily spooked by light and movements. They are also more irritable when the quills emerge.**	Change to fuzzies (week-old mice). 1-3 day old rat pups can also be fed—intro of small amount of fur; skinned, w/out legs and tail; moistened w/ RL.		Eye slits forming. Feather quills emerging. Dorsal air sac fully developed.
8	**29.0°C – 30.0°C**	**Every 4hr (4x day)**	**Day old chicks can be added to diet remove fluff and head. Cut whole chick up with a meat cleaver. SGH chicks seem to be able to digest cartilage but not bones.**		Eye slits both eyes.
9	**28.0°C – 29.0°C**		Put chicks out next to adult camp for short periods once eyes start opening. Ensure that chick is comfortable - not hot or cold. If adults show an interest in feeding chick ensure that	**40% of body weight**	

			what they feed will not cause impaction.		
11	**28.0°C** Move to brooder box w/ newspaper, non slip and green leaves during day + brooder at night. Night brooder should have the same substrate.		**Yolk of boiled egg can be added.**		Eyes ½ open or 1 eye ½ open; eager eaters at this age!
12	**27.0°C** Change bedding daily; move chicks to boxes or plastic crates during day back to brooder at night. As much time to be spent outside as possible near adults.	**Every 5hr (3x)**	Very young rat pups whole fuzzies; red meat meal worms flying ants, crickets etc. moistened w/RL.		If temperatures outside is low avoid stressing the chicks - rather return them to heat.
13	**26.0°C**		Add mice meat w/ crushed rib bones. No sharp pieces, must be smooth!		
15-16	**25.0°C** Female leaves the nest day 15-20 chicks can regulate own heat to certain degree.	From here on no need to give Ringers via syringe but DO keep food moist with Ringers.	Add dove (breast meat only; completely de-boned) or alternate food items per feeding (mice, chicken etc.)		Pin feathers emerging and so chicks may become stressed when picked up for weighing as feathers get pushed into body
18-20	**24.0°C** Moved to plastic tubs at day 20; Infrared lamps provided for heat; Place lamps at one end of crate allowing chick to	Every 6hr (2x)	Add small pieces of mouse pelt, 5mm² gradually ↑ to 1cm² over next several days until chick is eating a whole mouse by day 30.		Eyes fully open; eye lashes may be emerging; sitting upright during feedings.

	choose tempreture.one end of crate can be covered with a towel or blanket to keep heat.				
21	**23.0°C**	Every 6hr (2x)	Offer food in a bowl to chick; encourage self-feeding. Once chicks feed themselves they may become reluctant to pick dog food - feed with the tweezers		Legs strong and well developed; eye lashes more conspicuous.
22	**22.0°C** Outside in Boma next to adult birds .		Soak pellets ~2 hrs. prior to feeding in warm water *Dry dog food only!	**45% of body weight**	Sunning in boma next to adults.
23-25	**21.0°C**		Change to small adult mice; (cut skin into strips on mouse Add skinned and de-piped grapes; 2 grapes/chick cut in halves		
25-27	**20.0°C**		Moisten food with water prior to feeding. Feed less but still visit and vocalize to stimulate activity for safe tendon development – their legs appear wobbly at this stage but this is not of concern.		Chicks can be offered food on a small flat bowl to encourage self-feeding. Leave bowl for a few minutes in front of chick. Some chicks get the idea fast while others will learn by making a mess. Remember to feed left over food.
28-30	**19.0°C** Stop heating and maintain room temperature by keeping the room well		Change to small adult whole mice; (½ skinned); Leave a food dish between feedings. Add mealworms; 2/feeding		Feathers covering most of body;

	ventilated – this allows a smooth transition w/out heat. Chick needs to be monitored at night for chilling. A blanket over the crate may trap enough heat. The female still spends the night in the nest.				
33	No heat inside		Change to (small-med.) adult whole mice; ½ skinned and unskinned mice	**Ad lib**	Transfer before birds begin standing.
35-38	Outside all day; inside at night		3-day old Chicks		Chick may begin standing
40-45					Primary blood feathers may begin to develop.
46-51			Whole mice (not gutted) at day 50 Whole chicks at day 56 -60		
60		**Feeding Schedule: 0730; 1200; 1630 some chicks may choose to drop a feed eating more at another feed**	Change to 1-week old chicks; freshly killed, skinned, gutted, no head or legs and small rib bones crushed into small pieces. **Do not use chicks over 10 days old!** Chicks fed by group through the wire. **Never leave food in boma – attract wild animals**.		
62			May need to assist chicks w/ feeding		**First Casting**
68-70	Outside in Boma during day in upright dustbins w/ soft leaf lining; inside at night.	**Chicks will drop 1 feed a day, but never the same one.**	Begin adding skin and small feathers of 1-week old chicks to diet.		

78-84	Outside in Boma at night in upright dustbins/ crates		Change to chopped (1-week old to 10-day old) chicks in small pieces.		
84-90	Dustbins/ crates placed on side in Boma during the day; so chicks have access to hopping out onto low branches.	**Feeding Schedule:** 0730 and 1630	Feeding by group through wire of boma; difficult to assess how much food chicks are receiving.		Perching and roosting on high branches; walking and exploring boma. Fledging (88 days)
91 plus	Larger chick in boma w/ 1 adult bird.		Feed whole day-old chicks w/ skin, but continue to chop 3-week old chicks in pieces smaller than day old chicks		
114-120	Chicks out of Boma during day; inside Boma at night.				**Transmitters** (tail-mount) placed on birds.

**** at this fledging age allow introduction to the group to be gradual as it could be stressful for the chick.**

REMEMBER:

- The aim is strong, wild, non-imprinted birds that will be able to survive in the wilds and keep out of harm's way which is invariably humans so **avoid the temptation to rear them as one would for a captive situation**. Even if they end up remaining in a captive situation they are more likely to be socially healthy and productive if they are not imprinted on humans.
- Hornbill chicks will **impact** on fur, feathers, bones, insect exoskeletons, dirt, sand, and rocks. **Make all changes to roughage gradually**!
- **Air sacs** develop subcutaneously on these birds within a couple of days and are not cause for alarm
- **Monitoring of faecal output is crucial** throughout the entire rearing process and acts as an early warning system of any issues.
- Try and **speak to an experienced hand-rearer** often as this allows one to pick up problems earlier while mitigation is still possible and makes you feel part of a wider effort. Share what you are learning too with other rearers.
- Even **low grade stress will compromise their immune systems** – make sure the rearing situation is as close to that in the wild as possible and if you are having a stressed day spend as little time with the chicks as possible.
- When being parent reared the chick is fed by the female only for first 15-20 days there after the male is allowed to feed. As the chick matures other members of the group are allowed to feed. It is extremely important that the chick has a rearer that follows through

with the hand rearing until the chick is fledged. The chick must not be asked to leave its “comfort zone” until it is 86 days old as it is not emotionally or physically mature enough. The chick will experience low grade stress if all the things it’s familiar with are removed before its ready to fledge.

