Immobilizations and evaluation of clinical parameters from free-ranging elephants in southern Tanzania

Donald G. Mpanduji,[1,2] Thomas B. Hildebrandt,[1] Robert Fyumagwa,[3] Harald Wiik,[3] Ludwig Siege,[4] Rolf D. Baldus,[4] Salvatory B.P. Bittegeko,[2] Robert Hermes,[1] Rudolf Hahn,[4] Heribert Hofer[1] and Frank Goeritz[1]

[1] Institute for Zoo and Wildlife Research, Alfred-Kowalke Str. 17, D-10315 Berlin, Germany
[2] Sokoine University of Agriculture, Department of Veterinary Surgery and Theriogenology, Box 3020, Morogoro, Tanzania
[3] Tanzania Wildlife Research Institute, PO Box 661, Arusha, Tanzania
[4] Selous Conservation Programme/GTZ, PO Box 1519, Dar es Salaam, Tanzania
correspondence: goeritz@izw-berlin.de

Introduction

To study the seasonal movements of bush African elephants and collect data about their home range in the Selous–Niassa wildlife corridor (SNWC), a capture and radio-collaring programme was implemented within the framework of the SNWC project. The SNWC project is a joint programme between the Institute for Zoo and Wildlife Research (Berlin, Germany), the Selous Conservation Programme, German Technical Cooperation (SCP/GTZ), the Wildlife Division of the Tanzania Ministry of Natural Resources and Tourism, Sokoine University of Agriculture (SUA, Morogoro, Tanzania) and the Tanzania Wildlife Research Institute, with funding from the Tropical Ecology Support Programme of GTZ. Its objective is to collect baseline data to assist in implementing a planned development cooperation project to protect and manage the corridor by setting up a string of village wildlife management areas. The goal of the project is to protect the entire wildlife corridor by encouraging local communities to participate, to benefit from sustainable use of natural resources and to combat transboundary poaching.

Capture methods

To accomplish the above objectives, 12 elephants were immobilized and 10 were radio-collared during two periods. The first took place from late August to early September 2000, the second in November 2001. Throughout the capture operation, a knock-down dose of the immobilizing drug was administered according to the main age group, as suggested by as suggested by Kock MD et al. (1993), Kock RA et al. (1993) and Hoare (1999) to induce rapid recumbency and limit the animal's post-darting movements. Either a capture gun (Parker Hale) or a dart gun (Dan-Inject) was used to administer the immobilizing drug mixture remotely. Etorphine hydrochloride (M99, C-Vet Ltd.) was the principal immobilizing drug. During the first phase, a dosage of 10 to 12 mg of M99 was used for females and 12 to 15 mg for bulls (table 1). M99 was combined with 40 mg of azaperone (Stresnil®, Janseen-Cilag, Neuss, Germany) irrespective of the elephant's size. In addition, 3 to 4 drops of thermo-stable, tissue-accelerant compound (an experimental substance supplied by Prof. Henning Wiesner, Munich, Germany) was added to the dart to increase the rate of drug absorption and hence the speed at which immobilization and anaesthesia would take effect. Stresnil was included during the first period to prevent pink-foam syndrome as a certain degree of excitement and stress was expected during approaches on foot.

Haematology and blood chemistry

Blood for haematology and clinical chemistry was collected from the ear vein within 10 minutes of lateral recumbency, in vacutainer tubes (plain, EDTA, heparin and NaF tubes). These were kept at 4°C in a portable cool box. Plasma and serum separations, haemoglobin (Hb) and haematocrit (PCV) measurements were performed at the camp not later than six hours after the samples were collected from the field. Blood stabilized in EDTA was used to assess PCV and Hb concentration and to determine the number

Table 1. Date, time, location, sex, type of drug, dose and posture of elephants immobilized in different areas of the Selous-Niassa wildlife corridor in southern Tanzania

