INTERNATIONAL WILDLIFE
REHABILITATION COUNCIL

Volume 35, Number 1, 2015

JOURNAL OF WILDLIFE REHABILITATION



IN THIS ISSUE:

Comparing effects of two euthanasia compounds for feeder mice on rehabilitating hawks

Rehabilitation of captive wild-born yellow baboons for release

African penguin chicks abandoned by molting parents: raising, release, and survival

What's on your plate?

ABOUT THE JOURNAL

THE *Journal of Wildlife Rehabilitation* is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered online and on-site in numerous locations, and an annual symposium, IWRC works to disseminate information and improve the quality of the care provided to wildlife.



On the cover:
Yellow baboon *(Papio cynocephalus).*

PHOTO ©STEVE GARVIE, FLICKR.COM.
CC BY-NC-SA 2.0

Left:
Male greater sage-grouse courtship display at lek *(Centrocercus urophasianus).*

PHOTO ©DAN DZURISIN, FLICKR.COM.
CC BY-NC-SA 2.0

IWRC
International Wildlife Rehabilitation Council
PO Box 3197
Eugene, OR 97403 USA
Phone: 866.871.1869
Fax: 408.876.6153
Toll free: 866.871.1869
Email: office@theiwrc.org
director@theiwrc.org
www.theiwrc.org

JOURNAL OF WILDLIFE REHABILITATION

Volume 35(1)

CONTENTS

Editor
Kieran J. Lindsey, PhD
Center for Leadership in Global Sustainability
Virginia Tech University
Editorial office:
St. Louis, Missouri, USA

Art Director
Nancy Hawekotte
Cumulus Creative
Omaha, Nebraska, USA

Copy Editor
Heila Hubbard
Rescue, California, USA

PEER-REVIEWED PAPERS

7

The effects of feeding mice euthanized by isoflurane-CO_2 or CO_2 only to hawks in wildlife rehabilitation: a pilot study
Alex Boo, Sara Dubois, and I. Joanna Makowska

11

Rehabilitating captive wild-born yellow baboons *(Papio cynocephalus)* for reintroduction into the wild
Valentine Buh Ebua, Tsi Evaristus Agwafo, Mpoame Mbida, and Jonathan Vaughan

23

Hand-rearing, release, and survival of African penguin chicks abandoned before independence by molting parents
Richard B. Sherley, Lauren J. Waller, Venessa Strauss, Deon Geldenhuys, Les G. Underhill, and Nola J. Parsons

DEPARTMENTS

Editorial	4
In the News	5
In Memorium	5
Wild Rights	33
Tail Ends	36
Submission Guidelines	37

The *Journal of Wildlife Rehabilitation* is published by the International Wildlife Rehabilitation Council (IWRC), PO Box 3197, Eugene, OR 97403 USA.

©2015

(ISSN: 2166-9198).

All rights reserved.

BOARD OF DIRECTORS

President
Susan Wylie
Le Nichoir Wild Bird Rehabilitation Centre
Hudson, Quebec, Canada

Vice President
Adam Grogan
RSPCA
Horsham, West Sussex, UK

Secretary
Brenda Harms
Pelham, New York, USA

Treasurer
Mike Davidson
Isler CPA
Eugene, Oregon, USA

Francisca Astorga, MV
Cascada de las Animas Wild Animal Refuge
Santiago, RM, Chile

Lloyd Brown
Wildlife Rescue of Dade County
Miami, Florida, USA

Amanda Cyr
Wisconsin Department of Natural Resources
Wausau, Wisconsin, USA

Kelly Donithan
IFAW
Yarmouth Port, Massachusetts, USA

Kristen Heitman, CWR
Providence Wildlife Rehabilitation
Westfield, Indiana, USA

Kim Poisson
A2 Raptor Rescue
Ann Arbor, Michigan, USA

Kai Williams
Executive Director

Julissa Favela
Programs and Membership Manager

Laura Ratti
Office Administrator

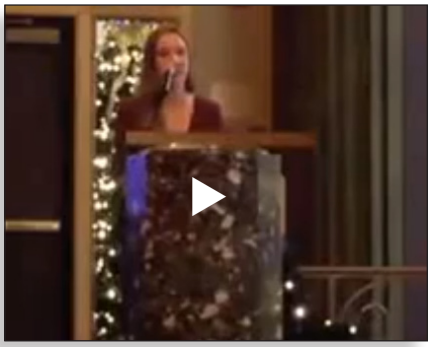
EDITORIAL

The challenges of growth: reaffirming our mission by welcoming change

December 31, 2014, marked the end of IWRC's 40th year working for wildlife rehabilitators. I'm pleased to say our organization is strong and providing education both here in North America and increasingly around the globe. After a challenging period in the late 2000s, IWRC rekindled membership engagement and services in 2010. We've been rebuilding IWRC's financial base, we prepared a strategic plan that connects with IWRC's core mission, and we ensured organizational governance exceeds industry benchmarks. We are continually striving to be the best organization possible for wildlife and for our membership. We are growing, and growth means change—in this case a decreased emphasis on symposia and more time spent on courses.

With our small staff, it is no surprise that allocating our time effectively is a key objective. In the past, the IWRC symposium required about 15 percent of our time. As a result, we've had less time to work on webinars, new courses, and other projects that will benefit our broad spectrum of members. At the same time, registration has been relatively low at the symposium, compared with IWRC in the early 2000s and with similar organizations. We've questioned whether the symposium is truly useful to the membership and if it is the best use of our limited staff time.

IWRC is an international organization. Our mission calls for us to provide training and education to wildlife rehabilitators worldwide. Our membership program does this; our courses do this. Our online courses can be taken anywhere with an internet connection. Our classroom courses go to students all over North America, with four courses a year now in Ireland and emergent opportunities for in-country instructors in India and South Africa.



Executive Director Kai Williams reflects on the 40th anniversary of IWRC at the 2014 Annual General Meeting.

The hard truth is that we can better accomplish our mission without hosting a symposium at this time.

So here is our course to the future. IWRC will be taking a multi-year break from hosting the symposium. We'll be hard at work finishing the Basic Manual revision, and you'll be seeing Julissa and me at a number of other events in the next few years. Look for us at NWRA, at some local events, and bridging with veterinary, conservation biology, and oiled wildlife conferences. We'll also be working with numerous groups to bring our courses in as workshops and pre-conference classes. You'll be seeing staff, board, and instructors at courses and events throughout the world.

IWRC is really growing strong, and that involves hard decisions, but we are continually striving to give the membership true benefits and make IWRC the most it can be. I welcome your feedback, comments, and participation right now, and over the next 40 years of IWRC.

Kai Williams
Executive Director

Burned Bear Takes Next Step to Release

LAKE TAHOE, California, USA (November 25, 2014)—A black bear cub found after a severe fire in Eastern Washington heads to its pre-release enclosure.

On Friday, November 21, Dr. Kevin Willitts, the official volunteer veterinarian for Lake Tahoe Wildlife Care, officially released Cinder from his medical care. On Sunday, she headed one step closer to home, via an eight-hour car ride to the Idaho Black Bear Rehabilitation Center (IBBR), just outside Boise, where she will spend the rest of the winter.

Her enclosure at IBBR will be next to a first-year bear cub for at least a short time, until they get to know each other. Over the next four months, her now-healed paws will have a chance to toughen up.

In the spring, Sally Maughan, founder of IBBR, will inform Washington wildlife bear specialist, Rich Beausoleil, when she is ready to go, then Rich will pick up Cinder and take her on her last car ride to release her in a suitable habitat where she will be free in the wild.

Historic Stranding of Kemp's Ridley Sea Turtles

CAPE COD, Massachusetts, USA (November 25, 2014)—To disperse a seeming tidal wave of stranded sea turtles washing up on Cape Cod, the New England Aquarium arranged for 243 rewarmed Kemp's Ridley sea turtles and green sea turtles to be flown to Florida and North Carolina on Tuesday.

Before dawn, 193 critically endangered Kemp's Ridley sea turtles were netted from the pools of the Aquarium's sea turtle hospital in Quincy, MA, loaded into padded boxes, and transported to Otis Air National Guard Base on Cape Cod where a Coast Guard plane transported the 3-10 pound, black-shelled turtles to Orlando where they were distributed to seven marine animal rehab facilities in north and central Florida. At mid-morning, 50 Kemp's and green sea turtles were also pulled and driven to suburban Norwood Airport where a private pilot flew them to North Carolina for distribution to the aquariums there. These turtles will spend at least a couple of months in the various rehab settings before being released back into the ocean.

The flights temporarily freed up critical tank space at the Aquarium's hospital for more turtles that have been rescued and have been waiting at the Massachusetts Audubon Sanctuary at Wellfleet Bay. Within two hours of the second flight departing Massachusetts, 50 more sea turtles were transferred to the sea turtle hospital from the Outer Cape nature center. The turtles remaining at the Audubon sanctuary have been under the care of an Aquarium veterinarian on site. After a week of nearly a hundred turtles washing up daily, Tuesday's mild weather gave rescuers a break as just a few live animals were found.

Only three weeks into the eight-week-long sea turtle stranding season, 2014 has already smashed prior records into oblivion. Since November 3, Mass Audubon had recovered 976 live and dead sea turtles. Just over 600 of those turtles

IN MEMORIUM

Donald L. Burton (November 16, 1951–November 18, 2014)



Donald L. Burton, DVM, of Columbus, Ohio, died November 18, 2014, of complications from ALS. He was 63. Don is survived by his wife of 26 years, Susan (Meckstroth); daughters, Stephanie (Danny) Rogers and Kristen Burton, as well as extended family.

Don was well known to the wildlife rehabilitation community for his founding of the Ohio Wildlife Center (OWC) in Columbus, now one of the largest such facilities in the US, and for his continual support of the wildlife rehabilitation community.

Don received his Bachelor of Science degree in Zoology from Ohio State University in 1975, MS in Fisheries and Wildlife Management in 1979, and his DVM degree in 1980.

Within his first years of practice, he fielded many inquiries from clients regarding injured, diseased, or orphaned wildlife, and in 1984 he founded OWC. Alongside his involvement in wildlife rehabilitation, Don maintained a Columbus-based veterinary practice, Animal Care Unlimited (ACU), caring for avian, exotic, and small animal companions. He was a 20-year consultant and guest lecturer for the Humane Society of the United States, was an adjunct associate professor at the Ohio State University College of Veterinary Medicine, and served on the Columbus Zoological Park Association Board of Trustees for 30 years. Columbus Zoological Park and Aquarium's "Eagle Habitat in the North American Region" display was dedicated to him.

Don received many awards for outstanding community service throughout his career. Faith played an abiding role in his life, and in his last five years he led a weekly Bible study for men at Jericho's Light Club in Columbus. According to his family, his loss of speech to ALS did not quench his mission of encouragement.

Condolences and memories can be shared at http://www.caringbridge.org/visit/donburton and at http://www.schoedinger.com/obituaries/Donald-Burton-4/.

Donations can be made in Don's name to any of the following: Xenos Christian Fellowship, 1340 Community Park Drive, Columbus, Ohio 43229; the Dr. Donald L. Burton Memorial Fund c/o Ohio Wildlife Center, 6131 Cook Road, Powell, Ohio 43065; or Jericho's Light Club, P.O. Box 211033, Columbus, Ohio 43221.

arrived alive. Including today's flights, 328 turtles have been re-warmed, stabilized, and transported to rehab facilities in Georgia, North and South Carolina, Florida, Pennsylvania, and Massachusetts. As of Tuesday night, 180 turtles are in residence at the Quincy sea turtle hospital and about 100 turtles remain in Wellfleet. The previous record for live turtles treated during a season was 242, and the average over the past decade was about 90! There are four to five weeks remaining in the stranding season, and regional sea turtle biologists are in disbelief and amazement at the number of cold-stunned juvenile sea turtles that have been recovered and possibly remain in Cape Cod Bay.



PHOTO © DEADMONKEY8984, ANIMALS.WIKIA.COM. CC-SE LICENSE.

The threatened spectacled hare-wallaby (*Lagorchestes conspicillatus)* has been rediscovered near Broome after nearly a decade without any recorded sightings.

Spectacled Hare-wallaby Still Exists!

BROOME, Western Australia (November 24, 2014)—The threatened spectacled hare-wallaby has been rediscovered near Broome after nearly a decade without any recorded sightings.

Using camera traps, Yawuru Country Managers and WWF have captured images of the marsupial during its nightly forage. The sensor cameras were set up as part of a pilot survey on Yawuru-owned Roebuck Plains Station where the species was last sighted in 2004.

The wallaby, named from the distinctive orange fur that surrounds each eye, is considered very rare in the Kimberley region. Although it is widespread throughout other parts of northern Australia, its population is considered to be in decline throughout their range.

Yawuru Corporation Board Director Dean Mathews states, "Positive identification of the spectacled hare-wallaby by the Yawuru Country Managers and WWF definitely reflects the value of building Traditional Ecological Knowledge into collaborative research partnerships.

"We now have an opportunity to rescue these animals and their habitats through the implementation of sustainable land management practices. The Yawuru Indigenous Protected Area, which will soon be dedicated, will enable the regeneration of the country in partnership with the Indigenous Land Corporation's environmentally sustainable rangeland management program so that this wallaby and other threatened species can thrive as they once did."

The spectacled hare-wallaby uses large grass tussocks for shelter from predators and the extremely hot daytime temperatures. Inappropriate fire regimes and trampling by larger animals can put the wallaby at risk of exposure.

The spectacled hare-wallaby is well suited for life in extreme arid conditions, having adapted to extract and retain water from its food. However, their population is still at risk from modern threats such as introduced predators, grazing, frequent fires, and extreme weather events such as droughts.

Yawuru Country Managers and WWF-Australia will continue to work together to monitor spectacled hare-wallabies and ultimately aim to address key threats to ensure this species thrives on Yawuru Country.

Good Samaritan Law Needed in Illinois

GREATER BARRINGTON, Illinois, USA (November 11, 2014)—Illinois currently has no Good Samaritan law protecting individuals who rescue injured and orphaned wildlife in need. As a result, any member of the public helping an injured or orphaned wild animal by rescuing it—even if one promptly takes it to a permitted wildlife rehabilitation facility—is at risk of prosecution.

A man who rescued two injured juvenile bald eagles whose nest was damaged in a storm was arrested even though he promptly turned these birds over to Flint Creek Wildlife Rehabilitation, a state and federally permitted wildlife rehabilitation center, where the eagles received necessary medical care for their injuries and were raised by an adult bald eagle. The man spent 16 months defending himself against the charges. The state's case was possible because there is not a Good Samaritan law in Illinois that would have protected a well-intentioned individual who was trying to save the life of a wild animal in need.

Flint Creek Wildlife Rehabilitation estimates that almost one-half of the 3,400 injured and orphaned wild animals admit-

CONTINUED ON PAGE 35

The effects of feeding mice euthanized by isoflurane-CO_2 or CO_2-only to hawks in wildlife rehabilitation: a pilot study

Alex Boo, Sara Dubois, and I. Joanna Makowska



PHOTO © DAS_MILLER ON FLICKR.COM. CC BY-NC-SA 2.0 LICENSE.

ABSTRACT: Raptors undergoing wildlife rehabilitation are often fed small rodents during their recovery. One possible source for these rodents is animal research facilities. Rodents used in research are typically killed by exposure to carbon dioxide (CO_2), but, for welfare reasons, new Canadian guidelines dictate that rodents first be anesthetized with isoflurane before killing with CO_2. Little is known about the effects of feeding wildlife undergoing rehabilitation rodents that have been exposed to an anesthetic, raising concerns about the suitability of this practice. A pilot study at the Orphaned Wildlife Rehabilitation Society in British Columbia, Canada, found no differences in observed behavioral changes in two hawks fed mice anesthetized with isoflurane before killing with CO_2 compared to a diet of mice killed with CO_2 alone. These results suggest that there is little risk associated with feeding raptors mice exposed to isoflurane before CO_2 and recommendations for future study are outlined.

KEY WORDS: raptor, rodent, euthanasia, residual anesthetic, feeding, welfare

CORRESPONDING AUTHOR
I. Joanna Makowska
Animal Welfare Program
Faculty of Land and Food Systems
University of British Columbia
2357 Main Mall
Vancouver, British Columbia V6T 1Z4
Canada
Phone: 604.822.5715
Email: makowska@interchange.ubc.ca

Introduction

Injured and orphaned raptors are typically fed small rodents in wildlife rehabilitation centers. These centers must either raise funds to purchase food for the animals in their care or rely on donations from local businesses or facilities that can provide animal carcasses. Such facilities may include institutions that use animals in research.

Typically, mice and rats used in research are killed by exposure to high concentrations of carbon dioxide (CO_2). Evidence suggests that rodents killed in this manner are safe for consumption by wildlife.[1] However, exposure to CO_2 is aversive to rodents;[2,3] thus, pre-exposure to an inhalant anesthetic such as isoflurane is more humane than CO_2 alone.[4-6] New rodent euthanasia guidelines in Canada now recommend that researchers anesthetize rodents in this way before exposing them to CO_2.[7] However, there is little data on the effects of anesthetics on carcass tissues, and it is unknown if rodents exposed to inhalant anesthetics are safe for consumption.