- **It is vital to keep accurate rearing records** to help you and any advisors correctly assess the chick should a problem arise.

- **ENJOY**! These are intelligent, long-lived, highly social birds and are a vital part of our savannah ecosystems and you are playing a vital role in helping them remain there.

3. Problems & solutions quick guide

(For more in-depth information refer to the full protocol)

ASPIRATION - inhalation of fluid into airways

Signs - Bubbles coming from nares
Difficulty breathing; gasping, open mouth breathing, and clicking sound when breathing
Depression

Causes - Inhalation of fluids or food while feeding (feeding too much, too fast)
Reluctant feeding response or no feeding response
Feeding unaccustomed water

Treatment - If the chick inhales a small amount of fluid stop feeding immediately. Watch to see if any bubbles appear at the nares, wipe nares carefully and gently w/ cotton swab or cotton gauze. Make sure chick stays warm, place back in brooder and monitor closely for difficulty breathing, listen carefully for any thick clicking sounds when breathing. Once chick is stable resume feeding schedule. Feeding should only take place when there is an active begging behaviour. If large amounts of fluid or food are inhaled, the bird may die from asphyxiation. Aggressive antibiotic and steroid therapy may be required to keep chick alive.

DEHYDRATION – loss of body fluids

Signs - Sunken eyes
Decreased skin elasticity; specifically skin of the eyelids; (skin tents – stays up for more than 1-2 seconds when pinched)
Tacky mucous membranes (white strands in mouth)
Wrinkled abdomen
Lethargy
Depression

Causes – Exposure to environment

Lack of fluids

Temperature of brooder is too high

Animal has diarrhea

Treatment - Stop feedings. Never feed an animal that is dehydrated because it cannot digest the food. Give warm rehydration fluids (Ringer's Lactate) orally. For week-old chicks; 1ml of warm RL each hour until hydration improves and chick resumes feeding response. When administering oral fluids, be very cautious to not aspirate the chick. Drip the fluids one drop at a time onto chicks beak, do not force beak open! If hydration doesn't improve and chick continues to be unresponsive and very weak, then warm Subcutaneous (SQ) fluids may be given at 5% of chick's body weight.

Fluids - Ringer's Lactate solution or a similar balanced isotonic solution warmed to (38.0C to 39.0C) is recommended for fluid replacement and shock therapy. Using warm fluids is particularly important with neonates to prevent hypothermia and shock. Emergency formula – 1tsp. Salt and 3 tsp. in 500 ml of warm water.

HYPERTHERMIA – high body temperature

Signs - Panting and rapid breathing
Holding wings stretched out and one of both legs extended to the rear.
Animal feels hot
Weakness and loss of muscle coordination
Tremors and or seizures

Causes - Exposure to high temperatures
High humidity and/or inadequate ventilation for an extended period
Direct rays of sun (during neonatal stage)

Treatment - Move animal to a cool, shaded area (if out in the field). If in the rearing room, check brooder and make sure temp. is correct. If too high remove chick immediately and transfer to another brooder.
Stop feedings and check for dehydration. If chick is responsive give oral fluids.
If the chick is unresponsive then place its legs and feet in cool water and if necessary wet feathers down to the skin with water or alcohol. Check rectal temperature every 10 minutes until reading is normal.
Monitor chick frequently until its condition is stable and allow chick to rest quietly until all signs are normal.

IMPACTION/ NOT DEFECATING –

Signs – No faeces seen in cage or after feeding (a healthy chick will faecal after each feeding).
It does happen that the chick may pass faeces giving the rearer a sense of everything is functioning correctly when in fact the chick is not passing the right amount of faeces. It is possible for some faeces to by-pass an obstruction. If this happens it will only become apparent until the chick shows the signs listed below or when the blockage moves and is eliminated. Rearers must keep this in mind when answering the question is the chick passing faeces as the answer may be yes but not enough. This should also be remembered if the chick is considered ill as it may just need extra fluid. Of course if the chick has been constipated for a while it may have secondary complications:
Distended abdomen; Anorexia; Depression; Regurgitation; Lack of appetite to no appetite; Lethargy

Causes – Foreign material ingestion (sand, grit, rock)
Roughage added to diet too quickly (fur, feathers, insect exoskeletons, and bones)
Food substances that are difficult to digest (large pieces of animal tissues, fruit)
Not enough moisture in the diet
Dehydration; Intestinal blockage; faecal impaction

Treatment - Stop feedings. If chick is giving a feeding response; give only warm oral fluids to stimulate faecaling. Do not feed again until chick has passed a faecal. A laxative of lactulose (Duphalac) may be given as well to help stimulate faecaling. Can try massaging abdomen to encourage faecaling as well as using warm damp cotton gauze wiped gently over the vent/cloaca to encourage faecaling. May also try K-Y Surgical Lube Jelly w/ small cotton Q-tip and very carefully insert Q-tip just into the opening of the vent/cloaca of the chick and very gently move Q-tip in one circular motion to stimulate chick to faecal. Do not try this on own unless someone experienced has shown you how to perform this procedure.

Chapter 10: Neonate Veterinary Care

Dr Katja Koeppel*

* Johannesburg City Parks and Zoo

Neonatal Ground-hornbills are very susceptible to stress and impaction. Impaction, infection and death have been associated with stress. Stress can be caused by a variety of factors such as noise, handling, temperature and socialisation. A calm and relaxed hand-rearer is important for the rearing process (Delicia Gunn, personal communication).

Deaths of neonates usually occur in the first 21 days with 77% of neonatal death in the 2012 and 2013 rearing season occurring before 21 days of age. Death associated with hatch, transport or immunocomprimisation of chick usually occurs in first 7 days. Although more recently two deaths occurred at 36 an 40 days of age. The later deaths were associated with incorrect/contaminated food.

Figure 1 shows the rapid growth between day 15 and 45. Any disease or nutritional imbalances during this phase will result is a delayed development or metabolic disturbance such as secondary hyperparathyroidism.