Date	Time	Location	Herd size	Sex	Type of drug[a]	Initial dose	Add'l dose dose & route	Total dosage	Recumbency position	Reversing agent	Other observations
27 Aug 00	2.15 pm	Likuyu	1	M	M99 Stresnil	M 15 mg, S 40 mg	M, 1 mg IV	M 16 mg, S 40 mg	—	M5050 (diprenorphine) 5 ml	Immobilized near Likuyu, fields of the old refugee area
28 Aug 00	3.07 pm	Mtilandambo	5	F	M99 Stresnil	M 12 mg, S 40 mg	none	M 12 mg, S 40 mg	semi-sternal	naltrexone 50 mg	Herd a matriarch, one subadult bull and two calves, found browsing on aquatic plants
03 Sep 00	9.14 am	Mkundi	12	M	M99 Stresnil	M 12 mg, S 40 mg	M, 1 mg IV	M 13 mg, S, 40 mg	left lateral	naltrexone 6 ml	After being darted the animal went into recumbency at the foot of dry river bank
04 Sep 00	3.03 pm	Mbarangandu	16	F	M99 Stresnil	M 12 mg, S 40 mg	3 mg	M 15 mg, S 40 mg	right lateral	M5050 3 ml naltrexone 1 ml	Single-tusk female; 69 adult elephants and 4 calves were seen in the vicinity
04 Nov 01	3.23 pm	Ndalala elephant route	5	M	M99	15 mg	none	M 13 mg	right lateral	naltrexone 5 ml	Ultrasound examination showed empty ampullae, which signify recent breeding
09 Nov 01	3.45 pm	Mkasha	1	M	M99	15 mg	M 1 mg IV	M 14 mg	right lateral	M5050 1 ml naltrexone 5 ml	A small suppurating wound on the lateral medial aspect on the right side of the neck was treated with oxytetracycline spray
10 Nov 01	11.10 am	Msanjesi	2	M	M99	15 mg	M 1.8mg IV	M 16.8 mg	left lateral	M5050 5 ml	Trunk traumatized by snare; wound was cleaned and treated with oxytetracycline spray
10 Nov 01	2.05 pm	Sasawala Forest	1	M	M99	15 mg	none	M 15 mg	left lateral	M5050 5 ml	Animal was aggressive immediately after reversal but was scared by our shooting in the air
11 Nov 01	11.00 am	Sasawala River	2	M	M99	15 mg	none	M15 mg	left lateral	M5050 5 ml	Animal died, trunk partially obstructed by tree; PCV and Hb low
12 Nov 01	11.00 am	Nampungu	1	M	M99	15 mg	2.8 mg IV	M17.8 mg	—	M5050 5 ml	—
12 Nov 01	1.22 pm	Sasawala Forest	1	M	M99	15 mg	2.7 mg IV	M 17.7 mg	right lateral	M5050 4 ml	—

M – M99; S – Stresnil

[a]The route for all initial doses was intramuscular

of red and white blood cells using standard methods as described by Coles (1986). PCV was measured by the micro-haematocrit method using a portable battery-operated micro-haematocrit centrifuge (Microspin®, Bayer, Germany) in which the PCV was read without removing the micro-capillary tubes. The acid haematin method was used to measure Hb concentration (Coles 1986). This method depends upon converting haemoglobin to acid haematin by using dilute hydrochloric acid. The resulting brownish yellow mixture is matched with a standard in a comparator. To determine the total white blood cell count, 50 µl of EDTA blood was mixed with 950 µl of Tuerk solution, while blood for the total red blood cell count was prepared by mixing 4 ml of sterile isotonic (0.85 N) solution with 20 µl of EDTA blood as described by Benjamin (1986). Both preparations were stored at 4°C until final analysis was done within 14 days at the SUA Faculty of Veterinary Medicine, Tanzania. Blood stabilized in heparin and NaF and in plain tubes was used to extract plasma and serum. After extraction, serum and plasma were deep frozen in liquid nitrogen for transportation to Germany. Blood samples stabilized in NaF were used to extract plasma in which glucose concentration was determined. Serum and plasma from blood collected in plain and heparin tubes were used to measure various clinical chemical parameters. With the exception of PCV and Hb (measured in the field) and red blood count and white blood count values (measured at SUA), all clinico-chemical parameters were determined using an automated analyser—Hitachi 747-400 or Hitachi 917-Japan (Roche, Germany). An accredited laboratory, the Labor für Medizinische Chemie und Serologie GmbH (Berlin, Germany), analysed the clinico-chemical parameters.