Uncertainty around the safety of feeding raptors rodents that have been exposed to an inhalant anesthetic means that rehabilitation centers sourcing rodents from facilities that use isoflurane may have to seek alternative food sources. Thus, the ability to donate rodents killed for research purposes may be restricted, which otherwise helps reduce feelings of guilt experienced by some animal researchers for animal use.[8]

The aim of this pilot study was to determine whether the consumption of mice

J. Wildlife Rehab. 35(1): 7–10. © 2015 International Wildlife Rehabilitation Council.

exposed to isoflurane before CO_2 during euthanasia leads to behavioral changes in raptors. Carcasses may contain enough residue of the anesthetic that could in principle affect the animals eating them. However, previous research shows that approximately 95% of the isoflurane inhaled by rodents is exhaled within the next breath, and less than 0.2% is metabolized in the liver.[9-11] Therefore, it is expected that only trace amounts of isoflurane would be present in rodent carcasses and, thus, the amount of isoflurane ingested by the raptors would be very small and there would be no measurable changes in behavior.

Materials and Methods

The study was conducted in July and August 2013 at the Orphaned Wildlife Rehabilitation Society (OWL) in Delta, British Columbia, Canada. This rehabilitation facility has been collecting rodents killed with CO_2 from the neighboring University of British Columbia (UBC) for the past several years. Two birds in rehabilitation were assigned to the study by OWL: a juvenile male Cooper's hawk (*Accipiter cooperii*) and a juvenile male Northern goshawk (*Accipiter gentilis*). Two treatments of frozen laboratory mice (*Mus musculus*) were donated from several laboratories across UBC and used as food in this study: mice euthanized by exposure to CO_2 alone ("CO_2-only") and mice euthanized by exposure to isoflurane followed by CO_2 ("isoflurane-CO_2"). All mice were euthanized according to UBC standard operating procedures for rodent euthanasia.[12,13]

The study used a crossover design. One hawk was fed isoflurane treated mice for 14 consecutive days, while the other hawk was on the opposite treatment. Treatments were then reversed for the next 14-day period. Hawks received one mouse per day, and this was the only food provided as per normal meal size established by the center staff. An observer blind to the feeding treatment stood by each bird's enclosure and recorded behavior before, during, and after feeding (Table 1). In addition, behavioral signs of possible isoflurane toxicity were scored throughout the observation period and included dyspnea, recumbency, lethargy, inability to stay perched, and loss of consciousness. Behaviors were scored 4-5 times per week. The length of the observation period before and after feeding was based on a previous study[14] and from personal experience of the observer.

Results

No behavioral signs of isoflurane toxicity were observed over the course of this study. Type of mouse eaten had no effect on any of the behaviors measured. However, irrespective of treatment, both birds spent more time on the floor, took more time to start eating, spent more time eating, and performed more perch jumping during the first 2-7 days of the study (see Fig. 1 as an example).

The hawks always ate the entire mouse, suggesting that both types of mice are palatable. After the first few days of the study, latency to start eating was in the range of 1-5 seconds for both birds and treatments. Eating time was variable, ranging from 140-1620 seconds for *A. cooperii* and 200-590 seconds for *A. gentilis*.

Most behaviors were bird-specific. Retreating to the back of the enclosure, scraping beak on the floor, and pecking at talons were only seen in *A. cooperii*, while walking around the enclosure with mouse in talons, ripping out fur, looking up between bites, and scraping beak on the water bowl were only seen in *A. gentilis*. Both birds scraped their beaks on the perch, and both birds did this more frequently near the end of the study than at the beginning.

Discussion

A 14-day diet of mice anesthetized with isoflurane before CO_2 euthanasia did not result in any behavioral changes compared to a diet of mice killed with CO_2 alone for either of the two hawks. The differences observed between the first few days of observation and the rest of the study are likely explained by habituation: at the beginning of the study, birds were not accustomed to the presence of the observer and therefore displayed more stress behaviors such as perch jumping and more vigilant behaviors such as longer time spent eating due to more time looking around.[15]

The amount of isoflurane in the mouse carcasses was not directly measured, but calculations suggest the dose ingested by the raptors was very small. The mass of the mice consumed in the current study was approximately 25g (adult C57BL/6 mouse strain = 25g[16]), which is 1/17th the mass of the *A. cooperii* (425g) and 1/27th the mass of the *A. gentilis* (685g) used in the pilot study. This means that the hawks would need to consume 17-27 mice to achieve an effective dose of anesthetic, and that is assuming that 100% of the isoflurane inhaled by the mice was ingested by the hawks. However, given that approximately 95% of administered dose of isoflurane is excreted in exhaled air,[9-11] with a 5% transferal rate, each hawk would need to consume between 340-540 mice in a single meal to achieve an effective dose of anesthetic (17/5% = 340; 27/5% = 540). On this basis, it should come as no surprise that a meal of one mouse is not sufficient to cause any detrimental effects. The above calculations also assume that ingesting versus inhaling isoflurane is an effective way of anesthetizing an animal; to our knowledge, this assumption is currently untested.

The calculation above assumes that the minimum alveolar concentration (MAC) values of the rodents and raptors are similar. MAC is defined as the concentration of the anesthetic vapor in the lungs that is needed to prevent movement in 50% of subjects in response to a surgical stimulus, and is used for establishing a minimal concentration of anesthetic required to prevent gross muscular movement in response to a painful stimulus.[17] As birds do not have pulmonary alveoli, for this study the term MAC refers to the minimum concentration of pulmonary (rather than alveolar) anesthetic drug. The MAC for C57BL/6 strain mice is 1.2 ± 0.05%[18] versus 2.05 ± 0.45% for the red-tailed hawk, *Buteo jamaicensis*.[20] The MAC of isoflurane is unknown for the two species of raptor used in the current study; the red-tailed hawk was the raptor most similar in size for which published values were available.

In addition to the 95% loss of isoflurane within the mouse's next breath, isoflurane was likely lost in several other ways before

it could be ingested by the birds. Mice continued to breathe CO_2 for 112 seconds before last breath.[19] Also, any isoflurane still present in the mouse was able to slowly volatilize while the mouse was stored in a freezer and then thawed at room temperature before feeding.

Limitations and Future Directions

This study examined the effects of feeding isoflurane-CO_2 mice to medium-sized raptors over the course of 14 days. No adverse behavioral effects were observed, but some caution is required when considering other feeding conditions. For example, some animals in rehabilitation feed on rats; these animals are much larger than mice and likely contain more residual isoflurane. Future studies may wish to assay mouse or rat tissues for isoflurane concentrations in the carcasses prior to feeding. However, values obtained may be underestimating the isoflurane concentration present in the intact carcasses because the process of assaying, which involves maceration of tissues and measurements with a Beckman™ infra-red medical gas analyzer, accelerates the evaporation of isoflurane. Also, caution should be used if rehabilitation centers are given rodents that die from the effects of isoflurane before CO_2 is turned on, as this was not tested here.

This study used medium-sized raptors; some species in rehabilitation are smaller and could therefore be affected by smaller amounts of ingested isoflurane. This study was limited by the species available at the time of the research; ideally, further studies should focus on only one species of raptor at a time. Hawks in the study only consumed the isoflurane-CO_2 mice for 14 days, but a typical stay in rehabilitation is closer to 3-4 months (Martina Versteeg, OWL bird care staff, personal communication). Thus, future studies could also be of longer duration.

The ultimate goal of wildlife rehabilitation is to release the orphaned and formerly injured animals back into the wild.[21] *A. cooperii* was released on December 22, 2013; *A. gentilis* was not released due to a wing injury present at admission, and later died in care on March 28, 2014, because of unrelated causes. Possible long-term detrimental effects that could occur as a result

TABLE 1: BEHAVIORS RECORDED BEFORE, DURING, AND AFTER FEEDING A MOUSE TO TWO HAWKS IN REHABILITATION AT OWL.

Before feeding (15 min)	During feeding (variable)	After feeding (30 min)
TIME SPENT ON FLOOR (SEC)	ACCEPTANCE OF FOOD	TIME SPENT ON FLOOR (SEC)
PERCH JUMPING (NO. OF TIMES)	WALKING AROUND ENCLOSURE	PERCH JUMPING (NO. OF TIMES)
	LOOKING UP BETWEEN BITES	SCRAPING BEAK ON PERCH
	RIPPING OUT FUR	SCRAPING BEAK ON WATER BOWL
	RETREATING TO THE BACK OF ENCLOSURE	SCRAPING BEAK ON FLOOR
	LATENCY TO START EATING (SEC)	PECKING AT TALONS

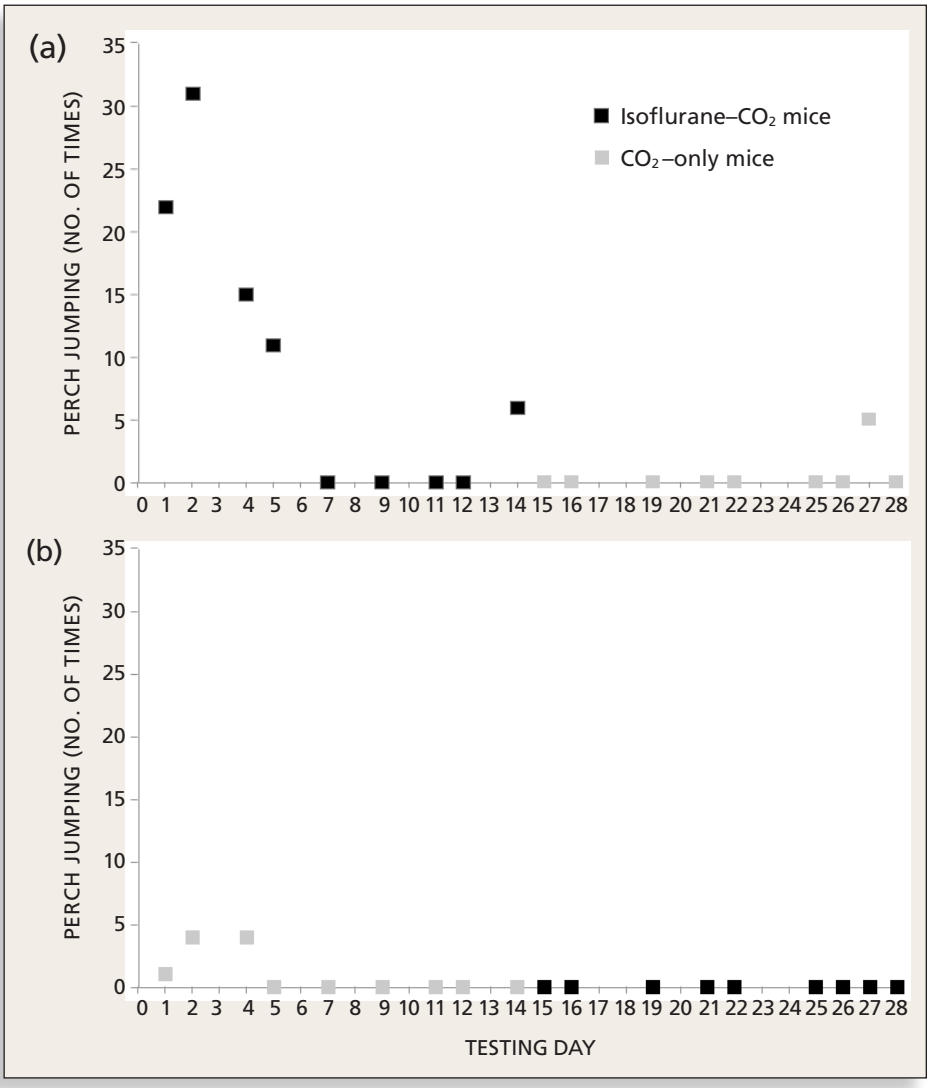


FIGURE 1. Number of times (a) *A. cooperii* (n=1) and (b) *A. gentilis* (n=1) moved between perches before eating isoflurane-CO_2 euthanized mice or CO_2-only euthanized mice. (Where data points are absent, birds were fed a mouse but behaviors were not scored.)

of potential isoflurane accumulation in the body were not able to be measured. Flight proficiency is essential to the survival of birds, perhaps especially so in predatory species such as raptors. Future work in this area should focus on measures associated with flight dexterity, as these measures may be particularly sensitive to anesthetic toxicity.[15] Blood biochemical parameters such as liver and kidney values in raptors regularly eating isoflurane-CO_2 euthanized mice long-term before release, or before admittance into permanent captivity, should also be collected and analyzed in future studies to ensure that the long-term health of the animal will not be compromised by isoflurane.

Conclusion

This pilot study showed that a 14-day diet of isoflurane anesthetized mice, killed by CO_2, had no behavioral effects on two raptors in rehabilitation care versus a diet of CO_2-only killed mice. On this basis, the welfare of both the rodents and the hawks may be best served if the rehabilitation facility uses rodents euthanized following a protocol that requires anesthesia with isoflurane.

Acknowledgments

We would especially like to thank Dr. Daniel M. Weary for his involvement and advice at all stages of this project. We extend our thanks to the volunteers and staff at Orphaned Wildlife Rehabilitation Society in Delta, BC, for their assistance and knowledge regarding *Accipiter* behavior.

Literature Cited

1. AVMA Guidelines for the Euthanasia of Animals: 2013 edition [Internet]. [AVMA] American Veterinary Medical Association; 2013 [cited 2013 October 15]. Available from: https://www.avma.org/KB/Policies/Documents/euthanasia.pdf.
2. Niel L, Weary DM. Rats avoid exposure to carbon dioxide and argon. *Applied Animal Behaviour Science*. 2007;107:100-109.
3. Kirkden RK, Niel L, Lee G, Makowska IJ, Pfaffinger MJ, Weary DM. The validity of using an approach-avoidance test to measure the strength of aversion to carbon dioxide in rats. *Applied Animal Behaviour Science*. 2008;114:216-234.
4. Leach MC, Bowell VA, Allan TF, Morton DB. Aversion to gaseous euthanasia agents in rats and mice. *Comparative Medicine*. 2002;52:249-257.
5. Makowska IJ, Vickers L, Mancell J, Weary DM. Evaluating methods of gas euthanasia for laboratory mice. *Applied Animal Behaviour Science*. 2009;121:230-235.
6. Wong D, Makowska IJ, Weary DM. Rat aversion to isoflurane versus carbon dioxide. *Biology Letters*. 2013;9:1-5.
7. CCAC guidelines on: Euthanasia of animals used in science [Internet]. [CCAC] Canadian Council of Animal Care; 2010 [cited 2014 March 17]. Available from: http://www.ccac.ca/Documents/Standards/Guidelines/Euthanasia.pdf.
8. Figley C, Roop R. *Compassion Fatigue in the Animal Care Community*. The Humane Society of the United States: Washington, USA. 2006. pp 1-90.
9. Agasti T. *Textbook of Anaesthesia for Postgraduates*. Book News Incorporated: Portland, USA. 2011.
10. Greenstein L, Hitt B, Mazze R. Metabolism *in vitro* of enflurane, isoflurane, and methoxyflurane. *Anesthesiology*. 1975;42:420-424.
11. Holaday D, Fiserova-Bergerova V, Latto I, Zumbiel M. Resistance of isoflurane to biotransformation in man. *Anesthesiology*. 1975;43:325-332.
12. Carbon Dioxide Euthanasia [Internet]. [UBC] University of British Columbia; 2008 [cited 2014 March 29]. Available from: http://www.ors.ubc.ca/sites/research.ubc.ca/files/uploads/documents/ORS/animalcare/CARBON%20DIOXIDE%20EUTHANASIA%20december%202008.pdf.
13. Euthanasia of Adult Rodents Using an Inhalant Anesthetic, Followed by Carbon Dioxide [Internet]. [UBC] University of British Columbia; 2012 [cited 2014 April 26]. Available from: http://www.ors.ubc.ca/sites/research.ubc.ca/files/uploads/documents/ORS/animalcare/SOP%20INHALANT%20EUTHANASIA%20FOLLOWED%20BY%20CARBON%20DIOXIDE.pdf.
14. Ford S. Raptor gastroenterology. *Journal of Exotic Pet Medicine*. 2010;19:140-150.
15. Park F. Behavior and behavioral problems of Australian raptors in captivity. *Seminars in Avian and Exotic Pet Medicine*. 2003;12:232-241.
16. C57BL/6 Inbred Mice [Internet]. Harlan Laboratories; 2012 [cited 2014 Aug 10]. Available from: http://www.harlan.com/products_and_services/research_models_and_services/research_models/c57bl6_inbred_mice.hl.
17. Eger E, Saidman L, Brandster B. Minimum alveolar anesthetic concentration: A standard of anesthetic potency. *Anesthesiology*. 1965;26:756-763.
18. Petrenko A, Tsujita M, Kohno T, Sakimura K, Baba H. Mutation of alpha1G T-type calcium channels in mice does not change anesthetic requirements for loss of the righting reflex and minimum alveolar concentration but delays the onset of anesthetic induction. *Anesthesiology (Philadelphia)*. 2007;106:1177.
19. Moody C, Makowska IJ, Weary DM. Testing three measures of mouse insensibility following induction with isoflurane or carbon dioxide gas for a more humane euthanasia. *Applied Animal Behaviour Science*. 2015;163:183-187.
20. Pavez J, Hawkins M, Pascoe P, Knych H, Kass P. Effect of fentanyl target-controlled infusions on isoflurane minimum anaesthestic concentration and cardiovascular function in red-tailed hawks (*Buteo jamaicensis*). *Veterinary Anaesthesia and Analgesia*. 2011;38:344-351.
21. Cooper JE. Raptor care and rehabilitation: precedents, progress, and potential. *Journal of Raptor Research*. 1987;21:21-26.