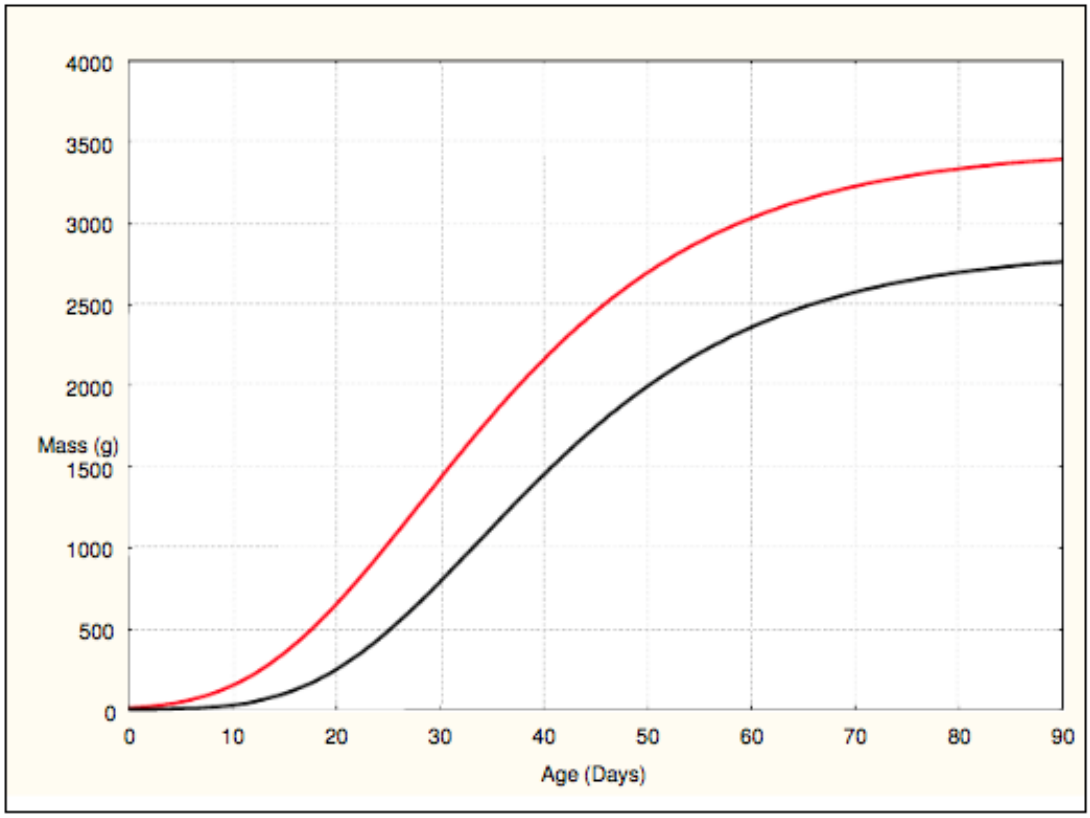


Figure 1 shows the typical growth curve if a Southern Ground-hornbill (n=7, red) (Engelbrecht et al., 2007).

1. Disease concerns in neonates

1.1 Bacterial infections: These are a common cause of morbidity and mortality, particularly in hand-reared chicks. A primary pathogen may be responsible or more commonly disease occurs as a result of the proliferation of opportunistic pathogens such as *Escherischia coli, Clostridium spp.* and *Salmonella spp.*, when the normal balance of intestinal flora is disrupted, for example in immunocompromised individuals.

Salmonella enteritis has been associated with one death in a hand-reared bird. Early indication of infection is a change in bacteria present in the faeces. A gram stain of fresh faeces will show a change in bacterial flora. Each chick has a unique flora and subtle changes are easy to be missed unless faecal smears are done regularly on the chick.

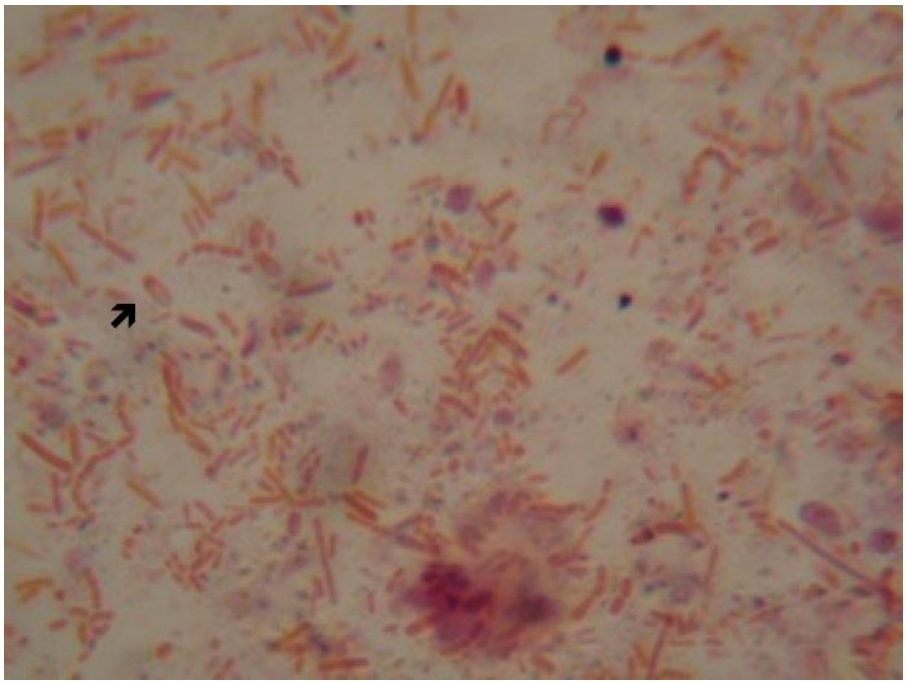


Figure 2: Gram stain of ground hornbill chick showing clostridial like bacteria (arrow)

Chicks stress very easily and oral antibiotic therapy according to results of culture and sensitivity of intestinal pathogens is recommended. Oral fluid intake should be increased to 2 x maintenance.
Fluid maintenance requirements: 50 ml per kg per day.

Aspiration pneumonia is another common cause. Enteritis, nephritis, hepatitis, air sacculitis, pericarditis and pneumonia have been seen in chicks up to 35 days of age. Gastrointestinal stasis is a common sequel to bacterial infection, which can result in apparent impaction.

Once the chick is collapsed IV fluids and antibiotics should be administered. Once the chick is collapsed the prognosis is guarded and many of these chicks develop fatal septicaemia.

Baytril (antibiotic, enrofloxacin) at 15 mg/kg orally twice daily for 5 days has been used as a broad spectrum antibiotic.

Acetylcysteine (mycolytic agent) and amikacin (antibiotic) have been used to nebulise chicks with respiratory infection and the chick made a complete recovery.

1.2 Gastrointestinal impactions: This is a fairly common complication in hand-reared ground hornbills. Impactions may be primary, due to feeding too much roughage such as fur and feathers, or secondary to dehydration and/or gastrointestinal stasis. Gastrointestinal impaction is more likely in small, premature or immunocompromised chicks and chicks below 55 g or dehydrated chicks at birth/day 2 should not receive any pinkie skin when fed as it will result in impaction (Delicia Gunn, personal communication).

1.3 Metabolic bone disease: This has been seen in several young ground hornbills fed diets low in vitamin D and calcium or with an inadequate calcium:phosphorus ratio, which result in a **nutritional secondary hyperparathyroidism** (see Figure 4). Feeding muscle meat such as beef or game greatly increases the risk. Lack of exposure to ultraviolet light can be a contributing factor. A variety of bony deformities may be seen including bent wings, bent and rotated legs and deformity of the spinal column and/or ribs. Pathological fractures may occur. Diagnosis can be made on radiography but prognosis is poor in advanced cases and prevention is key.