Results

In general, darting free-ranging elephants from the ground proved difficult and dangerous. The Selous ecosystem is thick miombo woodland, and the area has a history of ivory poaching and of licensed hunting, with up to 30 elephants sport-hunted every year. The first capture period illustrated that elephants tended to retreat into remote and extremely dense vegetation during the day and were very wary of people. The dense woodland and riverine vegetation made tracking elephants by car impossible and by foot difficult and time- consuming in areas with steep terrain. Due to these obstacles, a helicopter was used for the second capture period, and the anaesthesia protocol was modified accordingly. M99 was therefore used without Stresnil to decrease the recovery time (table 1). With a helicopter, it was possible for the pilot to manipulate the entire herd during immobilization by directing the movement of both darted and undarted animals into an open area within a short time, hence minimizing the amount of stress for the darted individual. With a helicopter, the recovery process could be closely monitored from the air, thus minimizing the danger to people that were present during ground darting. The helicopter could also be used to guide revived animals in a safe direction.

Four elephants were thus immobilized with a combination of M99 and Stresnil, and eight were successfully immobilized using M99 only (table 1). All 12 immobilizations were uneventful. Immobilization of one lactating female darted from the helicopter was soon reversed, because she was lying on her sternum and her calf that was 7 or 8 years old persistently refused to move away, regardless of the noise of the helicopter. One adult bull darted from the helicopter using M99 died before the capture team reached it. The remaining 10 elephants were successfully radio-collared.

The following definitions were adopted when referring to time events at different stages of immobilization and neuroleptoanalgesia. The time to first effect was the interval between administering an immobilizing agent and first observing immobilization effects such as slowing of pace, tail flaccidity, and separation from the herd. It is a common phenomenon for the darted animal to stand still soon after it has lost control of its trunk (Raath 2003). Induction time was the interval between administering an immobilizing agent to the point at which the depth of immobilization was sufficient to cause recumbency. Recovery time was the interval from administering the antidote until the animal stood again. Total down time was measured from the moment when the animal went into lateral recumbency until the time it stood up.

Physiology

Immobilization and physiological data are presented in table 2. The blood chemistry values for cholesterol, triglycerides, creatine, sodium, iron and total protein

Table 2. Immobilization, haematology and blood chemistry values in elephants from different areas of the Selous–Niassa wildlife corridor in southern Tanzania

Immobilization parameters	M99 and Stresnil (*n* = 3)	M99 (*n* = 6)	Literature values
Time to first effect (min)	not detectable, done from the bushy ground	8 (3–20)	
Induction time (min)	10.3 (7–15)	11.2 (5–22)	31 ± 9.1[a]
Recovery time (min)	6.3 (4–9)	4.2 (1–10)	2–5[b]
Total down time (min)	77 (61–106)	72 (50–109)	
Mean heart rate (per min)	64 (50–78)	58.2 (53–65)	72–98[b]
Mean respiration rate (per min)	(4–8)	6.25 (6–7)	4–6[b]

Haematology and blood chemistry	Values from M99 anaesthesia (*n* = 6)	Values from dead elephant	Literature values		Remarks
			Brown and White (1980)[c]	ISIS (1999)[d]	
PCV (%)	45.7 (41–50)	25 ↓	44 (38.2–49)	38.1 (25.7–52.2)	
Hb (g/dl)	11.7 (9.4–14.4)	8 ↓	14.3 (10.2–17.2)	13 (9.6–17.8)	
Total RBC (cells/l) x 10^{12}	2.4 (1.6–3.04)	haemo-lysed	3.6 (2.96–5.02)	3.11 (2.05–4.8)	haemolysed in transit from field
Total WBC (cells/l) x 10^{9}	11.4 (10.1–12.6)	14.4 ↑	10.2 (9–11)	11.03 (5.6–19.3)	
Glucose (mmol/l)	4.22 (3.74–5.5)	4.79	–	4.72 (2.28–8.44)	
Alkaline phosphatase (IU/l)	163.2 (103–213)	272	48	186 (64–411)	age & sex variations[c]
Gamma glutamyl transferase (IU/l)	6.8 (4–9)	8	–	13 (3–29)	
Glutamyl oxalo-transferase (AST) (IU/l)	9 (8–14)	10	–	22 (10–80)	
Glutamyl phosphotransferase (ALT) (IU/l)	3.2 (2–5)	3	3	8 (0–26)	
Lipase (IU/l)	4.5 (4–6)	5	–	0.83 (0.28–1.67)	
Alpha amylase (IU/l)	1473 (1272–1895)	1704	2650	307.1 (68.64–1380)	seasonal variations[c]
Bilirubin (μmol/l)	1.25 (0.51–2.22)	1.03	5	3 (0–9)	seasonal variations[c]
Cholesterol (mmol/l)	1.61(1.24–1.81)	1.45	1.58–2.99	1.99 (0.0–6.06)	
Triglyceride (mmol/l)	0.77 (0.50–0.85)	0.3	0.34–0.59	0.49 (0.19–1.08)	
Creatine (μmol/l)	167.96 (130.83–190.95)	169.73	131	159 (71–513)	seasonal & age variations[c]
Total protein (g/l)	82 (64–97)	79	87	77 (62–96)	
Uric acid (mg/dl)	0.13 (0.1–0.2)	0.1	0.05	0.02 (0.0–0.06)	
Urea (mmol/l)	7.86 (6.43–10)	5.72	3.4–9.5		seasonal & regional variations[c]
Sodium (mmol/l)	129 (94–134)	133	125–137	127 (107–145)	seasonal variations[c]
Pottassium (mmol/l	5.6 (3.7–8.9)	7.6	5.3–6.4	4.9 (3.3–7.9)	seasonal & age variations[c]
Calcium (mmol/l)	2.6 (2.2–2.9)	2.96	2.19–2.91	2.75 (2.38–4.45)	
Iron (μmol/l)	12.66 (8.06–16.66)	14.51		13 (6.265–23.27)	