Rehabilitating captive wild-born yellow baboons (*Papio cynocephalus*) for reintroduction into the wild

Valentine Buh Ebua,[1]* Tsi Evaristus Agwafo,[2] Mpoame Mbida,[1] and Jonathan Vaughan[3]

PHOTO © DAVID BYGOTT, FLICKR.COM. CC BY-NC-SA 2.0 LICENSE.



ABSTRACT: With the increasing number of rescued orphan primates in wildlife centers, most of these centers are faced with the problem of providing shelter to all the continuously saved individuals. A solution to this is to rehabilitate some of the captive wild-born individuals through a systematic approach and reintroduce them back into the wild for a conservation and welfare purpose. We have developed and made use of a scientific approach in rehabilitating yellow baboons *in situ* prior to release. This approach may not be practicable to all programs but can be used as a model to adapt a similar or succinct approach to other species. It is intended to set a pace and to encourage many centers to get involved in the rehabilitation process and reduce the problems of accommodating space faced in their centers. This model come-up is to add to other standardizing methods in the world concerned with reintroduction and help to prevent most unsuccessful releases carried out across the sphere.

KEY WORDS: reintroduction, rehabilitation, conservation, welfare, systematic approach, yellow baboons, captive wild-born individuals

CORRESPONDING AUTHOR
Valentine Buh Ebua
University of Dschang
Department of Animal Biology
Dschang, Cameroon
Email: ebuaval@gmail.com

Introduction

Rehabilitation and reintroduction programs have been used recently for decades as a method of conservation for mammal species[1] and these programs have also provided an opportunity for animals that have lived in captivity to have another chance at living in the wild, and it is considered as one way of reestablishing populations that have become locally extinct.[2] Reintroduction addresses conservation on two different levels. First, animals that are kept illegally as pets are rescued, rehabilitated, and then returned to the wild. Second, by reintroducing animals into areas where they are locally extinct, the wild populations are supplemented and potentially more forest can be protected.[3,1] It has been acknowledged that preservation of wild populations and their habitats is imperative for the conservation of wild species, and rehabilitation and reintroduction may play a significant role in supporting the wild populations, as well as raising awareness of the plight of these species.[4]

It is estimated that almost half of the world's nonhuman primates are threatened with extinction and 29% are categorized as endangered or critically endangered (International Union for Conservation of Nature and Natural Resources[5]). Current conservation efforts seek to preserve the diversity of the primate order and to ensure the survival of representative populations of species in their natural habitats.

Reprint: Ebua et al. *International Journal of Biodiversity and Conservation.* 2014;6(2):159-170. doi: 10.5897/IJBC2013.0660

The primary extrinsic threats to the majority of primates are undoubtedly loss of habitat and hunting. In addition, as remaining populations continue to decrease, the effects of secondary threats, such as the use of primates for traditional purposes and the illegal pet trade, become more important.[6,7] The illegal trade of primates can have a drastic effect on the last surviving populations of already rare species. Young primates are removed from the wild and, most often, reproductively viable adults are killed in the process. In addition, as a result of the illegal trade network, primates are becoming displaced and orphaned. These orphans are brought into various types of rescue and rehabilitation centers when the owners realize they can no longer control them or when seized.[8] This has brought about the increasing number of baboons in most wildlife centers, such as in the case of Lilongwe Wildlife Centre (Malawi) and likewise the Limbe Wildlife Centre (Cameroon) where baboons are the highest species of primates at the centers (per. obs.). All species of baboons (*Cercopithecinae* sub-family) have declined over the past 30-40 years, primarily due to loss of habitat and the subsequent fragmentation of forests through timber felling, charcoal burning, encroachment for cultivation of plantations, and industrial settlement.[8,9] Other factors contributing to their demise include the illegal wildlife trade, hunting, and the use of their body parts in traditional medicine.[8]

Most wildlife centers receive donated or confiscated pets and other species with the goal of restoring their physical and psychological health back to as high a level as possible. This process includes assessing their medical and behavioral status and placing them into an appropriate social environment of an adult male and female. These species have been removed from the wild at a young age and have lived as pets for most of their adult lives and are facing a lot of challenges because the complex social, psychological, and physical needs of primates cannot be met when they are kept as pets or in captivity. These challenges include: learning how to vocalize in the appropriate social context (predators, reproduction, etc.), appropriately socializing with conspecifics,[10] overcoming the potential prevalence of stereotypic or human-directed behaviors, learning how to locomote efficiently (brachiation, developing balance), and learning how to locate and procure food.[8,1]

It is imperative to have an understanding of species' behavior during the rehabilitation process before reintroduction in order to help ensure the troop or individual(s) will have the best opportunity to adapt to a life free from human dependency in the wild. Behavioral studies can contribute a significant amount of knowledge to reintroduction programs by examining the underlying evolutionary mechanisms of species' behavior, such as the driving forces behind social and spatial organization, and by developing an understanding of how they respond to different social and environmental conditions.[11] There are very few data available on the behavior of reintroduced primates and their ability to adapt to a new environment. Authors Grooves,[12] Kleiman,[1] and Cheney et al.[8] present the only comprehensive study of the rehabilitation process and reintroduction of primates to date. As they demonstrated in their work, during the rehabilitation process, it is crucial to document the behavior of individuals in captivity prior to their release, so that we are able to compare the pre- and post-release behavior as a way to determine the relative success of the reintroduction projects. Therefore, monitoring their behavior before they are released is a crucial component in the reintroduction program for the species and, with hope, it will ensure a successful release.

This study constitutes the first step at developing a more systematic approach to the reintroduction of yellow baboons by conducting a rehabilitation of 28 wild-born captive yellow baboons through scientific behavioral training (how to feed/forage, locomote, rest in safe locations, recognize their predators, etc.) so as to determine which of these individuals show behaviors that could permit them to survive in the wild.

Releasing rescued primates back into the wild requires careful thinking, research, and planning. Unfortunately, the release of wild-born/captive animals can be disastrous to individual animals, entire populations, species, and ecosystems if not done correctly.[1] This failure had generated significant scientific skepticism, fueled in large part by the tendency for the initial decisions concerning the design of release programs to be informed by pragmatism rather than by sound science.[13,14] A historic absence of scientific rigor within the framework of release schemes has certainly contributed to poor overall success rates and may, in some instances, have even lead to animals being harmed.[15] In light of such risks, and as a direct consequence of the increase in reintroduction programs, the International Union for Conservation of Nature (IUCN) set up the Reintroduction Specialist Group of the Species Survival Commission (SSC/RSG) to develop Guidelines for the Reintroduction of Non-Human Primates into the wild. These internationally accepted, best practice guidelines cover the main steps and considerations of a reintroduction effort and suggest an order of execution.[16-18] The deployment of such scientific guidelines within reintroduction programs, akin to long-term funding procurement, is considered absolutely essential for the implementation of a successful release scheme.[19,13,20] The guidelines are a "best-practice" model or an ideal code of conduct.

For the past decades, most reintroduction programs have existed but failed or are always unsuccessful because of no proper rehabilitation approach of captive wild-born individuals who have lost their natural talents due to captivity.[21] Second, even if there is a rehabilitation process, it is done without a good knowledge of the species' ecological behavior, and no feasibility studies are carried out to assess if the release site has a good habitat quality fit for the release individuals.[19] The complex social, physical, and psychological needs of primates cannot be met when they are kept as pets, are lonely, or in deprivation[4] which leads to the loss of natural talents which, when released, do not permit them to compete with wild conspecifics. Last, most of these reintroduction programs have concentrated in reintroducing a few individuals (<8) wherein this small number of individuals cannot constitute a cohesive group to defend their territory, resources, and mates against the most powerful wild troop. The lack of a proper scien-

tific approach before reintroduction has also led to many unsuccessful reintroduction programs where the released individuals are unable to reproduce for fitness. Even if these small numbers of individuals are released, they end up migrating because of no proper studies done on group cohesion and maintenance of proximity, and the biology of the conspecifics in the wild. Another weakness in these reintroduction programs has been the release of animals without any training awareness on the identification and recognition of predators and how to defend or escape from the predators. All this, therefore, requires the need for a scientific rehabilitation approach where the biology and the ecology of the species are taken into consideration, alongside an assessment of the release site (to determine if it has a good habitat quality fit as a carrying capacity).

Materials and Methods

Rehabilitation Site

The Lilongwe Wildlife Centre (LLWC) is a wildlife rescue, conservation, and environmental education facility. It is Malawi's only rehabilitation sanctuary for orphaned, injured, and rescued wildlife, and it is fully registered as a Malawian not-for-profit trust and non-governmental organization (NGO). The LLWC works in partnership with the Department of National Parks and Wildlife (DNPW) of Malawi to ensure that all political, cultural, and legal requirements of their work are met. At present, the LLWC is home for more than 150 Malawian primates, mainly vervet monkeys (*Chlorocebus pygerythrus rufoviridus*) and yellow baboons (*Papio cynocephalus cynocephalus*). The majority of these animals have been rescued or confiscated from persons or organizations involved in the illegal wildlife trade and exploitation. One of the main goals of the LLWC is to release these successfully rehabilitated animals back into the wild, whenever it is possible and appropriate. It is located in Lilongwe Town along the Kenyatta drive. It has a land surface of 33 hectares with natural trees, and captive and non-captive animals.

Enclosure Design

The yellow baboons were located in a pre-release rehabilitation enclosure, 180 x 200 x 4.5 m, located in the Wildlife Centre's grounds, surrounded by Coral Rag Forest and visited almost daily by wild troops of each primate species occurring in this area. The pre-release enclosure is vital for the successes of the release program as it incorporates designs that allow the research team to prepare the animals for release. It can be divided into four compartments of varying sizes, allowing for human access to the enclosure for feeding and cleaning purposes, without incurring direct contact with the baboons. The enclosure had two fences: the first is with barbed wires electrified and the second screened on all four sides by makuti fencing, with eight viewing windows. This acts as a barrier between humans and the monkeys, while also allowing for inconspicuous monitoring of the animals, observation, and collection of data, essential for performing life skills training. All interaction with humans is minimized to allow de-humanization. The size of the enclosure for 31 individuals approximates natural troops in terms of size and composition.

Study Troop

All the animals within the release stock were rescued from inside Malawi and are indigenous to Malawi. They are therefore predominately wild-born, captive stock, which is an important distinction to make, as wild-born animals fair better in reintroduction programs than do captive-born animals and strategies used in the introduction of wild-born captive individuals can be different from those used with captive born individuals.[22] All of the potential release stock animals have been at the center for one or more years, but rarely for more than four years. Most of the animals have come out of the illegal pet trade, have been confiscated in Malawi, or handed over out of free will to the LLWC; most were orphaned upon arrival. Two individuals arrived at the Centre after being orphaned at approximately 10 days old and the majority of the remaining individuals were anything from a few weeks old to less than six months old when removed from the wild.

Data Collection

Rehabilitation data

A multidisciplinary technique of data collection was employed based on the various aspects involved in the data collection process (behavior, proximity, feeding/foraging training techniques, and veterinary and body condition checks). Data was collected for six days a week and for 8-12 h a day. Censuses for sleeping sites selection were done at 6.00 to 7.00 h and later in the evening at 17.00-18.00 h, while focal and scan sampling of individuals was carried out from 7.00 to 18.00 h in order not to miss important early morning and late evening behaviors and proximities. Because of the long hours of data collection, four people were involved in the data collection process.

In an effort to collect equivalent amount of data for each individual, we rotated the order of observation for each day following the recommendations of Cheney et al.[8] We collected a total of 96 h (5,760 min) for each individual during the rehabilitation period of 18 months with a total of 2,880 h spent in 18 months to observe the entire group. For proximity, each individual was observed 288 times for 20 min each in 18 months.

Behavioral data collection

Behavioral data was collected using focal, instantaneous sampling. Focal animals were selected using random sampling, rotating according to a fixed, randomly selected schedule, through all individuals.[23] This method prevents prominent individuals from being studied more frequently than non-prominent individuals and ensures that different age and sex classes of the troop are studied at different times of the day, reducing bias in possible time associated behaviors such as feeding behavior and species eaten. Focal follows were done all day for 8 to 12 h a day (individuals were observed in the morning or afternoon study periods, depending on the research timetable). Each observer conducted

10 focal follows of 30 min (the first 5 min started with the selection of a focal individual, 20 min of focal sampling, and the last remaining 5 min were used to ensure the correct identity of plant and animal species eaten during the focal or the collection and labeling of samples for identification) a day. In order to generate an activity budget for each individual, we recorded the individual states observed with major activities including: feeding/foraging, locomotion, vocalization, and others. We recorded socio-positive association behavior such as grooming, playing, copulation, and other. Human-directed and stereotype behaviors were recorded as either events or states depending on the duration and frequency of occurrence. In addition, all interactions with other wildlife species that passed by the enclosure from the neighboring forest were recorded using all occurrences sampling. When an individual was recorded as feeding/foraging, additional dietary data was collected, recording the food type item (young leaves, mature leaves, roots, stems, flowers, shoots, or animal prey) and the species. Unidentified species were collected for later taxonomic identification.

Proximity, socio-positive data

In addition to recording the behavioral states at 1 min intervals, we recorded the focal individual's proximity to one another and their location in the enclosure every 10 minute interval for 20 min (0, 10th, and 20th min). Scan samplings were used to record all group members that were in contact (<1 m, 1-3 m, 3-5 m, and >5 m) to the focal subject. Instances of socio-positive behaviors including grooming, play, and body contact occurring between the focal subject and group members were recorded during the 20 minute focal follows, discussed above, using instantaneous sampling and recording of the identities of the individuals involved. When more than two individuals were involved in the socio-positive behavior, each was considered a separate partner to the focal individual and therefore considered as separate dyads. Distances between individuals were estimates; that is why this aspect of data collection was done by a single individual.

Feeding/foraging training techniques

The second part of the pre-release training involved the training techniques for foraging as well as accustoming the animals to a new diet which approximated their future diet in the wild. During the rehabilitation period, the animals were fed from a screened fence by people in animal careers that did not have any contact with the animals. Food was spread out all round the enclosure so as to encourage the animals to forage. Sixty percent of the food was spread out at night or very early in the morning and the troop would only discover food as they foraged along their paths. The food provided to the troop was void of any foodstuff they would find in the wild or nearby farms like tubers, corn, bananas, and other fruits; it involved mostly wild fruits and leaves. This was to limit human–wildlife conflicts. In order to build up their body weights, each individual was entitled to half a chicken and three eggs weekly. The animals were fed on a carefully planned workable random calendar and not on a fixed timetable as it was previously done where they fed daily at 8.30 and 17.00 h. It's also worth noting here that there was no data collection during or one hour after they had been provided with any foodstuff.

Data analysis

In order to determine whether the individuals were behaviorally ready for release, we compared the average percent of observation records observed in their major activities to the guidelines we proposed and adapted from those recommended by Cheyne et al.[4] for the Javan Gibbon rehabilitation project. Table 1 highlights the important aspects of wild behavior that a rehabilitated yellow baboon troop should master before they are reintroduced. It is also crucial that the individuals solicit little to no human interaction (soliciting grooming from keepers, begging, aggressive behavior) because once they are released this behavior could potentially be harmful and can hinder their chances of survival in the wild. We calculated the average percent of observation records of each baboon spent in major activities (rest, feeding/foraging, social, locomotion, and vocalization) during the observation period.

Results

Out of the 31 individuals rehabilitated, data or information was collected only for 28 individuals. The other three individuals were not considered for two reasons: because they were yearlings (less than or equal to one year old) and because they were captive born individuals and, according to IUCN guidelines,[21] these types of non-human primates are not supposed to be reintroduced because it would be difficult for them to acquire skills that permit them to survive in the wild.

Activity Budget

The average percent of observation records that each member of the troop spent engaged in particular activities during the 18 months of the rehabilitation process indicates that all the individuals show similar activity patterns but with some disparity in time spent at a particular activity by each member of the troop. Only two individuals (Richard and Baby Mckenzie) spent less than 25% of their time feeding/foraging (23.2% and 15.8%, respectively), while the other 26 individuals were engaged in more than 25% of their activities feeding/foraging. Chico, Magda, and Secha spent above 70% of their time in feeding/foraging. Baby Mckenzie, who spent less than 25% of its activity time feeding/foraging, was engaged in resting 71.2% of its total time. No individual spent more than 25% of its activities vocalizing. As concerns locomotion, Baby Jane was the only individual that spent 30% of its time moving round the enclosure. There were two individuals (Baby Jane and Baby Malinga) that did not engage in any other activity apart from feeding/foraging, resting, locomotion, and vocalization.

Mckenzie was the most groomed and highly copulated female. Agonistic behavior typically involved a "swat" or a quick grab. Most agonistic behavior resulted during copulation among the alpha males and females; this behavior was rampant during the estrus periods as it is a period to demonstrate dominance and hierarchy in the troop as the most dominant copulate more with

TABLE 1. SUMMARY OF AN EVALUATION OF BEHAVIORAL CRITERIA FOR PRE-RELEASE OBSERVATIONS.