1.4 Hatching abnormalities:

Figure 3: Skin defect at hatching (photo courtesy of Umgeni Bird Park)

Malformation of the chick has been associated with a variety of factors:

- Improper egg storage
- Jarring of egg or incorrect transport
- Heredity
- Nutritional deficiency: biotin, riboflavin, zinc, Mg

- Inadequate turning
- Improper egg orientation
- High or low incubator temperature
- Inadequate ventilation or shell with low porosity

Normal Respiratory parameters in chicks: Normal resting chick should have a respiratory rate less then 20 bpm. Transient increase is often seen after feeding but should resolve within 30 minutes. Respiratory rates of 24 to 32 bpm have been seen with colic. Resting respiratory rate is important as it can be observed without handling and stressing of the chick.

2. Supportive Care and therapeutics

Many hornbills, especially wild birds are presented in a critical condition. If available, the use of isoflurane to anaesthetise the bird for examination and provide initial treatment should be considered in these cases since it is less stressful than a conscious examination. Sick hornbills should be kept warm (25-30°C) and given fluid therapy and nutritional support. Daily maintenance fluid requirements are approximately 50ml/kg per day and sick birds should be assumed to be at least 10% dehydrated. Lactated ringers (Hartmanns) solution at 38°C is usually the fluid of choice and can be given subcutaneously at 20ml/kg into the pre-crural fold or intravenously at 10ml/kg bolus over 5 to 7 min. The medial metatarsal vein is easiest to catheterise (Figure 4). For short-term nutritional support, Hills AD or Oxbow Critical Care Formula for Carnivores can be used and given by gavage into the proventriculus. Handling results in severe stress in hornbills and oral fluids should be tried first especially in chicks younger then 6 weeks unless the chick presents already collapsed.

Suitable analgesics include:

- Carprofen 1-5 mg/kg daily PO or IM
- Meloxicam 0.1-0.5 mg/kg daily PO or IM
- Butorphanol 0.1-2 mg/kg every 6-12 hours IM

However, care should be taken when using non-steroidal anti-inflammatory drugs in hornbills. Concurrent fluid therapy should be considered and their use avoided in dehydrated birds or those with existing renal disease.

Figure 4: Intravenous fluid therapy with catheter in medial metatarsal vein (Note severe beak deformities in chick

Lactulose has been used to treat mild impaction at 0.5 to 1 ml per kg two to three times daily. Adding pawpaw to the diet also assists with mild impaction/constipation.

Antibiotics should be chosen according to antibiogram if available. Baytril (enrofloxacin) and Synulox (amoxicillin/clavuanic acid) are good broad-spectrum antibiotics which can be used prior to antibiogram results. Baytril is the drug of choice for Salmonella infections. Baytril has been associated with cartilage damage in juvenile mammals and should be used with caution in juvenile birds (Mitchell 2006).

Chapter 11: Clinical and Preventative Medicine

Dr Katja Koeppel* and Dr Michelle Barrows **

* Johannesburg City Parks and Zoo

** Bristol Zoo

1. Clinical techniques

Handling/Physical restraint: Ground hornbills can give a painful bite and should be restrained by experienced handlers. One arm should be placed firmly round the body immobilising the wings but taking care not to restrict sternal movements and the other used to firmly restrain the beak without occluding the nares. Manual restraint can be used for physical examination, blood sampling and other minor procedures although anaesthesia is advisable for prolonged procedures to minimise stress, particularly in wild or ill hornbills (Figure 1 and 2). It is advisable to always cover the eyes of the bird as it reduces stress for the bird and they calm as soon as they are in dark place, either with tehr eyes covered or in a dark crate.

Figure 5: Ground hornbill restraint for measurements and examinations with the eye cover removed only for measurement of the head and bill

Figure 6: Restraint of Ground Hornbill for veterinary examination

Anaesthesia: Inhalation anaesthesia is recommended with isoflurane or sevoflurane being the gaseous agents of choice. Masks can be fashioned out of 2 litre plastic bottles for induction (Figure3). Once anaesthetized, the hornbill should be intubated with a non-cuffed endotracheal tube. Warmed fluids such as lactated ringers solution should be given intravenously or subcutaneously during long procedures. Injectable anaesthetics, which could be considered in the field if inhalation anaesthesia is unavailable include medetomidine and ketamine, which can be reversed with atipamazole and tiletamine/zolazepam (Zoletil).

Figure 7: Anaesthesia by mask induction in an Abyssinian Ground Hornbill

Physical examination: This should be carried out using a standard systematic avian approach. Starting at the head, examine the beak, the casque, nares, periorbital area, ears and oral cavity for swelling, discharges or haemorrhage. Look at each eye, checking the eyelids and conjunctiva, third eyelid and cornea and noting the presence of blood or pus in the anterior chamber. The retina is most easily evaluated under isoflurane anaesthesia. Palpate the pectoral muscle mass to judge body condition (Figure 4) and obtain a body weight.

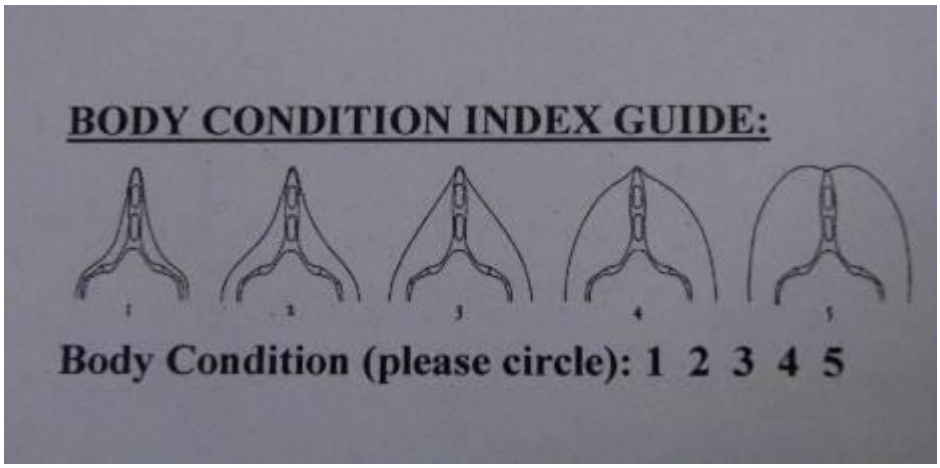


Figure 8: Avian body condition score

Listen to the heart (over the sternum), the lungs (dorsum between wings) and the air sacs ('abdominal' region). Examine the skin and plumage looking for ectoparasites, wounds or other lesions, and stress marks on the feathers. Check the uropygial gland for signs of impaction or infection. Palpate the abdomen (coelomic cavity) to check for masses/ fluid etc and look at the cloaca noting swellings, prolapse or soiling of the surrounding feathers. Examine the wings and legs, palpating all joints flexed and extended and noting any

crepitus, swelling or instability. Check the feet for pododermatitis (bumblefoot) lesions, wounds, or nail injuries.