[a] Douglas (1994), [b] Kock et al. (1993b), [c] Brown and White (1980) references for free-ranging African elephants; [d] ISIS (1999) reference for captive African elephants.
IU/l = international units per litre

were within clinically normal ranges. Slight increases were noted for alkaline phosphatase (AP), lipase, urea, potassium and calcium whereas a slight decrease was noted for α-amylase, bilirubin and aspartate amino transferases (AST). Sex, age and seasonal variations have been reported to induce minor variations in elephant blood parameters (Brown and White 1980). Leucocytosis and substantially lower values for PCV (25%) and Hb (8 g/dl) were observed in the elephant that died (table 2). Its total RBC count could not be determined because the sample haemolysed. Trauma and some disease conditions have been reported to lower PCV and Hb values in a variety of domestic animals (Doxey 1983; Benjamin 1986). Persistently low PCV coupled with normal plasma protein is usually suggestive of deficient erythropoiesis as a result of inflammation (Jones 2003). In humans, chronic bleeding and trauma are characterized by leucocytosis and a decrease in both PCV and Hb (Claudia Kühn, pers. comm. 2003). Other conditions associated with change in PCV and Hb include time of sampling in relation to the period of anaesthesia or death (Richard Kock, pers. comm. 2002). In the present case, the changes in PCV and Hb values were unlikely to be caused by neuroleptoanalgesia or death as sampling was done at approximately the same time as for other individuals. The type of anaemia was not established due to the lack of total RBC count values. Other than leucocytosis and low PCV and Hb values, parameters were within clinically normal limits (table 2).

Discussion

Use of M99 for elephant immobilization is a standard procedure and mortalities are rare. However, there are certain risks, which range from mild physical trauma to death. Physical reasons such as trunk obstruction and positional problems are the leading causes of hypoxia and death (Kock MD et al. 1993; Coetsee 1996; Elkan et al. 1998). Other reported causes of death during elephant capture and immobilization include acidosis associated with the consumption of lush vegetation (Njumbi et al. 1996) and viral infections weakening the heart, as has occurred with elephants in Kruger National Park, South Africa (Richard Kock, pers. comm. 2002). From our experience, bullet traumas to vital organs may also pose a risk. Under such circumstances, the wounded animal appears not to withstand the stress caused by neuroleptoanalgesics. Unfortunately, it is difficult to identify in advance by visual observation such a compromised individual. It is therefore important to investigate properly all mortalities including a thorough post-mortem examination, haematology and biochemistry.

Several important requisites have been suggested for successfully immobilizing elephants. Osofsky and Hirsch (2000) summarized some of these factors as 1) behaviour, social structure and the social status of the subject; 2) environment, such as ambient temperature, humidity, wind, terrain, amount of daylight; 3) animal welfare issues, including the type of drug to be used and dose selected, the species-specific response to different capture drugs, the availability of antagonists for the selected restraint drug, the proper assessment of the health status of individual animals, and measures to reduce stress associated with capturing and immobilization.