PROXIMITY CRITERIA / INDIVIDUAL	APPROPRIATE FORAGING/ FEEDING BEHAVIOR	APPROPRIATE REST BEHAVIOR	APPROPRIATE LOCOMOTORY BEHAVIOR	HUMAN AVOIDANCE	PREDATORY RESPONSE AND AVOIDANCE	GROUP COHESION FOR TERRITORIAL DEFENSE AND REPRODUCTION	SEXUALLY MATURE AND ACTIVE	GOOD HEALTH AND PHYSICAL CONDITIONS
Buddy	√	√	√	√	√	√	√	√
Juri	√	√	√	√	√	√	√	√
Lucky	√	√	√	√	√	√	√	√
Dedza	√	√	√	√	√	√	√	√
Archie	√	√	√	√	√	√	√	√
Mary	√	√	√	√	√	√	√	√
Jane	√	√	√	√	√	√	√	√
Mckenzie	√	√	√	√	√	√	√	√
Malinga	√	√	√	√	√	√	√	√
Mandy	√	√	√	√	√	√	√	√
Magda	√	√	√	√	√	√	√	√
Hastings	√	√	√	√	√	√	×	√
Chico	√	√	×	×	×	√	√	×
Richard	√	√	√	√	√	√	×	√
Eddie	√	√	√	√	√	√	√	√
Joshua	√	√	√	√	√	√	√	√
Baldwin	√	√	√	√	√	√	×	√
Kiiko	√	√	√	√	√	√	×	√
Yari	√	√	√	√	√	√	×	√
Wingnut	√	√	√	√	√	√	×	√
Zilly	√	√	√	√	√	√	×	√
Secha	√	√	√	√	√	√	×	√
Baby Mary	√	√	√	√	√	√	×	√
Baby Jane	√	√	√	√	√	√	×	√
Baby Malinga	√	√	√	√	√	√	×	√
Baby Mandy	√	√	√	√	√	√	×	√
Jane's Baby	√	√	√	×	×	√	×	×
Baby Mckenzie	√	√	√	×	×	×	×	×
Nam-Nam	o	o	o	o	o	o	o	o
Malinga's Baby	o	o	o	o	o	o	o	o
Freedom	o	o	o	o	o	o	o	o

× = did not meet the criteria; √ = satisfied the criteria; o = not considered. Source: Author.

all the alpha females. Mounting (not copulation) was a behavior that was noticed amongst the low ranking males (Eddie, Kiiko, Joshua, and Yari). During the day, individuals spent at least 3.5% of the total observation records engaged in allogrooming. However, they engaged in play behavior for 2.5% of their time, most especially the young ones and the sub-adults. Yari had 16% of its time engaged in grooming and playing with Baby Mckenzie, Kiiko, Zilli, and Joshua. We did not observe any playing between the adult males, between the adult females, or between the adult males and female. Common playing bouts were between the

sub-adults and the young ones or between the adults and the young ones. Dedza and Malinga were the only adults that did not spend a lot of time engaged in social behavior (3% and 1%, respectively). Dedza was hardly observed in the enclosure because he was always hiding from other adult males especially after an attempted fight between him and Buddy and Juri in the tussle for hierarchy or dominance.



PHOTO ©BRIANNE, FLICKR.COM. CC BY-NC-SA 2.0 LICENSE.

There was a significant increase in the troop's social behavior as the troop spent more time together especially during the last three months of the rehabilitation period (t-test, t = 2.185, df = 27, p = 0.012).

Stereotypic Behavior

Buddy, Juri, Lucky, Archie, and Dedza spent a total of 4.35% (21 h) of their observation records engaged in stereotypic behavior. The nature of their stereotypic behavior consisted of repetitive masturbation and the licking of their sperm. Buddy and Juri spent 1.19% swinging on a substrate and branches followed by bouncing up and down on top of the substrates and brachiation. The onset of such behavior typically occurred during feeding times. The highest fighting and chasing was noticed most especially when the troop was being fed with eggs and chicken. The alpha males and females running around the whole enclosure picked up at least 40% of the eggs and pieces of chicken, but this was not considered stereotypic behavior.

Pregnant and nursing females (Mandy, Mckenzie, and Malinga) had the lowest percent of stereotypic behavior of all the rehabilitated individuals. The most observed stereotypic behavior observed from these females was teeth scraping. However, it was a common phenomenon displayed by all the individuals especially during feeding and mostly by low ranking individuals when approached by a dominant member of the troop. Another common stereotypic behavior noticed was "leg presenting" to humans.

Human-directed Behavior

Out of a total of 86,400 observation behaviors in 5,184 h for 18 months, most of the individuals did not exhibit any human-directed behavior, affiliative or aggressive. Buddy (alpha male) had two instances of human-directed behavior and it was an open mouth threat directed at me when we passed through the screened fence to check why there was current failure in the pre-release enclosure. Each time an individual passed through the screened fence to go around the release fence, the alpha male would descend the trees and closely followed with snatching teeth, body fur raised up, and turning the head at all corners.

It was a common phenomenon that all the individuals grunted (vocalized) at any human spotted at a distance around the enclosure. They would climb up the trees, vocalize and scan for any other human presence in the area, particularly with strange or new faces.

Maintenance of Proximity

Being a group of 31 individuals, the group spent the majority of the observation records (83.49%) at a distance of between 1 m and 5 m (at least 1 m apart but rarely spent time more than 5 m away from our focal individuals). However, the percent of observation records these individuals spent in actual contact was relatively low (11.97%). They also rarely were more than 5 m away from each other (4.54%) when we focused on our focal individuals, but yet there were instances of some individuals being more than 20 m apart from the central core. This was mostly displayed by Richard (4.69% of its total observation records).

Jane, Lucky, Dedza, Magda, and Richard spent more than 10% of their time actually in contact with some members of the troop. Jane was the highest individual (with 19.5% of its total observation time being in direct contact with other individuals, sitting next to or touching each other) while Malinga and Joshua had the lowest (<2%) time spent in actual contact.

Malinga and Baby Mandy were the only individuals recorded as not maintaining any measures of proximity above 5 min. Others such as Joshua, Baldwin, Wingnut, Baby Mary, Baby Jane, Juri, Archie, Mary, Jane, Mckenzie, and Magda usually spent a negligible time of observation (<1%) at a distance more than 5 m, thus they were within relatively close proximity of between 1 m and 5 m to one another.

Location in the Enclosure

The results show that the troop would occasionally forage for food at the lower levels (1-3 m) of the canopy (18.51%), as well as come down to the floor of the enclosure (4.33%), but would rarely spend more than five minutes there. The troop spent most of the observation records at a level greater than 3 m above the ground (77.16%). Some of the individuals would often come down to the lower levels of the enclosure not only to forage on tubers, grasses, seeds, and insects but also to play and sit on the floor of the enclosure. A majority of their time was spent between the mid- and upper-levels (<3 m) of the enclosure (82.90%).

In comparison, most of the individuals came to the floor during feeding time, to drink, play, and forage when a food particle was spotted on the ground and thus would spend a minimal time on the floor. During foraging, an individual that spotted any food stuff would run down, pick it up, and rush back to the upper- or mid-level to munch.

Locomotion Modes

Out of the 28 individuals rehabilitated, 26 of these individuals spent more than 54% of their observation records brachiating with the exception of Lucky and Secha whose primary mode of locomotion was climbing (67% and 50%, respectively). During playing, most of them would hop up and down on the branches but this was not considered as brachiation but as jumping. Out of all the individuals, none had more than 10% of walking bipedally. The lowest was Buddy (1%) because its primary mode of travel around the enclosures was brachiation (94%).

Discussion

The objective of this study was to examine whether rescued and rehabilitated yellow baboons housed in a release enclosure at the Lilongwe Wildlife Centre have developed the appropriate behavioral repertoire necessary to be reintroduced and survive in the wild. Results are interpreted based on other comparative studies of behavioral and ecological characteristics of wild yellow baboons. We first discuss the general behavioral patterns observed, and we further discuss and interpret my observations with particular regards to social behavior, stereotypic and human-directed behaviors, maintenance of proximity, location in enclosure, and locomotion, in more detail. We also debate how these captive yellow baboons responded during the predator awareness training. Furthermore, we provide a discussion as to how the rescued and rehabilitated yellow baboons behave compared to the criteria recommended.

Behavioral Patterns

All the yellow baboons in this study spent a small amount of the observation recorded resting (average 22.76%) on a safe place. Most of the individuals were observed resting at positions higher than 5 m (upper level of the enclosure) which was in accord to the criteria developed as recommendations for suitability in the wild, and no individual was found resting in a position easily reached by predators. The low percentage of time resting (13.11%) for wild yellow baboons seems more appropriate considering they spend more time foraging/feeding and locomoting. A relatively high percentage of time spent resting by captive yellow baboons is likely unavoidable considering the fact that these captive yellow baboons are confined to their enclosures and have one-third of their food provided for them. When wild yellow baboons are not traveling through the forest, they tend to spend the majority of their time resting and feeding (pers. obs.). In fact, the majority of time (42.77%) observed for the captive yellow baboons was during foraging and feeding which is similar to the wild yellow baboons observed in Kasungu National Park (48.98%). This enclosure allows the baboons the opportunity to engage in forms of enrichment and stimulation from the natural environment by foraging for leaves, fruits, seeds, tubers, and small animals such as insects. The difference in percentage of their observed time feeding/foraging between the rehabilitated and wild troops again is most likely due to the fact that one-third of their food was provided for them and they did not have to search for it. The issue of being confined to an enclosure would explain the difference in percentages for the two groups. But all the individuals were observed using appropriate foraging behavior and showed proper feeding techniques. However, it should be noted that the yellow baboons spent 10.47% of their observed time traveling or engaged in particular modes of locomotion at different heights. This aspect was dispensed with on a satisfactory note as most of the movement was through brachiation which avoided going to the ground before climbing the next tree, thus limiting their encounter with predators.

The average percent of observation records that the yellow baboons spent vocalizing was 9.05%. This is considerably lower than wild troops that spent approximately 13.3% of the observed time vocalizing; both male and female yellow baboons will attempt to defend their territories by engaging in physical displays and vocalizing. Therefore, the wild troops' higher rate of vocalizing could be due to their engagement in vocal territorial disputes on a regular basis while the rehabilitating troops are in enclosures that are hidden among trees and not entirely visible to one another but are still relatively close to each other. It is possible that the rehabilitating troop could not vocalize in the same social context as wild yellow baboons (not needing to physically defend their territories from each other). Most of the vocalization was a result of other wildlife that came near their enclosure and some human influences such as workers at the Centre. Meanwhile, wild troops would often begin vocalizing upon hearing other wild yellow baboons in the park vocalize.

Social Behavior

Yellow baboons have traditionally been believed to engage in very high affiliative social behavior in comparison to other primates like gibbons.[24] After an extensive review of field studies on yellow baboons' behavior and ecology, Altmann[23] concluded that, "Yellow baboons spend surprisingly a lot of time socializing with one another. Mating takes up about four percent of the activity period, grooming and social play usually more (20.3 percent), thus a total of 24.3 percent. Only the lack of social partners may contribute to any low levels of interaction." The rates of social behavior observed in yellow baboons are dependent on the number of available social partners and, because yellow baboons live in larger family units, this could explain why there are higher rates of social behavior observed in the wild (pers. obs). Juveniles and sub-adults are primarily responsible for the majority of social behavior observed in wild troops and for initiating social behavior with the adult. This social behavior linked to juveniles and sub-adults is similar to what was observed in gibbons by Bartlett.[25]

In a similar study carried out by Cheney et al.,[8] she included juveniles and sub-adults in her study, which was potentially the reason why the gibbons at Kalaweit had a relatively higher average of time spent in social behavior (8%) while gibbons are known to have very low activity time in social behavior,[24] where wild Javan gibbons at had an average of 6.7% observed time spent in social behavior. Regardless, the display of grooming, playing, and copulation suggest a well bonded pair. Playing and grooming were the two most commonly observed behaviors. It was interesting to observe how the whole troop engaged in more social behavior (play, grooming, and copulation). They also spent more time in close proximity and hundreds of instances of copulation were observed. Close-proximity (within one meter), or "sitting together," without allogrooming or copulating, was considered to be one of the primary social interactions of adult yellow baboons (pers. obs.). The increase in social behavior may have been due to the fact that there were not any other baboons in the area and there was far less of a human presence around the rehabilitating enclosure. Their overall behavioral profile would seem to indicate a cohesive pair-bond, which will be beneficial for their survival in the wild. Wild yellow baboons will not necessarily feed, forage, or even sleep in the same tree, but for this study measuring how much time they spend in close proximity was useful for learning more about the nature of the pair-bond in captivity. For example, it was observed with the other troop of yellow baboons at the Centre (not included in this study) that they would not even sit on the same side of the enclosure as one another. The males would chase any adult male that came close to any resource, while the females would move around the enclosure more, engage in a physical display consisting of vigorously brachiating around the enclosure and shaking substrates or the fence. The nature of this behavior is not indicative of a cohesive pair-bond. Considering the point that these captive yellow baboons did not meet the percent of total activity time engaged in social behavior by wild troops, they do show slightly similar results to other wild troops (~2-3%) in terms of social behavior.[23] This study does not find that the behavioral criteria of positive pair association as displayed by wild troops necessarily corresponds to pair-bond cohesiveness for the captive yellow baboons.

Stereotypic Behavior

The observed troop of captive yellow baboons did exhibit mild forms of stereotypic behavior. Most commonly observed was masturbation by the males and licking of their sperm, repetitive bouncing on a fixed substrate, repetitive brachiation, and, less frequently, teeth scraping. The baboons would most often engage in repetitive swinging or brachiation around feeding times and mostly the females exhibited a mild form of teeth scraping, usually upon my arrival for observations. The stereotypic behavior of masturbation and licking of sperm displayed by the males of this captive yellow baboon has never been reported in the wild. This would seem to suggest that stereotypic behavior could be caused by captivity, or at least exacerbated by captivity. We believed that the aspect of masturbation is a welfare effect due to lack of sufficient females in the troop for enough and constant copulation to be carried out. Some researchers believe that stereotypic behavior is a means of coping with a present or past aversive situation.[26,27] Stereotypic behaviors become ingrained in the behavioral repertoire of the animal and are probably the result of poor rearing conditions from when they were kept as pets, or can develop in any captive animal as the result of a stressful environment.[26] The most dangerous form of stereotypic behavior was that of "leg presenting" to humans done by two individuals (Hastings and Yari) which, if done in the wild, would allow them to be easily trapped by poachers. Considering the fact that each yellow baboon included in this study exhibited a relatively low level of harmless stereotypic behavior, it is unlikely these behaviors would persist once they are released or hinder their survival in any way and should not prevent an individual from being reintroduced.

Human-directed Behavior

Human-directed behavior was relatively uncommon in the all the individuals included in our study, except for a few. It was more common for Buddy (the alpha male) to exhibit human-directed behavior than any other individual. Buddy had two instances of human-directed behavior while the rest rarely exhibited any human-directed behavior. As part of the criteria for deeming a pair suitable for release, we expected to observe very little human-directed behavior from the yellow baboons. It could prove detrimental to the survivability of any individual if it was still domesticated and sought human attention once released into the forest. All of the yellow baboons did not solicit grooming or petting. Hastings and Yari, on the other hand, had a comparatively high rate of human-directed behavior (Hastings: 9 instances/86,400 behavioral records; Yari: 34 instances/86,400 behavioral records) by running towards any human who passed through the screened fence into the released enclosure and presented their legs, a behavior never observed with wild troop. This particular behavior could be explained by the type of individual who kept these two individuals as pets and the environment in which they were kept, and thus could be some sort of a human habituated behavior. This behavior has not been documented in the literature. In addition, if someone approached their enclosure, Buddy would typically present a posterior display or behave in a display-like manner by brachiating around the top of the enclosure, bouncing, and shaking the substrates. We believe that the posterior display is a signal to conspecifics and could be a result of fear, or anger followed by aggression. The "anger followed by aggression" behavior was the most common observed response from Buddy. While it was clear that humans were the focus of this behavior, we never had the opportunity to observe if yellow baboons would also display this behavior to conspecifics. The most directed conspecific anger or aggressive behavior was chasing and fighting. One explanation for the aggressive behavior is that the yellow baboons are treating humans as potential threats, specifically when the behavior is directed at the same-sex human.

Altmann[23] states that aggressive or territorial behavior in wild yellow baboons is almost always intrasexual: males displace males and females displace females. The posterior display, in addition to other forms of human-directed behavior, is most likely a construct of captivity and of being in continuous close proximity to humans. The levels at which yellow baboons in captivity, who are also candidates for release, engage in forms of aggressive human-directed behavior should be monitored more closely and can potentially provide some insight in to how the yellow baboons will respond to humans once they are released (see discussion on post-release behavioral observation with regards to human-directed behavior). Primates that were former pets (human-raised) can sometimes be aggressive towards humans upon reaching sexual maturity and tend to direct this aggression at the same-sex individual.

Location in Enclosure

Yellow baboons are canopy occupants and professional at feeding from the terminal branches and seeds of the tall trees. They make use of their home range three-dimensionally in space, as they exploit the canopy upwards and downwards to about 8 m above the ground. Wild yellow baboons rarely come to the ground due to higher risk of predation, though captive-raised individuals are very comfortable spending time on the ground and will walk on the ground bipedally. Yellow baboons from the illegal pet trade were removed from the wild as infants or young adults and most likely never had the opportunity to learn valuable predator avoidance behaviors from their parents. Furthermore, they probably were kept in small cages relatively low to the ground, if not actually on the ground, hence never being able to spend time at a higher level. This explains why, during the rehabilitation process, an area full of tall trees with many branches was selected to mimic their natural environment where they would be released in Kasungu National Park.