Stress lines (Figure 5) can be found in the primary feathers and tail feathers they are usually associated with a period of stress associated with disease and/or incorrect or too little nutrition. Once the lines are seen the period of stress has passed but long-term physiological effects may still be present.

A growth rate of 4 to 5mm daily has been recorded in rock pigeons (Mallet-Rodrigues 2012) and if a similar growth rate is assumed in hornbills the time of stress can be calculated.

Figure 9: Stress lines in tail feathers in a Ground Hornbill

Blood sampling: Brachial and medial metatarsal veins (Figure 6) are easier to access in ground hornbills than the jugular vein, with the metatarsal vein most easily accessed in manually restrained birds. Blood volume is approximately 10% of body weight and in a healthy bird 10% of blood volume can be safely removed. This would equate to 50ml from a 5kg bird, although 3-5ml is more than enough for routine diagnostic testing! Heparin is the anticoagulant of choice for haematology, as the cells lyse in EDTA. Serum or heparin is used for biochemistry. As with all avian species, manual haematology and differential counts are essential as automated cell counters will not distinguish nucleated erythrocytes from leucocytes. The medial metatarsal vein is suitable for placing intravenous catheters for fluid therapy in debilitated birds.

Figure 10: Blood sampling from medial metatarsal vein

Figure 11: Blood collection tubes

The above blood tubes (Figure 7) are standard for veterinary medicine. The yellow and red tubes are for serum and the green tube (heparin) should be used for haematology.
EDTA (purple) should only be used for genetics.

Other basic diagnostic techniques: Faecal samples are useful for cytology (direct smear stained with Gram stain or Diff Quik) and parasitology (wet preparation and floatation) as well as for *Chlamydophila* PCR (MDS). Cloacal swabs, and aspirates, for example from swollen joints may be taken for cytology and bacterial or fungal culture.

Microchip placement: If required, microchips may be placed subcutaneously in the dorsal midline at the base of the neck or intramuscularly in the left pectoral muscles. (AZA

Institutinal Data Management Advisory Group, March 2010).

Behavioural manifestations of illness: Signs of illness are often non-specific and include lethargy, anorexia, abnormal faeces or urates and increased respiratory rate and effort (see Figure 12). Like all birds, ground hornbills mask signs of illness and even subtle changes in behavior, appearance or appetite are likely to be significant.

Figure 12: Depressed Ground Hornbill chick

2. Preventative medicine

For captive birds, preventative care relies on providing the correct husbandry, including diet, appropriate social grouping and pest control. In addition important preventative medicine procedures include quarantine of newly acquired hornbills, regular health checks and post mortem examinations on all hornbills which die to determine cause of death, identify diseases of concern and collect data for research purposes. Other preventative interventions which may be advisable include faecal screening and/or regular anthelmintic treatment for gastro-intestinal endoparasites, treatment for ectoparasites, vaccination and neonatal examinations. Tissue and serum should be banked with the Biobank at the National Zoological Gardens of South Africa.

Anthelmintic treatment: Suitable anthelmintics include:

- Ivermectin 0.2mg/kg IM single dose.
- Moxidectin 0.4mg/kg IM single dose
- Fenbendazole 20 mg/kg PO daily for five days. Doses above 25mg/kg should be used with caution due to reports of toxicity in other avian species.
- Praziquantel 10mg/kg for tapeworms.

Ectoparasite Control: Fipronil (Frontline) is recommended as a topical spray for ectoparasites such as lice.

Immunoprophylaxis protocols:
Vaccines which have been used in ground hornbills in South Africa and may be considered for birds thought to be at risk include *Clostridium botulinum* type C and D vaccine (Onderstepoort Biological Products) and Paramyxovirus-1 vaccines (Deltammune). *Yersinia pseudotuberculosis* vaccines have been used in Europe. See table 1 for protocols.

We are currently working on an oral vaccine for Ground hornbill that can be administered *in situ* to reduce handling of release candidates and allow for easy boosting post-release.

Vaccine	Primary course	Day 28	Annual booster
C.botulinum	1ml single dose intramuscularly (IM)	n/a	1ml IM
Paramyxovirus	Live enteric Ulster strain primer few drops intraocularly (Figure 3)	1ml inactivated $AlHO_3$ adjuvanated Ostrich vaccine (Struvac) subcutaneously (SC)	1ml Struvac SC

Table 1: Vaccination protocols

Figure 13: Intraocular paramyxovirus vaccine administration.

3. Disease concerns in adult ground hornbills:

3.1 Infectious disease:

3.1.1 Bacterial infections: Little information is available on bacterial infections in adult ground hornbills other than one report of acute haemorrhagic septicaemia due to *Aeromonas hydrophila* (Ocholi & Kalejaive 1990). Most bacterial infections are likely to be due to gram negative bacteria. Respiratory disease is occasionally seen and can be divided into upper (nares and sinuses) and lower (trachea, syrinx, air sacs and lungs) respiratory tract disease. Other potential causes include fungal and parasitic infections as well as intraspecific or other trauma. Clinical signs of respiratory tract disease include increased respiratory effort, ocular and/or nasal discharge, periorbital swelling, head shaking, open-mouth breathing, weight loss, lethargy and anorexia. *Chlamydophila psittaci* has been diagnosed in other hornbill species in South Africa. It is zoonotic, notifiable and a potential cause of respiratory, ocular and hepatic disease in ground hornbills. It can be diagnosed from avian faecal samples or cloacal swabs by PCR (MDS) but false negative results are common due to intermittent excretion of the organism. Immunocomb (Biogal, South Africa), a semi-quantitative antibody test can also be used to detect exposure to *C. psittaci*. Treatment is with doxycycline given for 45 days.

Yersinia pseudotuberculosis is a common cause of hornbill mortality in Europe, particularly during the winter months but has not been reported in hornbills in South Africa. Ground hornbills should be considered susceptible to botulism caused by ingestion of *Clostridium botulinum* type C toxin for example in contaminated meat or carcasses.

3.1.2 Viral infections: Ground hornbills are susceptible to Newcastle's disease caused by paramyxovirus-1 and have suffered acute mortality after ingestion of infected doves (Abolnik *et al*, 2008). Vaccination against paramyxovirus-1 should be considered especially if outbreaks of the disease in wild or feral columbiformes are common. Recently a ground hornbill chick was found to carry antibodies against Newcastle disease without exhibiting signs of disease (Lucy Kemp, personal communication, Aug 2012). There might be different strain affecting ground hornbills with different virulence.

3.1.3 Parasitic disease: Endoparasites including nematode worms, tapeworm and protozoa such as cryptosporidium may be seen in ground hornbills. Parasites are usually an incidental finding in wild hornbills but can be significant in captive birds especially in juvenile hornbills or those with concurrent disease. *Capillaria sp* have been seen in captive ground hornbills. Although these birds were asymptomatic, *Capillaria sp* have caused mortality in other hornbill species and can be difficult to treat since resistance to anthelmintics is common. Eggs can survive in the environment for several months and reinfection, either directly or via intermediate invertebrate hosts is common. The most common ectoparasites seen are lice. High burdens usually indicate immunosuppression and another underlying problem.