The combination of these factors thus determines the scouting method, dosage protocol and type of follow-up to be undertaken. Therefore, the capture protocol for elephants in open savannah or semi-wooded habitats differs from that used in the dense miombo woodland and riverine vegetation of Selous. The latter is characterized by low visibility, high variability of terrain and difficulty of locating individuals at a safe distance. These situations create unique and challenging situations, which require much flexibility during the capture operation.

Acknowledgements

This study would not have been possible without the assistance of many people, including Dr W. Rietschel (Wilhelma Zoo, Stuttgart, Germany), Mr Mzamilu Kaita and Mr M.O. Mwangalimi (SUA, Morogoro, Tanzania), Mr David Kaggi from SCP/GTZ (Dar es Salaam), and Mr Nalimi Madatta and Mr Dickson Koishwa, district game officers for Songea and Tunduru, respectively. The services of the game assistants, village game scouts and traditional hunters from several villages in the corridor are greatly appreciated. We also extend our gratitude to our pilots, Ms Sybille Quandt, Mr Martin Bower, Mr Peter Otto and Mr Friedrich Alpers, for their expertise, and to the independent observers from the Tanzania People's Defence Force, Maj. Nandala and Maj. Athanas and Dr Richard A. Kock (Inter-African Bureau for Animal Resources) for helpful comments on an earlier draft. This project was financed by the Tropical Ecology

Support Programme of GTZ, Germany, through the Institute for Zoo and Wildlife Research and run in collaboration with SCP/GTZ and the Division of Wildlife, Ministry of Natural Resource and Tourism, Tanzania. We thank the Messerli Foundation, Switzerland, for their material support.

References

Benjamin, M.M. 1986. *Outline of veterinary clinical pathology*., 3rd ed. Iowa State University Press, Ames, Iowa.

Brown, I.R.F., and White, P.T. 1980. Elephant blood haematology and chemistry. *Comparative Biochemistry and Physiology* 65:1–12.

Coetsee, C. 1996. Elephant translocation. *Pachyderm* 22:81–82.

Coles, E. H. 1986. *Veterinary clinical pathology,* 4th ed. W.B. Saunders, Philadelphia.

Doxey, D.L. 1983. *Clinical pathology and diagnostic procedures,* 2nd ed. Bailliere Tindal, UK.

Douglas, C.P. 1994. Anaesthesia and chemical restraints. In: Susan K. Mikota, Eva Lee Sargent and G.S. Langlack, eds *Medical management of the elephants*. Indira Publishing House, West Bloomfield, Michigan.

Elkan, P.W., Planton, H.P., Powell, J.A., Haigh, J.A., and Karesh, W.B. 1998. Chemical immobilization of African elephants in lowland forest, southwest Cameroon. *Pachyderm* 25:32–37.

Hoare, R. 1999. Reducing drug induction time in the field immobilization of elephants. *Pachyderm* 27:49–54.

[ISIS] International Species Information System. 1999. *Physiological data reference value.* ISIS, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA.

Jones, W.E. 2003. Anaemia: sport medicine article for the *Quarter Racing Journal*. http://www.gateway.net. au/~mcvc/index.html. Accessed 22 August 2003.

Kock, M.D., Rowan, B., Martin, M.S., and Kock, N. 1993. Chemical immobilization of the free ranging African elephants, *Loxodanta Africana*, in Zimbabwe, using Etorphine (M99) mixed with hyaluronidase and evaluation of biological data collected soon after immobilization. *Journal of* Zoo *and Wildlife Medicine* 24(1):1–10.

Kock, R.A., Morkel, P., and Kock, M.D. 1993. Current immobilization procedures used in elephants. In: Fowler, M.E. ed., *Zoo and wild animal medicine: current therapy,* vol. 3. W.B. Saunders Company, Philadelphia.

Njumbi, S., Waithaka, J., Gachago, S., Sakwa, J., Mwathe, K., Mungai, P., and Litoroh, M. 1996. Translocation of elephants: Kenyan experience. *Pachyderm* 22:64–65.

Osofsky, S.A., and Hirsch, K.J. 2000. Chemical restraint of endangered mammals for conservation purposes: a practical primer. *Oryx* 34(1):27–33.

Raath, J.P. 2003. Chemical capture of the African elephant *Loxodanta africana*. In: A.A. McKenzie, ed., *The capture and care manual.* http://www.wildlifedecisionsupport.com/captureandcare/section/ b4_elephant/01_raath.html. Accessed 24 August 2003.