After these individuals were introduced into their enclosure, they all spent the whole day in the trees and immediately developed the innate habits of spending most of their time on the canopy and not the ground as was the case while they were in their previous enclosures. They only came down to the floor of their enclosures to retrieve fallen food or forage, but rarely will spend more than a few minutes there, typically grabbing the food and then quickly climbing back up to the higher level of the enclosure. This behavior would seem to indicate an innate desire for the yellow baboons to remain within a higher level of space. However, some of the individuals would often sit on the floor of the enclosure to drink. Resting and playing was only done in a clear area where their vision is at least 180 degrees. This is because we never observed any individual resting, sitting, or playing in tall grass. Juveniles also appeared to be quite comfortable spending time in the lower levels of the enclosure; they are seen climbing/swinging on branches at lower levels. If captive yellow baboons are to avoid predators and parasites once they are released, they must be encouraged to spend time at the higher levels of their enclosures and must demonstrate a preferred use of the top of the enclosure. All of the individuals rehabilitated in this study met a satisfactory result (in percent of time spent at the upper level of their enclosure) to survive in the wild.



PHOTO © GEOFF GALICE ON FLICKR.COM. CC BY 2.0 LICENSE.

Yellow baboons among a herd of impalas *(Aepyceros melampus).*

Locomotion

While studying wild troops of yellow baboons, we observed that they cover approximately 60-68% of their territory by brachiation. Therefore, for a rehabilitation program, yellow baboons should be utilizing brachiation as their main mode of locomotion. Yellow baboons in captivity often do not have the space in their enclosures to brachiate for long distances, which may also explain why some individuals engage in stereotypic forms of repetitive brachiation. However, in order for rehabilitated yellow baboons to be suitable for release, they must demonstrate they are capable of effectively traveling around their enclosure while utilizing natural locomotive movements as are observed in wild troops.

The captive yellow baboons being rehabilitated are somewhat restricted with the size limitation of their enclosures, but are still capable of acquiring the appropriate forms of locomotion and utilizing them within their enclosure. All individuals in this study demonstrated their ability to effectively locomote, and utilized brachiation as their primary mode of locomotion with the exception of Lucky and Secha whose primary mode of locomotion was climbing (67% and 50%, respectively). With regards to walking bipedally, none had above 10%. Buddy had a high level mode of stereotypic brachiation, thus why his primary mode of locomotion was 94% of brachiation, though at times it was difficult to ascertain between simply traveling around the enclosure and when

it became "stereotypic." Therefore, there could be a discrepancy in the data between the levels of stereotypic behavior and brachiation displayed by Buddy. However, what is important is that they are capable of effectively brachiating and, if they are going to be released into the wild, they would be able to successfully traverse through the canopy.

Evaluation of Behavioral Criteria

Based on the research we conducted with wild troops of yellow baboons during a habitat assessment to determine its quality as a suitable release site for yellow baboons, we collected data on some non-habituated wild troops of yellow baboons and then developed a "Behavioral Checklist" for yellow baboons in our rehabilitation program (Table 1). We highlighted important behavioral aspects of wild yellow baboons that a rehabilitated troop of yellow baboons should master before they are released. We then evaluated the rehabilitating group of yellow baboons based on these criteria to determine which individuals met these criteria to be suitable for reintroduction.

The first recommendation is that the yellow baboons should be able to move around their enclosure efficiently and should be utilizing brachiation as their primary mode of travel, then climbing as the second option, and the least option to employ should be moving bipedally. Bipedal movement should only be employed when drinking or foraging/feeding because yellow baboons spend a great deal of time on the ground when foraging/feeding, moving in grassland areas because of no trees in which to brachiate. All of the yellow baboons in this study, except a few, satisfied this requirement. Considering it is crucial that yellow baboons in the wild are able to effectively traverse through the forest using brachiation as their main form of travel, we would say this is a necessary criterion that yellow baboons in the rehabilitation program should meet if they are to be considered for release. It is suggested that yellow baboons should spend no more than 8% of their time on the ground level of their enclosure, and they should be at the upper level of their enclosure at least 35% of the time. All of the yellow baboons in this study met this requirement.

Once released, if the yellow baboons are to avoid risk of predation and survive in the wild, they must remain in the upper level of the canopy especially during rest or sleep. Former pet yellow baboons may be very comfortable spending time on the ground and if this behavior is present during the rehabilitation program, it must be eliminated prior to release. This requirement is a necessary part of the rehabilitation procedure. According to data collected on wild troops of yellow baboons, we recommend that a troop of yellow baboons should be spending at least 15% of their time engaged in positive pair association (that groom, play, copulate), with at least 5% of total activity time spent allogrooming. Most of the individuals in this study satisfied these criteria with the exception of few that were often seen isolated from the group. However, the criteria as proposed acknowledge that one of the primary forms of social interaction for adult yellow baboons is "sitting together" within close proximity (within 1 m), thus it is included as a positive association behavior. All individuals in this study met the suggested requirement of observation records in close proximity. We would suggest that including the maintenance of close proximity in a positive association behavior category as part of the necessary criteria for rehabilitation programs is a factor that determines the cohesiveness existing with the group.

The guidelines also state that the individuals should be copulating successfully and each individual should be able to initiate copulation with the other. All the adult males and females were at one time observed initiating or displaying copulation. However, this was not taken into consideration when it came to the juveniles and some sub-adults, but we took keen interest to see if all individuals would at least display behavior of copulation. When it came to the juveniles, any behavior of attempted mounting both for females and males was considered as copulation but with reference to their ages. The breeding individuals were observed copulating all the times especially during the breeding season. This at times led to a lot of fighting amongst the males and females. It is necessary that yellow baboons in a rehabilitation program are observed copulating, via human observation or video camera, prior to their release, so that they do contribute to the wild population.

In general, the yellow baboons in this study showed similar models of behavior with regards to the activity budgets of wild troops of yellow baboons. The ways in which they differ were most likely due to the captive environment. For example, the rehabilitating troop in this study spent more time resting and less time feeding/foraging than their wild counterparts; this is likely because wild troops do have to spend more time traveling to locate food sources while the rehabilitating troop was provided with some food during the process. We expected a higher percent of resting in captive yellow baboons because they do not have the space to travel farther distances and they have their food provisioned. In an ideal manner, yellow baboons in a rehabilitation program should exhibit similar behavioral patterns to their wild conspecifics, while at the same point in time we must concede the limitations placed on them as a result of a captive environment.

The guidelines state that yellow baboons in a rehabilitation program should not be exhibiting severe stereotypic behavior (rocking or self-harm). Considering the nature of the stereotypic behavior displayed by the yellow baboons in this study, we think it was not severe; we considered all individuals to have satisfied this criterion. The primary stereotypic behavior observed was repetitive brachiation or swinging on a substrate, and it is unlikely that when the individuals are released these behaviors will continue; these behaviors are the result of a captive atmosphere. However, stereotypic behavior should be monitored during the rehabilitation program and, depending on the nature of the behavior, the decision to deem an individual suitable for release can be assessed based on the severity of the behavior. We recommend that if a troop member exhibits severe stereotypic behavior, it should not be released into the wild. Perhaps the individual would be more beneficial remaining at the Centre and could be used for a captive breeding program, and then any future offspring may be released

into the wild.

The rehabilitating troop in their pre-release enclosure had fruit, tubers, seeds, roots, insects, and foliage, and they were also provisioned with some that were collected from the forest in the areas of Kasungu and incorporated into their diet. This was done so that the yellow baboons would be accustomed to eating a more natural diet. It is important that any yellow baboon who is a candidate for reintroduction must show a preference for wild fruit and foliage before they are released. They must enjoy eating these sources of food and become familiar with them visually, so that when they are living in the wild, they are able to identify them in the canopy.

Another aspect is that any individual to be released must be in good health and physically strong to avoid the risk and susceptibility of zoonotic infections. After all the individuals were evaluated from rehabilitation, the last determining factor was their good health and physical appearance which is what disfavored some individuals despite the fulfillment of most rehabilitation criteria. Any individual that was diagnosed was not selected for fear of a potential spread of diseases to other wildlife and those that were not physically strong were not released because they could be easily be preyed upon by predators because of their poor ability to run or rest in safe places.

Overall, the behavioral checklist is an effective tool for determining the preparedness of a pair of individuals prior to reintroduction, but based on my data it could be amended. The rehabilitation and reintroduction of yellow baboons is a relatively new conservation strategy and there are very little or no data published on the successful reintroduction of yellow baboons back into the wild.

Conclusion

With most primate species currently listed as Endangered or Critically Endangered,[5] the future of all primates remains uncertain, even that of yellow baboons not yet seen as endangered. But with the current trends of poaching, it would be no exception in the next seven years because it is now the target of most poachers who cannot locate primates such as chimpanzees, gibbons, gorillas, and bonobos for bushmeat. The rehabilitation and reintroduction of former pets and most especially primates may play a significant role in the preservation of many of these threatened species. However, it is crucial that the rehabilitation procedure is fully documented. This is the only way to establish a well-formed rehabilitation/ reintroduction program that adheres to methodical guidelines and principles of rehabilitating yellow baboons and other primates.

Acknowledgments

We would like to thank the following for making this research a success: the Malawian Department of National Park and Wildlife for their help, the people of Kasungu for their hospitality, the Rangers of Kasungu National Park for collaboration; funding organizations: the Born Free Foundation (BFF); Stichting AAP, the Tusk Trust; the United Nations Development Programme-Global Environment Fund (UNDP-GEF); Gesellschaft Fur Internationale (GIZ); the International Primate Protection League (IPPL); and the International Primate Society (IPS). We would like to thank all the staff of Lilongwe Wildlife Centre, especially the caretakers, and our families for their relentless efforts and for supporting our absence during this study period. Most importantly, all great and honor goes to the Almighty God for supplying our needs according to his riches in Heaven.

About the Authors

[1]University of Dschang, Department of Animal Biology, Cameroon
[2]University of Dschang, Department of Forestry, Cameroon.
[3]Lilongwe Wildlife Centre, Malawi.

Literature Cited

1. Kleiman DG. Reintroduction of captive mammals for conservation. *Bioscience.* 1989;39:152-161.
2. Komdeur J, Deerenberg C. The importance of social behavior studies for conservation, *In*: J. R. Clemmons & R. Buchholz (Eds.), Behavioral approaches to conservation in the wild. Cambridge, England: Cambridge University Press. pp. 262-276.1997.
3. Cheyne SM. Wildlife reintroductions: Consideration of habitat quality at the release site. *BMC Ecology.* 2006;6:1-8
4. Cheyne SM, Chivers DJ, Sugardjito J. Biology and behavior of reintroduced gibbons. *Biodiversity Conservation.* 2008;17:1741-1751.
5. International Union for Conservation of Nature and Natural Resources (IUCN). 2010.
6. Cowlishaw G, Dunbar R. Primate conservation biology. University of Chicago Press, Chicago. 2000.
7. Nijman V, Yang Martinez CF, Shepherd CR. Saved from trade: donated and confiscated gibbons in zoos and rescue centres in Indonesia. *Endangered Species Research.* 2009;9:151-157.
8. Cheney DL, Seyfarth RM, Fischer J, Beehner J, Bergman T, et al. Factors affecting reproduction and mortality among baboons in the Okavango Delta, Botswana. *International Journal of Primatology.* 2004;25(2):401-428.
9. Nijman V, Van Balen S. A faunal survey of the Dieng Mountains, Central Java, Indonesia: Distribution and conservation of endemic species. *Oryx.* 1998;32:145-156.
10. Mootnick AR, Nadler RD. Sexual behaviour of maternally separated gibbons (*Hylobates*). *Developmental Psychobiology.* 1997;31:149–161.
11. Clemmons JR, Buchholz R. Linking conservation and behavior. *In*: J.R. Clemmons & R. Buchholz (Eds.), Behavioral approaches to conservation in the wild. Cambridge, England: Cambridge University Press. pp. 3-22. 1997.
12. Grooves CP. Primate taxonomy. Washington, DC: Smithsonian Press. 2001.
13. Sarrazin F, Barbault R. Reintroduction: challenges and lessons for basic ecology. *Trends in Ecology & Evolution.* 1996;11(11): 474-477.

14. Ewen JG, Armstrong DP. Strategic monitoring of reintroductions in ecological restoration programmes. *Ecoscience.* 2007;14(4):401-409.
15. Moinde NN, Suleman MA, Higashi H, Hau J. Habituation, capture and relocation of Sykes monkeys (*Cercopithecus mitis albotorquatus*) on the coast of Kenya. *Animal Welfare.* 2004;13(3):343-353.
16. Farmer KH, Buchanan-Smith HM, Jamart A. Behavioral adaptation of *Pan troglodytes troglodytes*. *International Journal of Primatology.* 2006;27(3):747–765.
17. Farmer KH, Courage A. Sanctuaries and reintroduction: a role in gorilla conservation? *In*: Stoinski, TS, Steklis, HD, & Mehlman, PT (eds). Conservation in the 21st Century: Gorillas as a Case Study. Springer. pp.79-106. 2008.
18. Soorae PS, Baker LR (eds.). Re-introduction NEWS: Special Primate Issue, Newsletter of the IUCN/SSC Re-introduction Specialist Group, Abu Dhabi, UAE. No. 21:60. 2002.
19. Kleiman DG, Stanley-Price MR, Beck BB. Criteria for reintroductions. *In*: Creative Conservation: Interactive Management of Wild and Captive Animals. Olney, PJ S, Mace, GM and Feister, ATC (eds). Chapman and Hall. pp. 288-303. 1994.
20. Armstrong DP, Seddon PJ. Directions in reintroduction biology. *Trends in Ecology & Evolution.* 2007;23(1):20-25.
21. International Union for Conservation of Nature and Natural Resources (IUCN). Reintroduction specialist group. Guidelines for nonhuman primate re-introductions. *Reintroduction News.* 2002;21:29-57.
22. Chivers DJ. Guidelines for re-introductions: Procedures and problems. *In*: Beyond Captive Breeding: Re-introducing endangered mammals to the wild. Gipps, J.H.W., (ed.) Oxford: Clarendon Press. pp. 89-99. 1991.
23. Altmann, SA. Baboon, space, time and energy. *American Zoology.* 1974;14:221-48.
24. Smith (2011).
25. Bartlett TQ. Intragroup and intergroup social interactions in white-handed gibbons. *International Journal of Primatology.* 2003;24:239-259.
26. Mason GJ. Stereotypes: A critical review. *Animal Behavior.* 1991;41:1015-1037.
27. Mason WA, Berkson G. Effects of maternal mobility on the development of rocking and other behaviors in rhesus monkeys: a study with artificial mothers. *Developmental Psychobiology.* 1975;8:197-211.

Hand-rearing, release, and survival of African penguin chicks abandoned before independence by molting parents

Richard B. Sherley,[1,2]* Lauren J. Waller,[1,3] Venessa Strauss,[4] Deon Geldenhuys,[3] Les G. Underhill,[1] and Nola J. Parsons[4]



PHOTO © JOSH MORE, FLICKR.COM. CC BY-NC-ND 2.0 LICENSE.

ABSTRACT: The African penguin *Spheniscus demersus* has an "Endangered" conservation status and a decreasing population. Following abandonment, 841 African penguin chicks in 2006 and 481 in 2007 were admitted to SANCCOB (Southern African Foundation for the Conservation of Coastal Birds) for hand-rearing from colonies in the Western Cape, South Africa, after large numbers of breeding adults commenced molt with chicks still in the nest. Of those admitted, 91% and 73% respectively were released into the wild. There were veterinary concerns about avian malaria, airsacculitis and pneumonia, feather-loss and pododermatitis (bumblefoot). Post-release juvenile (0.32, s.e. = 0.08) and adult (0.76, s.e. = 0.10) survival rates were similar to African penguin chicks reared after oil spills and to recent survival rates recorded for naturally-reared birds. By December 2012, 12 birds had bred, six at their colony of origin, and the apparent recruitment rate was 0.11 (s.e. = 0.03). Hand-rearing of abandoned penguin chicks is recommended as a conservation tool to limit mortality and to bolster the population at specific colonies. The feasibility of conservation translocations for the creation of new colonies for this species using hand-reared chicks warrants investigation. Any such program would be predicated on adequate disease surveillance programs established to minimize the risk of disease introduction to wild birds.