3.2 Non-infectious disease:

If ground-hornbills are brought in for treatment the following information is beneficial for both the rehabilitation of the bird and also if necessary the release. It is important that this information is gathered to add to the mortality database and that post-mortem results…

- Location of incident (GPS preferable):
- Were other ground-hornbills present at or near the scene?:
- A clear description of the scene (e.g. were there other sick or dead bird species present in the area; where there any granular or powder like substances at the scene; at or near a transformer box).

3.2.1 Gastrointestinal foreign bodies: Ground hornbills, especially juveniles will ingest harmful foreign bodies such as nails and wire. Fatal ventricular perforation has been reported. Metal foreign bodies can be seen on radiographs and may be removed using flexible endoscopy or surgically via coeliotomy.

3.2.2 Trauma: Trauma is a common cause of morbidity and mortality, both in captive and wild ground hornbills. In captivity, inter and intra-specific aggression is common. Ground hornbills should not be kept with other species and care should be taken when introducing birds.

3.2.3 Electrocution: Electrocution has been associated with ground hornbills roosting on transformer boxes (Lucy Kemp, personal communication, May 2012). Signs of electrocution are sudden death or trauma. Cutaneous burns, cutaneous and visceral petechiae and bone fractures are indication of electricution. Fractures are a common presentation of electrocution due to the bones becoming for brittle. In humans damage to internal organs and heart can lead to death even after a few days. Increase in creatinine kinase (CK) and Lactate dehydrogenase (LDH) are indicative but other severe muscle trauma can also lead to increase in these enzymes.

3.2.4 Leg problems and lameness: Leg problems including paresis and lameness may be caused by infection, renal disease, arthritis, pododermatitis (bumblefoot) or trauma, including fractures, dislocations and soft tissue injuries. In addition, lameness in juvenile hornbills can result from metabolic bone disease or angular limb deformities. Fractures usually involve the long bones. It is important to delay orthopaedic surgery until the hornbill is stable. Fluid therapy, analgesia and protection and immobilisation of the fracture site are important. Fractures of wings and legs can be repaired using a variety of techniques. Best results are achieved using techniques, such as intramedullary pins tied-in to half-pin external fixators, which allow immediate weight bearing and result in no joint immobilisation. Success is inversely proportional to the time that has elapsed since the original injury.

3.2.5 Visceral gout (Figure 4) is a symptom rather than a disease in its own right but is relatively common on post mortem examination of ground hornbills and may occur secondary to renal disease, dehydration or the use of nephrotoxic drugs.

Figure 14: Visceral gout with uric acid crystals on pericardium and liver in a ground hornbill

3.2.6 Poisoning: Wild ground hornbills may be presented with organophosphate or carbamate poisoning. Clinical signs include depression, paresis, muscle tremors, ataxia, seizures and gastrointestinal signs such as vomiting and diarrhea. Prognosis is often poor. Treatment may include atropine and the cholinesterase reactivator 2-pralidoxime hydrochloride along with supportive care.

3.2.7 Lead toxicosis: In the past lead toxicosis has been associated with a captive environment and the ingestion of metal from aviaries, building sites or rubbish. Recently it has been observed in a free ranging hornbill due to the ingestion of a lead pellets (Koeppel & Kemp in press). Birds respond to chelate therapy.

Figure 15: Radiograph of adult Ground-hornbill showing three pieces of heavy metal in gizzard.

3.2.8 Nutritional disease: Nutritional diseases which may be seen in captive ground hornbills include obesity, which can lead to secondary hepatic lipidosis (fatty liver)

and atherosclerosis which is associated with high fat diets. Clinical signs of hepatic lipidosis include obesity, poor feather quality, diarrhoea, yellow or green urates, anorexia and lethargy. Blood may be lipaemic, liver enzymes and serum bile acids are raised and hepatomegaly may be seen on radiography. Haemochromatosis (iron storage disease) has been reported in other hornbill species especially frugivorous Asian hornbills but is an unlikely cause of liver disease in ground hornbills (Sheppard & Dierenfeld 2002). However, haemosiderosis, iron deposition in the liver without associated pathology has been seen in captive ground hornbills.

3.2.9 Cardiovascular disease: This has been reported as a cause of mortality in ground hornbills and may be under-diagnosed. As mentioned above, high fat diets as well as limited exercise can predispose to atherosclerosis in captive hornbills. Degenerative changes and presence of mineralised plaques may be seen in the aorta and vessels of the brachiocephalic trunk. This may be apparent on radiographs.

4. Physiological norms

Ground hornbill biochemistry and haematology reference ranges for all ages and both sexes combined (taken from International Species Information System © I.S.I.S.

Parameter	Units	Mean	St. Dev.	Min value	Max value	Sample size	No animals sampled
WHITE BLOOD CELL COUNT	*10^9/L	15.27	7.512	6.900	33.20	22	15
RED BLOOD CELL COUNT	*10^12/L	2.55	0.59	1.25	3.12	10	7
HEMOGLOBIN	g/L	247	210	117	560	4	3
HEMATOCRIT	L/L	0.431	0.102	0.187	0.570	23	15
MCV	fL	199.3	54.5	166.7	352.0	10	7
MCHC	g/L	1220	1537	333	2995	3	2
HETEROPHILS	*10^9/L	9.388	4.400	3.540	20.80	22	15
LYMPHOCYTES	*10^9/L	4.448	3.133	0.896	11.60	22	15
MONOCYTES	*10^9/L	0.656	0.676	0.089	2.324	19	12
EOSINOPHILS	*10^9/L	1.380	2.917	0.075	9.810	11	8
BASOPHILS	*10^9/L	0.249	0.167	0.075	0.654	12	7
CALCIUM	mMol/L	2.13	0.43	1.10	2.73	21	15
PHOSPHORUS	mMol/L	1.78	1.62	0.26	6.59	16	13
SODIUM	mMol/L	146	14	120	160	13	12
POTASSIUM	mMol/L	2.9	1.0	1.2	5.2	13	12
IRON	µMol/L	16.47	3.222	14.50	21.30	4	3
CREATININE	µMol/L	27	27	9	106	9	7
URIC ACID	mMol/L	0.363	0.190	0.000	0.833	22	17
TOTAL BILIRUBIN	µMol/L	3	2	2	7	8	7
GLUCOSE	mMol/L	14.21	4.107	7.104	22.20	22	16
CHOLESTEROL	mMol/L	1.813	1.114	.0000	3.652	9	7
CREATINE PHOSPHOKINASE	U/L	591	457	165	1412	15	12
LACTATE DEHYDROGENASE	U/L	1147	764	308	3380	14	12
ALKALINE PHOSPHATASE	U/L	281	356	10	1064	11	9

ALANINE AMINOTRANSFERASE	U/L	46	22	14	73	8	7
ASPARTATE AMINOTRANSFERASE	U/L	324	258	138	1380	23	17
GAMMA GLUTAMYLTRANSFERASE	U/L	15	18	0	52	8	6
AMYLASE	U/L	313.8	99.53	214.2	413.1	3	3
TOTAL PROTEIN (COLORIMETRY)	g/L	28	5	20	37	22	17
GLOBULIN (COLORIMETRY)	g/L	17	4	12	24	13	11
ALBUMIN (COLORIMETRY)	g/L	12	4	4	17	13	11

5. References

Abolnik, C., Gerdes, G. H., Kitching, J., Swanepoel, S., Romito, M., & Bisschop, S. P. R. 2008. Characterization of pigeon paramyxoviruses (Newcastle disease virus) isolated in South Africa from 2001 to 2006. *The Onderstepoort Journal of Veterinary Research*, *75*(2), 147–52.

AZA Institutinal Data Management Advisory Group. (n.d.). *Guidelines for Transponder Placement and Recording* (pp. 1–6).

Koeppel, K., & Kemp, L. (in press). "Lead toxicosis in Southern Ground-Hornbills Bucorvus leadbeateri: a case from South Africa." *Journal of Avian Medicine and Surgery*.

Mallet-Rodrigues, F. 2012. Replacement and growth of primary feathers in captive rock pigeons, Columba livia (Aves: Columbidae). *ZOOLOGIA*, *29*(2), 121–125.

Sheppard, C., & Dierenfeld, E. 2002. Iron Storage Disease in Birds: Speculation on Etiology and Implications for Captive Husbandry. *Journal of Avian Medicine and Surgery*, *16*, 192–197.

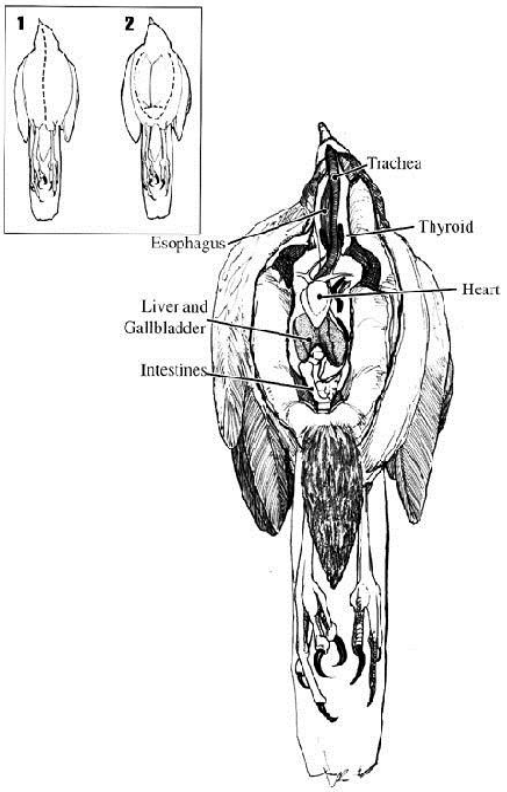
Chapter 12: Post mortem protocol

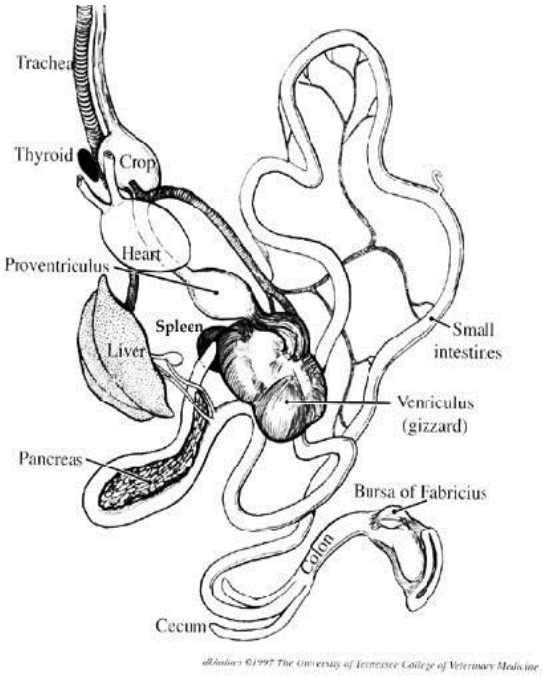
Dr Emily Lane
National Zoological Gardens of South Africa

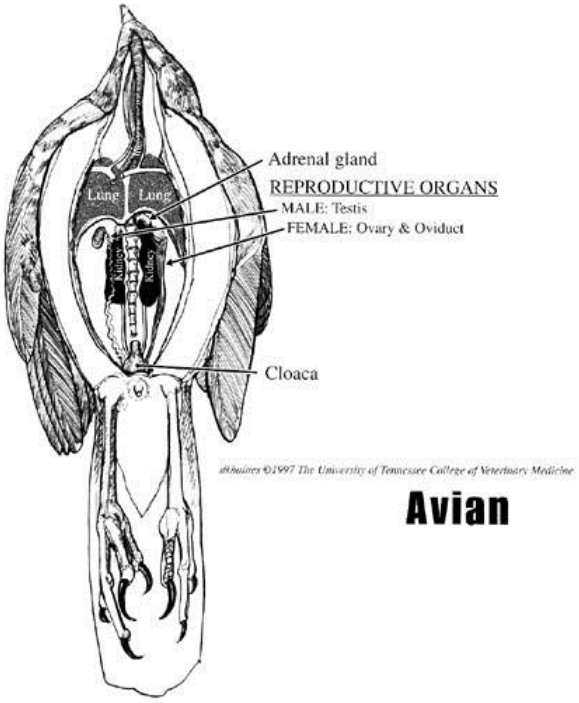
Ground Hornbill Post mortem protocol
(examine in a biosafety cabinet if possible)

- Pull out a few feathers and place in a paper envelope (for genetic studies)
- Spray the hornbill with soapy water to wet the feathers
- Place a sample of any ectoparasites in 70% alcohol
- Take tracheal and cloacal swabs for Avian Influenza
- Place the bird on its back
- Incise the skin between the left leg and the body wall
- Make two blood smears, or if the blood is clotted, make an impression smear of the lung, spleen or liver when they are available. These can be air dried and wrapped in soft paper.
- Disarticulate a hip joint, expose and place a section of the sciatic nerve in formalin for histology
- Take a small sample of skin and muscle for biobanking (in DMSO).
- Cut the femur in half and remove bone marrow for histology (if there is none in the femur, check the tibia or toes).
- Collect the femoral head and neck for histology.
- Open the skin from the beak to the vent; take a sample of skin with feather follicles in it for histology.
- Make a horizontal cut at the bottom edge of the keel bone extending on each side through the body wall.
- Cut through the pectoral muscle on both sides and take a sample of pectoral muscle for histology then remove the keel bone, cutting the muscle and bony attachments.
- Take samples for histology of the air sacs.
- Find the spleen at the junction of the glandular and muscular stomachs. Measure and weigh the spleen. Take a sample for histology as well as bacteriology, molecular diagnostics as needed.
- Take samples from the liver for histology as well as bacteriology or molecular diagnostics as relevant.
- Save up to 200g liver (frozen in a Ziploc bag).
- Examine the oesophagus, proventriculus and gizzard, intestine and pancreas; sample for histology, as well as bacteriology, virology and toxicology if indicated.
- Save the empty gizzard (frozen, in a Ziploc bag)
- Preserve any worms in 70% alcohol, or if the bird is a free-ranging one, place remaining GIT in alcohol.
- Sample gonads for histology (2 testes in the male or 1 ovary in the female) which are located at the top of the kidneys.
- Sample for histology both adrenal glands (located just below the gonads and attached to the body next to the spine), measuring and weighing the left adrenal if the bird is large enough.