KEY WORDS: African penguin, endangered, captive care, release, survival

CORRESPONDING AUTHOR
Dr. Richard Sherley
Environment and Sustainability Institute
University of Exeter
Penryn Campus
Penryn, Cornwall TR10 9FE United Kingdom
Email: richard.sherley@gmail.com

Introduction

The conservation status of the world's seabirds is poor with c. 47% of species showing population declines and c. 28% occupying positions in the IUCN Red List's threatened categories.[1] In many cases, species face numerous threats, not all of which are well understood in form or function. This highlights the need for further research to improve seabird conservation,[2] but also the importance of management actions that can reduce mortality and sustain populations in the short-term.[1]

The African penguin *Spheniscus demersus* is "Endangered" following a decrease in the

Reprint: Sherley, et al. *PLoS ONE* 9(10): e110794. doi:10.1371/journal.pone.0110794

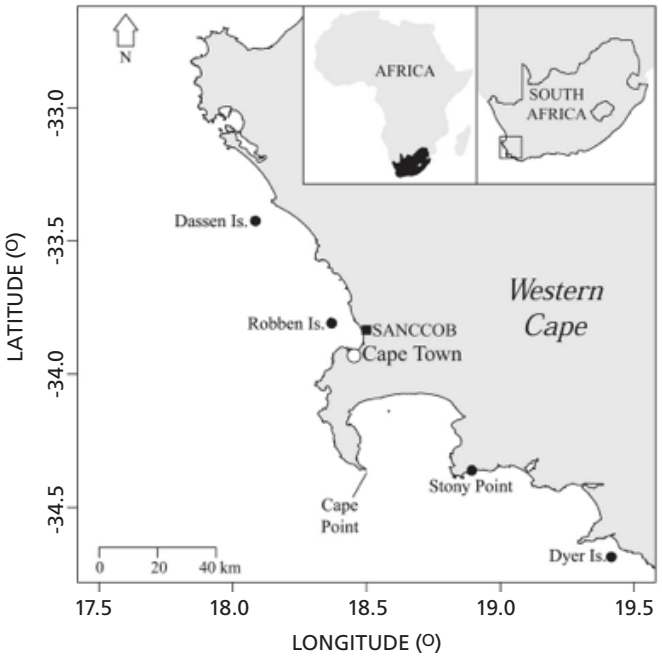


FIGURE 1. Map of the Western Cape, South Africa, showing the locations of the main African penguin breeding colonies (black circles) mentioned in the text and the location of SANCCOB (black square) in relation to Cape Town (white circle).
DOI:10.1371/JOURNAL.PONE.0110794.G001

global population of >70% between 2001 and 2013.[3,4] Decreases in the Western Cape of South Africa (Fig. 1) conform to an altered distribution of their main prey species, sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus*.[3,5] Adult survival, juvenile survival, and breeding productivity of African penguins have been influenced by the availability these two forage fish species[3,6–9] and competition with the local purse-seine fishery has been noted.[3,10] In addition, growth rates and body condition of chicks at Robben Island decreased between 2004 and 2009,[11-13] while fledging periods increased concurrently in apparent response to a decline in the availability of sardine.[8] Spatial management of the fishery has been recommended[3,8–10] and the potential benefits of alternative approaches are being investigated.[10,14]

Concurrently, conservation efforts are focused on strategies to increase breeding success, such as providing artificial nests,[15] and to reduce mortality at breeding colonies, for example by rehabilitating oiled and injured adults[16] and their chicks abandoned as a result.[16,17] Chicks hand-reared after catastrophic oil spills had survival and recruitment rates analogous to naturally-reared cohorts[17,18] and reproduced successfully once they entered the breeding population.[17] On that basis, a number of African penguin chicks are hand-reared each year at the Southern African Foundation for the Conservation of Coastal Birds (SANCCOB), Cape Town. These chicks may be removed from the wild during the breeding season because they have been orphaned or abandoned by their parents following flooding of their nest site, building operations or the parents being removed for rehabilitation after being oiled.[16] In addition, at the end of the breeding season, some adults may enter molt with chicks still present in the nest.[16] African penguins usually make short foraging trips (<24 hours[10]) and leave their chicks unattended when feeding conditions are poor (the post-guard phase [19]). However, molting penguins are without adequate waterproofing and must fast for c. 21 days;[20] unfledged chicks would thus starve in the nest.[21] Here, we use the term "abandoned" to indicate situations where chicks are no longer being provisioned prior to independence, rather than temporary abandonment that occurs naturally in penguins during the post-guard phase.[22]

From 2001 to 2005, small numbers (24–99) of abandoned African penguin chicks were retrieved annually from Robben and Dyer Islands and sent to SANCCOB for hand-rearing (Table S1). However, in 2006 and 2007, large numbers (>400) of chicks were abandoned at Dyer Island between September and December, as their parents entered molt. This paper is a case study of the interventions made in 2006 and 2007 to hand-rear these chicks and considers the conservation merit of rearing penguin chicks abandoned prematurely by molting parents.

Methods

In the Western Cape, penguins breed from February to September[23] and predominately molt between September and January, once chicks have fledged.[24] The penguin colonies at Dyer Island, Robben Island, and Stony Point (Fig. 1) were checked regularly for signs of abandoned chicks from the end of the breeding season. Abandoned chicks, identified by appearance and behavior (apparently low mass relative to structural growth, "hollow" abdomens, lethargy, peck wounds on head and neck), were removed from all three sites and sent to SANCCOB to be hand-reared.

Chick Removals from Dyer Island

At Dyer Island, most adults molt from October to December[24] and do so in in groups within the breeding colony (LJW pers. obs.). The colony was monitored for signs of abandoned chicks from September each year. In 2006, a large proportion of the breeding adults at Dyer Island commenced molt while chicks were still present in nests (Table S2). The managing authority was concerned about the impact that regular approaches into the colony to search for abandoned chicks would have on adult molters, with birds showing signs of stress at a distance of 20–30 m. It was thus decided to remove chicks en masse in both 2006 and 2007 based on four considerations: (1) one operation would minimize disturbance to molting adults; (2) the timing of molt is highly synchronized at Dyer Island,[12] so the remaining chicks would likely be abandoned when parents ultimately commenced molt; (3) hand-reared chicks could potentially boost the breeding population in three to five years' time, depending on juvenile survival and recruitment processes;[25,26] (4) the poorer the condition of a chick when it reached the rehabilitation center, the smaller the chances for successful rearing and release.

At Dyer Island, penguins form small, localized sub-colonies. Sub-colonies were slowly surrounded by 4 to 5 people to prevent adult birds, especially molters, from moving off, while one person captured the chicks by hand. The chicks were sorted by size into

indoor holding pens and gavaged 60 ml electrolyte solution after capture and again before removal to the mainland if kept overnight. The chicks were transported in aerated boxes by boat to the mainland (c. 0.5 hour) and then to SANCCOB by truck (c. 3 hours). In 2006, chicks were removed in large groups and were generally transported to SANCCOB the day after being removed from their nests. In 2007, daily capture numbers were smaller and chicks were transported to SANCCOB on the capture date.

Chick Removals from Robben Island and Stony Point

At Robben Island, the colony was monitored from the end of October, and at Stony Point the colony was monitored in November and December. Abandoned chicks were captured from nests by hand on an individual basis or in small groups. There were placed in aerated boxes and transported to SANCCOB the same day by truck (c. 2 hours) from Stony Point and by ferry (c. 0.5 hour) and truck (c. 0.5 hour) from Robben Island.

Hand-rearing Procedures

On arrival at SANCCOB, chicks were grouped into stages of development based on their weight and the level of down present[11,27] (Appendix S1), and their condition was estimated by "habitus," scored from 1–4 (weak to strong; Appendix S1).[16]

Chicks were reared following guidelines based on Turner and Plutchak.[28] Chicks were given formula (liquidized fish and vitamin mixture), fluids, and whole fish. Veterinary treatment requirements, changes in mass, and waterproofing of feathers were evaluated on a weekly basis.[16] Blood samples (hematocrit, total serum protein, and blood smears) to evaluate blood parasites, anemia, and systemic inflammatory response were taken weekly or fortnightly. Both flies and mosquitoes were abundant during the chick-rearing period; the netting surrounding the center at the time was inadequate to exclude insects. Insecticides were used in the pens and applied locally to the birds' heads to help prevent flies and mosquitoes. Various fly traps and fly control products were also employed.

On live birds, conditions such as airsacculitis and pneumonia, avian pox, bumblefoot, and feather-loss disorder were diagnosed based on clinical symptoms and lesions only. On birds that died, avian malaria was diagnosed on macroscopic pathology lesions together with positive blood and/or kidney impression smears.[29] Most other diagnoses were determined from macroscopic pathology lesions only. Fungal airsacculitis and pneumonia was differentiated from bacterial cases on the presence of fungal plaques and mats and was not specifically identified to species level. When a bird died, the carcass was refrigerated immediately and post-mortem examination conducted on c. 85% of cases within four days. Histopathology and other tests were not routinely performed, except in cases where the cause of death could not otherwise be determined.

Release and Resighting Data

Juvenile penguins that met the criteria outlined by Parsons and Underhill[16] were released ashore at Dyer or Robben Islands or else at sea near to Robben Island. Movement of juvenile penguins is extensive[30] and breeding at non-natal colonies occurs.[6,26] It was thus not deemed vital to return chicks to their natal site. Of those released, 511 were marked with flipper bands from the 2006 cohort and 190 from the 2007 cohort (Table S3).

As part of routine monitoring carried out at African penguin colonies, searches were made for banded individuals and band numbers from throughout the species range (Namibia and South Africa) were reported to a central database (see Sherley[6]). The records from this database covering the period 1 January 2007 to 31 December 2012 were searched for resightings.

Ethics Statement

Capture, transportation, rearing, diagnostic screening, care, and release of the birds were carried out by SANCCOB on behalf of the Western Cape Nature Conservation Board (CapeNature) and the then Department of Environmental Affairs and Tourism (DEAT, now the Department of Environmental Affairs) under permits (Reference No. V1/1/5/1) issued by DEAT according to the Sea Birds and Seals Protection Act No. 46 of 1973 and the Marine Living Resources Act No. 18 of 1998. SANCCOB is a registered veterinary practice with the South African Veterinary Council (registration number FCO02/5650) and blood samples were taken by a state registered veterinarian to ensure that the birds were fit to be released and were not carrying any diseases that might be introduced to the wild population. Stainless steel flipper bands were applied under license from the South African Bird Ringing Unit (SAFRING) and according to the guidelines approved by the Banding Forum and the Animal Ethics Committee of the DEAT.[31]

Statistical Analyses

We estimated survival (φ), encounter (or resighting) (ρ), and recruitment (ψ) probabilities using multistate mark-recapture models (e.g., Lebreton[32]). We considered three states: "alive as a non-breeding individual," "alive and confirmed breeding," and "dead," and three events: "not encountered," "encountered as a non-breeding individual," and "encountered as a breeder," which were conditional on the states (see Appendix S2). We implemented our multistate models in a hidden Markov models framework[33] using program E-SURGE v1.9.0[34] and tested for goodness-of-fit using U-CARE v2.2.3, which indicated little evidence for overdispersion ($\hat{c}$ = 1.11). Parameter estimates are given 61 standard error (s.e.), with 95% confidence intervals (95% CI) computed from the Hessian matrix.

We developed a set of candidate models that assumed survival probabilities to depend on age, encounter probabilities to be either constant or to vary with time, and recruitment probabilities to depend on age (years after release), time, or be constant across time. Due to sparse resighting data, we did not attempt to estimate time-dependent survival, or to estimate separate survival parameters for the two release cohorts. For the age effects on survival, we distin-

TABLE 1. NUMBERS OF AFRICAN PENGUIN CHICKS ADMITTED TO AND RELEASED FROM SANCCOB BY COLONY IN 2006 AND 2007.

YEAR	COLONY	ADMISSIONS	RELEASES	RELEASE RATE	MEAN ± SD DURATION
2006	Robben Island	113	90	80%	35 ± 21
	Dyer Island	694	647	93%	45 ± 16
	Stony Point	34	29	85%	42 ± 18
2007	Robben Island	7	3	43%	25 ± 8
	Dyer Island	427	324	76%	48 ± 22
	Stony Point	47	24	51%	47 ± 25
TOTAL		**1322**	**1117**	**84%**	**45 ± 19**

The mean 6 standard deviation (SD) duration (in days) of stay in rehabilitation for the released birds is also shown. *doi:10.1371/journal.pone.0110794.t001*

TABLE 2. THE HABITUS OF AFRICAN PENGUIN CHICKS ADMITTED TO SANCCOB IN 2006 AND 2007.

HABITUS	2006			2007		
	ADMISSIONS	RELEASES	MEAN±SD DURATION	ADMISSIONS	RELEASES	MEAN±SD DURATION
1	29	16	58 ± 16	25	11	59 ± 11
2	140	113	53 ± 21	173	116	57 ± 25
3–4	672	637	42 ± 15	283	224	43 ± 20
TOTAL	**841**	**766**	**44 ± 17**	**481**	**351**	**48 ± 22**

Habitus is scored from 1–4, with one being weak and four being strong (Appendix S1[16]). The mean 6 standard deviation (SD) duration (in days) of stay in rehabilitation is also shown for those birds that were released. *doi:10.1371/journal.pone.0110794.t002*

TABLE 3. CAUSES OF DEATH OF ABANDONED AFRICAN PENGUIN CHICKS ADMITTED TO SANCCOB IN 2006 AND 2007.

CAUSE OF DEATH	2006			2007		
	N	DEATHS	MEAN ± SD DURATION	N	DEATHS	MEAN ± SD DURATION
Abscess on heart	1	1.3%	(28)	–	–	–
Airsacculitis and pneumonia	16	21.3%	41 ± 32	23	17.6%	41 ± 31
Fungal airsacculitis and pneumonia	5	6.6%	31 ± 15	3	2.3%	34 ± 24
Multiple organ infection	8	10.5%	33 ± 29	1	0.8%	(52)
Pododermatitis (Bumblefoot)	1	1.3%	(84)	1	0.8%	(46)
Enteritis	–	–	–	3	2.3%	59 ± 28
Blind	1	1.3%	(47)	–	–	–
Nervous symptoms	2	2.6%	48 ± 52	–	–	–
Avian malaria	27	35.5%	48 ± 26	77	59.2%	58 ± 28
Weak, emaciated chick	11	14.7%	7 ± 5	11	8.5%	10 ± 9
Tubed down trachea	2	2.6%	10 ± 6	1	0.8%	(96)
Died during transport	–	–	–	7	5.4%	47 ± 3
Undetermined	1	1.3%	(8)	3	2.3%	54 ± 34
Total	**75**		**36 ± 29**	**130**		**50 ± 30**

The mean ± standard deviation (SD) duration (in days) in rehabilitation for individuals in each cause of death category is also shown. Where only one individual died in any category, the duration of stay (days) for that individual is given in parentheses. *doi:10.1371/journal.pone.0110794.t003*

guished between juveniles (first year after release) and adults (all subsequent years, Sherley[6]). For recruitment probabilities, we modeled three age categories: 0–1 years old, 1–2 years old, and >2 years old as African penguins usually breed for the first time at 3 years of age or older.[25] Model selection was performed using the Akaike's Information Criterion adjusted for small sample size and overdispersion (QAICc, Burnham[35]).

Results

In total, 841 and 481 chicks were removed from the three colonies in 2006 and 2007, respectively (Table 1). At Dyer Island, 19 chicks were collected between 18 September and 15 October 2006, prior to the decision to remove chicks en masse. Between 16 and 21 October 2006, 668 chicks were captured at Dyer Island on three separate days and transported to SANCCOB. In 2007, the decision to remove all abandoned chicks from Dyer Island was taken on 27 October and 427 chicks were collected. An additional 201 chicks were admitted to SANCCOB from the other two colonies across the two years (Table 1).

Hand-rearing Success

The abandoned chicks were generally underweight for their age[15] and many were not yet losing their down, indicating that they were at least 20 days from fledging.[18] In 2006 and 2007, respectively, 6% and 20% of chicks from Dyer Island were small to medium downy chicks, for Stony Point the corresponding values were 6% and 2%, while none of the birds from Robben Island were small to medium downy chicks.

TABLE 4. MODEL SELECTION RESULTS FOR MARK-RECAPTURE MODELLING OF HAND-REARED AFRICAN PENGUINS RELEASED BY SANCCOB IN 2006 AND 2007.

MODEL NO.	MODEL STRUCTURE	*K*	DEVIANCE	QAICc	ΔQAICc	*w*
2	$\varphi(a)\rho(t)\psi(c)$	11	1000.05	1022.37	0	0.82
1	$\varphi(a)\rho(t)\psi(a)$	14	1025.38	1025.38	3.01	0.18
3	$\varphi(a)\rho(t)\psi(t)$	20	1034.15	1034.15	11.78	0.00
5	$\varphi(a)\rho(c)\psi(c)$	6	1066.51	1066.51	44.15	0.00
4	$\varphi(a)\rho(c)\psi(a)$	9	1069.45	1069.45	47.09	0.00
6	$\varphi(a)\rho(c)\psi(t)$	15	1078.07	1078.07	55.70	0.00

The model components were survival (φ), encounter (ρ) and recruitment (ψ), the rate of transition from a non-breeder to a breeding individual. Survival probabilities were assumed to depend on age (*a*), encounter probabilities to be either constant (*c*) or to vary with time (*t*), and recruitment probabilities to depend on age (years after release), time, or be constant across time. *K* is the number of estimated parameters in each model, QAICc is Akaike's information criterion (AIC) adjusted for overdispersion and sample size, DQAICc is the difference in QAICc between each model and the best model and *w* denotes the Akaike weights (relative support given to each model). *doi:10.1371/journal.pone.0110794.t004*

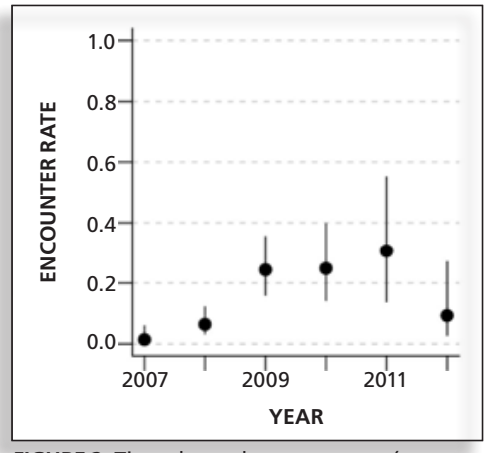


FIGURE 2. Time-dependent encounter (or re-sighting) probabilities for banded, hand-reared African penguins released by SANCCOB in 2006 and 2007. Resightings were made over the period 2007 to 2012. Encounter probabilities are based on model 2, Table 4. Error bars show the 95% confidence intervals. *doi:10.1371/journal.pone.0110794.g002*

The chicks were reared in 2006 for a mean of 44 days (range: 11–127 days) for those that were released and 36 days (range: 0–88 days) for those that died. In 2007, rearing lasted a mean of 48 days (range: 15–130 days) for those released and 50 days (0–158 days) for those that died (Table 2 and 3). In both years, chicks that died had a lower habitus on admission than those that were released (2006: $\chi^2 = 76.0$, $p<0.001$; 2007: $\chi^2 = 19.2$, $p<0.001$; Table 2).