- Sample left cranial and right caudal kidneys for histology; and put the rest in a Ziploc bag for freezing.
- Take both the thyroid glands for histology (at the base of the neck above the heart) and the thymus which runs along the neck next to the prominent veins.
- Remove the heart and if large enough sample the right ventricle and aortic valve as well as the left papillary muscle. Put a small sample for NZG BIOBANK in DMSO and freeze the rest (Ziploc bag). If the heart is too small, snip off a small sample of an atrium for NZG BIOBANK and put the rest in formalin.
- Sample the oesophagus and distal trachea (just before the bifurcation) for histology.
- Dissect the lungs away from the body wall and take a sample of the left caudal and right 2 cranial lobes for histology.
- Save the ribs of one side (frozen, in a Ziploc bag)
- Cut open the mandible and oesophagus to the proventriculus, and open the trachea looking for any foreign material.
- Trim off the maxillary beak close to the head and check the sinuses.
- Remove a section of skull covering the brain, and place the brain in formalin. In small birds the brain is best exposed by a sagital section through the skull.







References

Abolnik, C., Gerdes G.H., Kitching, J., Swanepoel, S., Romito, M. & Bisschop, S.P.R. 2008. Characterisation of pigeon paramyxoviruses (Newcastle disease virus) isolated in South Africa from 2001 to 2006. Onderstepoort Journal of Veterinary Research 75(2):147-152.

Munson, L. *Necropsy of Wild Animals*. Wildlife Health Center, School of Veterinary Medicine, University of California, Davis

Ocholi, R.A. & Kalejaive, J.O. 1990. *Aeromonas hydrophila* as cause of haemorrhagic septicaemia in a ground hornbill (*Bucorvos abyssinicus*). Avian Disease 34(2):495-6.

Chapter 13: Complete reference list

Abolnik, C., Gerdes, G.H., Kitching, J., Swanepoel, S., Romito, M. & Bisschop, S.P.R. 2008. Characterisation of pigeon paramyxoviruses (Newcastle disease virus) isolated in South Africa from 2001 to 2006. Onderstepoort Journal of Veterinary Research 75(2):147-152.

AZA Institutinal Data Management Advisory Group. (n.d.). *Guidelines for Transponder Placement and Recording* (pp. 1–6).

BBC Wildlife. May 1996. Vulnerable Birds. Pg. 34.

Galama W., King C. and K. Brouwer. 2002 EAZA Hornbill Management and Husbandry Guidelines. The EAZA Hornbill TAG, National Foundation for Research in Zoological Gardens.

Kemp, A.C. The Ground Hornbills: Kemp. *Bulletin ABC*. 1 (1). Pp10-11.

Kemp, A.C. 1995. *Bird families of the world The Hornbills*. Oxford University press. Oxford. Pp302.

Kemp, A. 1995. Bird Families of the World. In *The Hornbills Bucerotiformes: Bird Families of the World* (1st ed., pp. 94–99). Oxford: Oxford University Press.

Kemp A.C. 1995. The hornbills, *Bucerotiformes*. Oxford: Oxford University Press.

Kemp, A.C. 1988. The behavioural ecology of the Southern Ground Hornbill: are competitive offspring at a premium? In *Proceedings of International 100 Deutscheornitologen-Gesselschaft Meeting Current topics in avian biology* (pp. 267–271). Bonn.

Kemp, A.C. 2000. Southern Ground Hornbill. In: *Eskom Red Data Book of Birds South Africa, Lesotho and Swaziland*. Birdlife South Africa. Johannesburg. Pp117-119.

Kemp, A. C., & Kemp, M. I. 1975. Studying the basic biology of the Southern Ground Hornbill. *Bulletin of the African Bird Club*, *March*, 6–7.

Kemp, A. C., & Kemp, M. I. 1980. The Biology of the Southern Ground Hornbill Bucorvus leadbeatri (Vigors) (Aves: Bucerotidae). *Annals of the Transvaal Museum*, *32*(February), 65–100.

Koeppel, K., & Kemp, L. (in press). “Lead toxicosis in Southern Ground-Hornbills Bucorvus leadbeateri: a case from South Africa.” *Journal of Avian Medicine and Surgery*.

Mallet-Rodrigues, F. 2012. Replacement and growth of primary feathers in captive rock pigeons, Columba livia (Aves: Columbidae). *ZOOLOGIA*, *29*(2), 121–125.

Morrison, K., Daly, B., Burden, D., Engelbrecht, D., Jordan, M., Kemp, A., Kemp, M., Potgieter, C., Turner, A. and Friedmann, Y. 2005. *Southern Ground Hornbills (Bucorvus leadbeater) PHVA Workshop Report*. Conservation Breeding Specialist Group (SSC/IUCN)/CBSG South Africa; Endangered Wildlife Group.

Munson, L. *Necropsy of Wild Animals*. Wildlife Health Center, School of Veterinary Medicine, University of California, Davis

Nevill, H. 1984. Some birds in Xhosa Folklore. *Bokmakierie*. 36 (2). Pp 29.

Ocholi, R.A. & Kalejaive, J.O. 1990. *Aeromonas hydrophila* as cause of haemorrhagic septicaemia in a ground hornbill (*Bucorvos abyssinicus*). Avian Disease 34(2):495-6.

Rehse, T.P. 2014. 2014 African regional studbook for the Southern Ground Hornbill (*Bucorvus leadbeateri*), 8th Edition. PAAZA publication number PP89/2-14.

Sheppard, C., & Dierenfeld, E. 2002. Iron Storage Disease in Birds: Speculation on Etiology and Implications for Captive Husbandry. *Journal of Avian Medicine and Surgery*, *16*, 192–197.

Theron, N., Jansen, R., Grobler, P., Kotze, A. 2013. The home range of a recently established group of Southern ground-hornbill (*Bucorvus leadbeateri*) in the Limpopo Valley , South Africa. *Koedoe*, *55*(1), 1–8.

Vernon, C. J. 1986. The Ground Hornbill at the Southern extremity of its range. *Ostrich* 57:16-24.

Wilson, G., & Hockey, P.A.R. 2013. Causes of variable reproductive performance by Southern Ground-hornbill *Bucorvus leadbeateri* and implications for management, *2*, 476–484.