In 2006 and 2007, 114 chicks (14%) and 112 chicks (23%), respectively, were found to be positive for avian malaria *Plasmodium* spp. (Table S4). Positive birds were treated according to a set of basic treatment protocols (Appendix S1). Those that were released took 20% longer in 2006 and 95% longer in 2007 than all chicks to reach the conditions for release. Malaria was diagnosed as the cause of death for 36% of deaths in 2006 and 59% in 2007 (Table 3).

The second main cause of death was bacterial airsacculitis and pneumonia (Table 3), which can spread from the lungs to infect other organs. No specific etiological diagnosis was made. Fungal airsacculitis and pneumonia caused 7% of deaths in 2006 and 2% in 2007 (Table 3). Birds diagnosed as "chesty" (labored breathing, crackly lung noises on auscultation and coughing) were treated with a course of systemic antibiotics (Appendix S1) and nebulized in an enclosed box with a disinfectant. Attempts were made to isolate "chesty" birds, although there was a lack of space when there were large numbers of birds in the facility. Antifungal treatment was also given if there was no response to the antibacterial treatment (Appendix S1).

One bird was euthanized due to blindness caused by avian pox (Table 3). Lesions occurred around the eyes, the ceres, the beak, inside the mouth, and occasionally on the feet of the chicks that contracted the disease.[36] The pox lesions were debrided and treated locally with antibiotic eye cream. When swelling occurred around the eyes, the penguins were also treated with systemic antibiotics and anti-inflammatories (Appendix S1). The lesions usually healed after three weeks; in severe cases, scarring caused a smaller eye opening.

In both years, a number of chicks also contracted pododermatitis (bumblefoot; Table 3). Lesions were treated with topical antibiotics and severe cases were also treated with systemic antibiotics and anti-inflammatories (Appendix S1). In 2007, bandages were applied as cushioning to provide some relief to the birds when standing. One bird was euthanized each year due to bumblefoot (Table 3). A feather-loss disorder also occurred in both years, delaying hand-rearing significantly, but did not cause any mortality. These results are discussed in detail by Kane et al.[37]

Release, Survival, and Recruitment Rates

In 2006, 766 hand-reared penguins were released (91% of admissions) and, in 2007, 351 chicks were released (73% of admissions, Table S3). Of those released with flipper bands, 92 (13%) were resighted by 31 December 2012. Twelve individuals were confirmed as breeding, all from the 2006 cohort, and 22 others were resighted at breeding age. Of the breeding birds, six were at Dyer Island, three were at Robben Island, two at Stony Point, and one at Dassen Island (Table S5). They all originated from Dyer Island (Table S5).

Model selection on the resighting data favored the model with a constant recruitment probability and time-dependent encounter rates (Model 2, Table 4). Apparent survival was 0.32 ± .08 (95% CI: 0.18–0.49) in the first year after release (juvenile survival) and 0.76 ± 0.10 (0.51–0.90) in subsequent years (adult survival). Encounter rates were low initially at 0.01 ± 0.01 (0.00–0.06) in 2007 and 0.06 ± 0.02 (0.03–0.12) in 2008, but increased to 0.31 ± 0.11 (0.14–0.55) in 2011, before falling back in 2012 (Fig. 2). The recruitment probability was 0.11 ± 0.03 (0.06–0.19) and there was no support for a change in this parameter over time or within the age structure we identified (Table 4).

Discussion

The use of hand- or captive-reared chicks to reinforce or restore threatened bird populations is now relatively widespread.[38] The approach has been used successfully in combination with translocation in the conservation of at least 11 seabird species worldwide.[39-42] However, efforts to restore or reinforce penguin populations appear to be scarce,[42] even though the *Spheniscidae* may represent good candidate species. All members of the family exhibit apparent post-fledging independence, they generally have low levels of parental attendance following the guard stage, and they can be easily hand-fed.[43] Although prolonged hand-feeding of nestlings can reduce fledging success in some seabirds,[44] this does not occur with African penguins and, because hand-reared chicks are as fit as naturally-reared chicks,[17,27] the species has been considered a promising candidate for reinforcement and conservation translocation.[17]

Our results confirm that the success of hand-rearing African penguin chicks after oiling incidents extends to chicks abandoned by molting parents. Survival in the first year after release (0.32 ± 0.08) was within the range of estimates for chicks hand-reared after oil spills (0.20–0.42, Barham[17] and Whittington[45]) and apparent adult survival (0.76 ± 0.10) was also similar to estimates for chicks hand-reared after the 1994 (0.79, Whittington[45]) and 2000 oil spills.[17] In addition, juvenile survival compared well to a previous estimate from naturally-reared birds at Robben and Dassen Islands from 1987 to 1994 (0.35, Whittington[45]) and was towards the upper end of estimates for both juvenile (0.06–0.52) and adult (0.46–0.77) survival at these colonies during our study period.[3,6]

Despite a decreasing breeding population in the Western Cape and poor feeding conditions between 2005 and 2010,[3] an estimated 11% of the hand-reared chicks subsequently recruited into the breeding population. Survival rates measured in this study suggest that around 14% would have survived to breeding age (4 years old, Whittington[25]). Half of those individuals confirmed as breeding returned to their natal colony, suggesting that this action ultimately acted to reinforce the breeding population at the source colonies.[17] However, removing and hand-rearing African penguin chicks is expensive, labor intensive, and has potential implications for the source populations. Collection of penguin chicks can cause disturbance to molting adults or other breeding seabirds if not carefully managed. In addition, rearing of chicks in captivity exposes them to diseases which could potentially be introduced to wild populations and fledglings may be returned to an environment which cannot support them if prey availability is poor.

Role of Prey Availability in Chick Abandonment

Long-lived birds can alter their reproductive performance according to their body condition and the needs of their offspring,[46] choosing not to breed or to abandon a breeding attempt in order to safeguard their own survival.[5] In contrast, molt is obligatory in penguins.[24] It must be undertaken annually and, once initiated, cannot be abandoned prematurely.[47,48] Thus, the acquisition of insufficient reserves prior to molt compromises survival[21] and the need to exploit a predictable food source during summer–not the fledging of chicks–appears to determine the timing of molt in African penguins.[24,49]

In the Western Cape, molt coincides with the availability of high energy prey[24] while the breeding season is synchronized to the availability of fish in the vicinity of the colonies in winter.[50] During good years, African penguins can successfully rear two broods in a season, but chick growth rates show high plasticity in response to variable feeding conditions.[8,11] The duration of the fledging period varies as a function of both the local foraging conditions and the energy that parents can afford to invest in chick provisioning.[8,48] Thus, we hypothesize that the date of egg-laying in the nests which produced the abandoned chicks was early enough to produce fledglings in most years but, in 2006 and 2007, the chicks exhibited such slow growth that they were still nestlings at a point when their parents could no longer delay the initiation of molt. Very slow growth rates were observed at Dyer Island in subsequent years[11] and an increase in fledging periods, similar to that observed at Robben Island,[8] may well have occurred. Prey availability in the Western Cape was relatively poor in both 2006 and 2007,[3] such that abandonments could have been mediated either by poor food availability close to the colonies during chick-rearing, poor availability of adult fish during the preceding pre-breeding period, or a combination of the two.[8]

African penguins exhibit some natal philopatry[26] and half of the birds breeding in this study returned to their natal site. This was despite evidence that juvenile African penguins may emigrate to non-natal colonies if the food environment is heterogeneous,[3,5] and apparently poor conditions for breeding penguins at Dyer Island in recent years.[12,51] However, if the poor prey availability persists, their subsequent survival and reproductive success would be compromised relative to birds at colonies where conditions are more favorable.[3,6,8] As the situation for African penguins has continued to deteriorate on the West Coast,[3,6] plans have been developed to use conservation translocations to establish new breeding colonies in areas of higher prey availability along the South African coast.[52]

Our results suggest abandoned chicks as an obvious source of birds for such an endeavor, but the split in recruitment to natal and non-natal sites in birds from Dyer Island suggests that natal imprinting in African penguins occurs before fledging. Nevertheless, translocated individuals will undertake some prospecting behavior to evaluate the quality of their new habitat, relative to that available to the rest of the meta-population.[53] As such, return rates to translocation sites might well be higher if those sites can be placed in areas perceived to be of high habitat quality or prey availability.[53] The current approach of rearing chicks at SANCCOB to release back at existing colonies (natal and non-natal) provides an opportunity to better understand the dispersal and recruitment process of African penguins.[17] In the future, consideration should to be given to whether more could be gained by employing alternative strategies to maximize the conservation benefit of translocations. Rearing birds *in situ* at future release sites has yielded high success rates in chick translocation projects

with *Procellariiformes*.[42] However, this approach comes with additional logistical and financial costs, as well as different risks of disease introduction and environmental impacts. In addition, it may not be necessary for all seabird species, as little penguins *Eudyptula minor* have been successfully translocated by simply keeping them overnight at a release site in artificial nest boxes (N. Carlile, pers. comm.).

Veterinary Concerns

The hand-reared chicks were susceptible to various conditions, in part due to being in captivity (pododermatitis), at high-density (airsacculitis and pneumonia, avian pox) and being exposed to vectors transmitting disease (avian pox, avian malaria).

Pododermatitis can be avoided through the use of varied substrate levels and textures and by having birds regularly walk through disinfectant baths; however, these techniques are generally incompatible with the logistics of large-scale captive rearing. The condition generally improved once the birds were swimming and spending less time standing and does not pose a risk to wild populations.

The severity of avian pox varies between species[36,54] and the symptoms seen in African penguins are mild to moderate, although mortality of Magellanic penguin *S. magellanicus* chicks has occurred.[55] Prevention of the disease involves control of the vector, isolating heavily infected birds and thorough disinfection of pens, equipment, and clothing.[36] It is unlikely to pose a risk to wild populations after release as the lesions resolved over time, although outbreaks can occur in the wild dependent on vector occurrence.

Infections of avian malaria are an ongoing concern at SANCCOB.[16] Avian malaria is present at a low prevalence in wild African penguins[56,57] although the possibility exists of spreading a pathogenic species from rehabilitated birds into the wild population.[29] This risk is reinforced by the identification of potential vectors on some of the offshore islands (SANCCOB unpubl. data). The incidence of avian malaria at the facility has been dramatically reduced since the erection of new shade cloth netting in 2008 (SANCCOB unpubl. data).

Fungal airsacculitis and pneumonia (most likely to be caused by *Aspergillus* sp.) occasionally causes deaths in wild African penguin chicks (SANCCOB unpubl. data) and is likely to be more widespread than reported. This is not a condition in released birds that poses a threat to the wild population due to the ubiquitous nature of the organism where infections generally occur secondarily to an immunosuppressive event.[54]

While it is possible that releasing large numbers of hand-reared birds into the wild introduced disease into the population,[17,29,58–60] this seems unlikely as surveillance of the colonies is near-continuous and there were no mass mortalities of African penguins during the study period. Sub-clinical diseases remain a possibility,[58-60] although the comparable subsequent breeding success of hand-reared and naturally-reared African penguins[17] makes this unlikely, too. All birds undergo basic disease screening and veterinary evaluation before release in order to reduce any disease introduction risk. A program of ongoing disease surveillance throughout the breeding range is also recommended to minimize this risk.

Finally, one missing element in the strategy for chick removal in this study was quantitative criteria to decide whether individual chicks were in sufficiently poor condition to conclude that they had been abandoned. The development and use of a body condition index for African penguin chicks[13] provides the opportunity to relate chick condition at admission to survival and to generate adaptive decision rules about the need for chick removal and its timing in the future.

Conclusions

Hand-rearing of African penguin chicks is a valuable conservation tool in light of the declining population. Continued monitoring of body condition in penguin chicks should be a priority in the management of colonies to ensure the timely collection of abandoned chicks. Further research on the relationship between these abandonment events and variations in prey availability at different temporal and spatial scales is warranted and a program of disease surveillance is recommended to help limit any possibility of disease outbreak. Finally, additional research on how the dispersal of fledging African penguins relates to prey availability could pave the way for successful conservation translocations to establish new colonies in favorable breeding localities for this "Endangered" species.

Supporting Information

Appendix S1: Additional information on the chick-rearing methods and results: (a) the system used to classify chicks by stage of development, (b) the system used to classify chicks by Habitus, (c) the basic treatment protocols used during hand-rearing.(PDF)

Appendix S2: The state-transition and observation matrices for the multistate models. (PDF)

Appendix S3: Data on the African penguin chicks admitted to SANCCOB in 2006 and 2007. (XLSX)

Table S1: Numbers of African penguin chicks admitted to SANCCOB from 2001 to 2005. (PDF)

Table S2: Numbers of African penguin chicks removed in 2006 and 2007, compared to the number of breeding pairs at Dyer Island, Robben Island, and Stony Point. (PDF)

Table S3: Numbers of abandoned African penguin chicks released according to area of origin and area of release, with number of banded individuals. (PDF)

Table S4: Numbers of African penguin chicks which were positive for avian malaria. (PDF)

Table S5: Additional information on the 12 hand-reared chicks observed breeding by December 2012. (PDF)

Acknowledgments

The staff of CapeNature, Robben Island Museum (RIM), the City of Cape Town's (CCT) Environmental Resource Management Department, Overstrand Municipality, and SANCCOB captured and removed chicks. The Dyer Island Conservation Trust, K. de Kock and RIM provided boat transport. Staff and volunteers of SANCCOB, CapeNature, CCT and the International Fund for Animal Welfare (IFAW) oil spill response team helped rear the chicks. Flipper bands were supplied by the Department of Environmental Affairs (DEA) and the Bristol Zoological Society (BZS). Banding information was administered by the South African Bird Ringing Unit (SAFRING) at the Animal Demography Unit (ADU). This study contributes to the African Penguin Chick Bolstering Project, a partnership between SANCCOB, BZS, ADU, DEA (Oceans and Coasts), CapeNature, RIM, BirdLife South Africa and IFAW. We thank Nicholas Carlile and Ralph Vanstreels for helpful comments on an earlier version of the manuscript.

About the Authors

[1]Animal Demography Unit and Marine Research Institute, University of Cape Town, Rondebosch, Western Cape, South Africa
[2]Bristol Zoological Society, Bristol Zoo Gardens, Bristol, United Kingdom
[3]CapeNature, Hermanus, Western Cape, South Africa
[4]Southern African Foundation for the Conservation of Coastal Birds, Bloubergrant, Western Cape, South Africa

Author Contributions

Conceived and designed the experiments: RBS LJW VS DG LGU NJP. Analyzed the data: RBS NJP. Wrote the paper: RBS NJP. Contributed substantially to revisions: RBS NJP LGU. Contributed to data collection: RBS LJW VS DG LGU NJP.

Editor: William Hughes, University of Sussex, United Kingdom

Data Availability: The authors confirm that all data underlying the findings are fully available without restriction. All relevant data are within the paper and its Supporting Information files.

Funding: The authors acknowledge financial support from our institutes, the SeaChange Programme of the National Research Foundation, the Earthwatch Institute, Dyer Island Conservation Trust, the Norway South Africa Fisheries Agreement (NORSA), IFAW and the Leiden Conservation Foundation. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

Literature Cited

1. Croxall JP, Butchart SHM, Lascelles B, Stattersfield AJ, Sullivan B, et al. Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International.* 2012;22:1–34. doi:10.1017/S0959270912000020.
2. Lewison R, Oro D, Godley B, Underhill L, Bearhop S, et al. Research priorities for seabirds: improving conservation and management in the 21st century. *Endangered Species Research.* 2012;17:93–121. doi:10.3354/esr00419.
3. Crawford RJM, Altwegg R, Barham BJ, Barham PJ, Durant JM, et al. Collapse of South Africa's penguins in the early 21st century. *African Journal of Marine Science.* 2011;33:139–156. doi:10.2989/1814232X.2011.572377.
4. Crawford RJM, Makhado AB, Waller LJ, Whittington PA. Winners and losers–response to recent environmental change by South African seabirds that compete with purse-seine fisheries for food. 2014. *Ostrich.* 2014;85(2):111–117. doi: 10.2989/00306525.2014.955141. doi:10.2989/00306525.2014.955141.
5. Crawford RJM, Underhill LG, Coetzee JC, Fairweather T, Shannon LJ, et al. Influences of the abundance and distribution of prey on African penguins *Spheniscus demersus* off western South Africa. *African Journal of Marine Science.* 2008;30:167–175. doi:10.2989/AJMS.2008.30.1.17.467.
6. Sherley RB, Abadi F, Ludynia K, Barham BJ, Clark AE, et al. Age-specific survival and movement among major African Penguin *Spheniscus demersus* colonies. *Ibis.* 2014;156:716–728. doi:10.1111/ibi.12189.
7. Duffy DC, Wilson RP, Ricklefs RE, Broni SC, Veldhuis H. Penguins and purse seiners: competition or coexistence? *National Geographic Research.* 1987;3:480–488.
8. Sherley RB, Underhill LG, Barham BJ, Barham PJ, Coetzee JC, et al. Influence of local and regional prey availability on breeding performance of African penguins *Spheniscus demersus*. *Marine Ecology Progress Series.* 2013;473:291–301. doi:10.3354/meps10070.
9. Durant JM, Crawford RJM, Wolfaardt AC, Agenbag K, Visagie J, et al. Influence of feeding conditions on breeding of African penguins–importance of adequate local food supplies. *Marine Ecology Progress Series.* 2010;420:263–271. doi:10.3354/ meps08857.
10. Pichegru L, Ryan PG, Eeden R Van, Reid T, Grémillet D, et al. Industrial fishing, no-take zones and endangered penguins. *Biological Conservation*. 2012;156:117–125. doi:10.1016/j.biocon.2011.12.013.
11. Sherley RB. Factors influencing the demography of Endangered seabirds at Robben Island, South Africa. PhD thesis. Bristol: University of Bristol. 2010. 237 p.
12. Waller LJ. The African penguin *Spheniscus demersus*: conservation and management issues. PhD thesis. Cape Town: University of Cape Town. 2011. 290 p.
13. Lubbe A, Underhill LG, Waller LJ, Veen J A condition index for African penguin *Spheniscus demersus* chicks. *African Journal of Marine Science.* 201436:143–154. doi:10.2989/1814232X.2014.915232.
14. Robinson WML. Modelling the impact of the South African small pelagic fishery on African penguin dynamics. PhD thesis, University of Cape Town, Cape Town. 2013. 221 p.
15. Sherley RB, Barham BJ, Barham PJ, Leshoro TM, Underhill

LG. Artificial nests enhance the breeding productivity of African Penguins (*Spheniscus demersus*) on Robben Island, South Africa. *Emu.* 2012;97:97–106. doi:10.1071/MU11055.
16. Parsons NJ, Underhill LG. Oiled and injured African penguins *Spheniscus demersus* and other seabirds admitted for rehabilitation in the Western Cape, South Africa, 2001 and 2002. *African Journal of Marine Science.* 2005;27:289–296. doi:10.2989/ 18142320509504087.
17. Barham PJ, Underhill LG, Crawford RJM, Altwegg R, Leshoro MT, et al. The efficacy of hand-rearing penguin chicks: evidence from African Penguins (*Spheniscus demersus*) orphaned in the Treasure oil spill in 2000. *Bird Conservation International.* 2008;18:144–152. doi:10.1017/ S0959270908000142.
18. Underhill LG, Bartlett PA, Baumann L, Crawford RJM, Dyer BM, et al. Mortality and survival of African penguins *Spheniscus demersus* involved in the Apollo Sea oil spill: an evaluation of rehabilitation efforts. *Ibis. 1*999;141:29–37.
19. Seddon PJ, van Heezik YM. Behaviour of the jackass penguin chick. *Ostrich.* 1993;64:8–12. doi:10.1080/00306525.1993.9634188.
20. Cooper J. Moult of the black-footed penguin *Spheniscus demersus*. I*nternational Zoo Yearbook.* 1978;18:22–27. doi:10.1111/j.1748-1090.1978.tb00211.x.
21. Kemper J, Roux J-P, Underhill LG. Effect of age and breeding status on molt phenology of adult African penguins (*Spheniscus demersus*) in Namibia. *Auk.* 2008;125:809–819. doi:10.1525/auk.2008.06262.
22. Wilson D. Causes and benefits of chick aggregations in penguins. *Auk.* 2009;126:688–693. doi:10.1525/auk.2009.9709b.
23. Crawford RJM, Williams AJ, Hofmeyr JH, Klages NTW, Randall RM, et al. Trends of African penguin *Spheniscus demersus* populations in the 20th century. *South African Journal of Marine Science.* 1995;16:101–118. doi:10.2989/025776195784156403.
24. Crawford RJM, Hemming M, Kemper J, Klages NTW, Randall R, et al. Molt of the African penguin, *Spheniscus demersus*, in relation to its breeding season and food availability. *Acta Zoologica Sinica.* 2006;52 (Supp.):444–447.
25. Whittington PA, Klages NTW, Crawford RJM, Wolfaardt AC, Kemper J. Age at first breeding of the African penguin. *Ostrich.* 2005;76:14–20. doi:10.2989/ 00306520509485468.
26. Whittington PA, Randall RM, Crawford RJM, Wolfaardt AC, Klages NTW, et al. Patterns of immigration to and emigration from breeding colonies by African penguins. *African Journal of Marine Science.* 2005;27:205–213. doi:10.2989/ 18142320509504079.
27. Barham PJ, Underhill LG, Crawford RJM, Leshoro TM. Differences in breeding success between African penguins (*Spheniscus demersus*) that were and were not oiled in the MV Treasure oil-spill in 2000. *Emu.* 2007;107:7–13. doi:10.1071/ MU06028.
28. Turner WA, Plutchak L. SeaWorld California penguin hand-rearing guidelines. *Penguin Conservation.* 1998;11:2–9.
29. Grim KC, van der Merwe E, Sullivan M, Parsons N, McCutchan TF, et al. Plasmodium juxtanucleare associated with mortality in black-footed penguins (*Spheniscus demersus*) admitted to a rehabilitation center. *Journal of Zoo and Wildlife Medicine.* 2003;34:250–255. doi:10.1638/02-070.
30. Sherley RB, Ludynia K, Lamont T, Roux J-P, Crawford RJM, et al. The initial journey of an endangered penguin: implications for seabird conservation. *Endangered Species Research.* 2013.21:89–95. doi:10.3354/esr00510.
31. Petersen SL, Branch GM, Crawford RJM, Cooper J, Underhill LG. The future for flipper banding African penguins: discussion recommendations and guidelines. *Marine Ornithology.* 2005;33:E1–E4.
32. Lebreton J-D, Nichols JD, Barker RJ, Pradel R, Spendelow JA. Modeling individual animal histories with multistate capture–recapture models. *In*: Caswell H, editor. Advances in Ecological Research. Burlington: Academic Press. 2009;41:87–173. doi:10.1016/S0065-2504(09)00403-6.
33. Gimenez O, Lebreton J-D, Gaillard J-M, Choquet R, Pradel R. Estimating demographic parameters using hidden process dynamic models. *Theoretical Population Biology.* 2012;82:307–316. doi:10.1016/j.tpb.2012.02.001.
34. Choquet R, Rouan L, Pradel R. Program E-Surge: A software application for fitting multievent models. *In:* Thomson DL, Cooch EG, Conroy MJ, editors. Modeling Demographic Processes In Marked Populations. Boston: Springer US. 2009;845–865. doi:10.1007/978-0-387-78151-8.
35. Burnham KP, Anderson DR. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. New York: Springer. 2000.
36. Hansen W. Avian pox. *In*: Friend M, Franson JC, editors. Field manual of wildlife diseases: general field procedures and diseases of birds. Washington DC: United States Geological Survey, Biological Resources Division. 1999;163–169.
37. Kane OJ, Smith JR, Boersma PD, Parsons NJ, Strauss V, et al. Feather-loss disorder in African and Magellanic penguins. *Waterbirds.* 2010;33:415–421. doi:10.1675/063.033.0321.
38. Jones CG, Merton DV. A tale of two islands: the rescue and recovery of Endemic birds in New Zealand and Mauritius. *In:* Ewen J, Armstrong D, Parker K, Seddon P, editors. Reintroduction Biology: Integrating Science and Management. Chichester, UK: Wiley-Blackwell. 2012;33–72.
39. Miskelly CM, Taylor GA, Gummer H, Williams R. Translocations of eight species of burrow-nesting seabirds (genera *Pterodroma, Pelecanoides, Pachyptila* and *Puffinus*: Family Procellariidae). *Biological Conservation.* 2009;142:1965–1980. doi:10.1016/j.biocon.2009.03.027.
40. Deguchi T, Jacobs J, Harada T, Perriman L, Watanabe Y, et al. Translocation and hand-rearing techniques for establishing a colony of threatened albatross. *Bird Conservation International.* 2011;22:66–81. doi:10.1017/ S0959270911000438.
41. Carlile N, Priddel D, Madeiros J. Establishment of a new,

secure colony of Endangered Bermuda Petrel *Pterodroma cahow* by translocation of near-fledged nestlings. *Bird Conservation International.* 2012;22:46–58. doi:10.1017/S0959270911000372.
42. Jones HP, Kress SW. A review of the world's active seabird restoration projects. *Journal of Wildlife Management.* 2012;76:2–9. doi:10.1002/jwmg.240.
43. Gummer H. Chick translocation as a method of establishing new surface-nesting seabird colonies: a review. DOC Science Internal Series 150. Department of Conservation, Wellington. 2003. Available: http://csl.doc.govt.nz/ documents/science-and-technical/dsis150.pdf.
44. Miskelly CM, Taylor GA. Establishment of a colony of common diving petrels (*Pelecanoides urinatrix*) by chick transfers and acoustic attraction. *Emu.* 2004;104:205–211. doi:10.1071/MU03062.
45. Whittington PA. Survival and movements of African penguins, especially after oiling. PhD thesis. Cape Town: University of Cape Town. 2002. 296 p.
46. Erikstad KE, Fauchald P, Tveraa T, Steen H. On the cost of reproduction in long-lived birds: the influence of environmental variability. *Ecology.* 1998;79:1781–1788. doi:10.2307/176796.
47. Payne R. Mechanisms and control of molt. *In*: Farner DC, King JR, editors. Avian Biology Vol. 2. New York and London: Academic Press. 1972. 103–155.
48. Randall RM. Jackass penguins. *In*: Payne AIL, Crawford RJM, van Dalsen AP, editors. Oceans of Life of Southern Africa. Cape Town: Vlaeberg. 1989. 244–256.
49. Wolfaardt AC, Underhill LG, Crawford RJM. Comparison of moult phenology of African penguins *Spheniscus demersus* at Robben and Dassen Islands. *African Journal of Marine Science.* 2009;31:19–29. doi:10.2989/AJMS.2009.31.1.2.773.
50. Crawford RJM, Barham PJ, Underhill LG, Shannon LJ, Coetzee JC, et al. The influence of food availability on breeding success of African penguins *Spheniscus demersus* at Robben Island, South Africa. *Biological Conservation.* 2006;132:119–125. doi:10.1016/j.biocon.2006.03.019.
51. Ludynia K, Waller LJ, Sherley RB, Abadi F, Galada Y, et al. Processes influencing the population dynamics and conservation of African penguins on Dyer Island, South Africa. *African Journal of Marine Science.* 2014;36:253–267. doi:10.2989/1814232X.2014.929027.
52. Schwitzer C, Simpson N, Roestorf M, Sherley RB. The African Penguin Chick Bolstering Project: a One Plan approach to integrated species conservation. *WAZA Mag.* 2013;14:23–26.
53. Oro D, Martínez-Abraín A, Villuendas E, Sarzo B, Mínguez E, et al. Lessons from a failed translocation program with a seabird species: Determinants of success and conservation value. *Biological Conservation.* 2011;144:851–858. doi:10.1016/j.biocon.2010.11.018.
54. Ritchie B, Harrison G, Harrison L. Avian medicine: principles and application. Lake Worth, Florida: Wingers Publishing Inc. 1994.
55. Kane OJ, Uhart MM, Rago V, Pereda AJ, Smith JR, et al. Avian pox in Magellanic penguins (*Spheniscus magellanicus*). *Journal of Wildlife Diseases.* 2012;48:790–794. doi:10.7589/0090-3558-48.3.790.
56. Brossy J-J. Malaria in wild and captive jackass penguins *Spheniscus demersus* along the southern African Coast. *Ostrich.* 1992;63:10–12.
57. Graczyk TK, Cranfield MR, Brossy JJ, Cockrem JF, Jouventin P, et al. Detection of avian Malaria infections in wild and captive penguins. *Journal of the Helminthological Society of Washington.* 1995;62:135–141.
58. Peirce MA. The significance of avian haematozoa in conservation strategies. *In*: Cooper JE, editor. Diseases and Threatened Birds. Cambridge: ICBP Technical Publication No. 10, Vol. 10. 69–76. 1989.
59. Brossy J-J, Plös AL, Blackbeard JM, Kline A. Diseases acquired by captive penguins; what happens when they are released into the wild? *Marine Ornithology.* 1999;27:185–186.
60. Jones HI, Shellam GR. Blood parasites in penguins, and their potential impact on conservation. *Marine Ornithology.* 1999;27:181–184.

What's on your plate?

By Deb Teachout, DVM



IMAGE ©N HAWEKOTTE. SOURCES ©RO IRVING, NEST; ©JEREMY BROOKS, FLATWEAR. ALL CC BY-NC 2.0 LICENSE.

What does the hamburger on my plate have to do with the wildlife I rehabilitate?

Eat less meat and love more wildlife–that's what the Center for Biological Diversity advises in its recent campaign called Take Extinction Off Your Plate.[1] I ran across an explanation of this campaign, *Saving Endangered Species One Meal at a Time*, in its *Endangered Earth*, Summer 2014, newsletter.

We know from the medical community that decreasing our meat consumption may improve our overall health and treat certain illnesses, but decreasing our meat consumption to save endangered species from extinction–how does that work? Turns out it's all related to the huge impact of global meat production on climate change and on competition for natural resources. Climate change is a key factor in pushing wildlife toward extinction (think polar bears and American pikas). But also, the production of meat requires huge amounts of water and land (think former wildlife habitat) and creates huge amounts of pollution (think contaminated and dead ecosystems).

Annually, the average American eats 270 pounds of meat and the average European consumes 145 pounds. To make just one quarter-pound hamburger, you need a cow, 6.7 pounds of grains and forage for feed, 52.8 gallons of water for the cow to drink and for irrigating feed crops, 74.5 square feet of land for cow grazing and growing feed crops, and 1,036 BTUs of fossil fuel energy to transport the feed to the cow, the cow to slaughter, and finally the hamburger to where you are eating it.[2]

Climate change: And there's a lot of methane produced. Methane is considered a potent green house gas, 25 times more potent that carbon dioxide. On an annual basis, 80 million metric tons of methane are produced by livestock globally. At least 14.5% of global greenhouse gases come from livestock–that's more than from cars, trains, and airplanes combined. Some studies put this figure much higher at 51%.[3] Scientists think polar bears could be extinct by 2100 because of resultant climate change.

Resources: Land and water and wildlife habitat. Almost half of the land mass of the lower 48 states is used to raise and feed livestock. In the western United States, about 270 million acres of public land including wilderness areas, wildlife refuges, national forests, and national parks are grazed by livestock. Even the most remote wilderness areas of the western United States, including the thick forested areas, have been foraged and trampled by cattle, and the species that rely on this lush habitat to survive are in trouble. Nearly 50% of the water used in the United States goes toward raising animals for food. To support the growing rise in per-capita meat eating, livestock farming expands, shrinking and fragmenting natural habitats in the process.

Eat less meat and love more wildlife–that's what the Center for Biological Diversity advises in its recent campaign called "Take Extinction Off Your Plate."

Livestock grazing is among the greatest direct threats to imperiled species and affects 14% of threatened or endangered animals. Native grazing animals and predators are frequently killed to protect meat-production profits. When native predators (wolves, coyotes, foxes, jaguars, bobcats, bears) are forced to adapt to continually shrinking habitat and declining natural prey food sources, ranchers call upon government help to shoot, trap,

poison, and gun predators down from helicopters. Grass eaters such as elk, deer, and pronghorn have been killed en masse to reserve more feed for cattle. Beaver populations have been destroyed because they disrupt the grazing landscape desired by ranchers. Ranching in the 20th century eliminated 98% of prairie dog towns, and there are 170 species (including ferrets, hawks, owls, mice, and snakes) dependent on these prairie dogs and their burrows. Predator control programs designed to protect the livestock industry have helped drive keystone predators such as the California grizzly bears and Mexican gray wolves extinct in their ecosystems, and the livestock industry is the leading opponent to the popular efforts to recover species such as the Mexican gray wolf in Arizona and New Mexico. Sage grouse, prairie dogs, and grizzly bears are among the 175 endangered species living on federal lands that are threatened by the livestock industry. Other sensitive species include pronghorn, bighorn sheep, wolves, black footed ferret, yellow-billed cuckoo, Mexican spotted owl, lesser prairie chicken, Aplomado falcon, steelhead salmon, bullhead trout, desert tortoise, and Chiricahua leopard frog. Livestock grazing degrades grass cover and nesting sites for grassland breeding birds, the most rapidly declining guild of birds in North America.[4]



PHOTO © DON BURKETT, FLICKR.COM. CC BY-NC-ND 2.0 LICENSE.

Mexican "gray" wolf *(Canis lupus baileyi).*

Destruction and pollution. In addition to competition for resources, the grazing cattle also destroy native vegetation, damage soils and stream banks, and contaminate waterways with fecal waste. Lush streams and riparian forests are reduced to flat, dry, wastelands. Livestock ranching is the most potent force behind desertification in the United States. Pigs and chickens are raised in concentrated animal feeding operations or CAFOS. These CAFOS generate enormous amounts of waste–they have polluted more than 35,000 miles of rivers in 22 states and contaminated ground water in 17 states. This has impaired wetlands, lakes, estuaries and imperiled already endangered fish, amphibians, and reptiles.



Chiricahua leopard frog *(Rana chiricahuensis)*

PHOTO © USFWS, FLICKR.COM. CC BY 2.0 LICENSE.

The Center for Biological Diversity is asking people to pledge to reduce the amount of meat in their diets by one-third or more. If the number of people already taking the pledge sticks with it, they figure we will have saved billions of gallons of water, thousands of acres of land, and the greenhouse gas equivalent of taking 4,400 cars off the road for a year! If you want to learn more about this campaign, go to www.TakeExtinctionOffYourPlate.com.

Meat production creates a mammoth ecological footprint. Want to save wildlife? Need more habitat for them? Eat less meat. ✣

Literature Cited

1. Feldstein, S. Saving Endangered Species One Meal at a Time. *Endangered Earth.* p. 4. 2014, Summer.
2. Barclay, E. A Nation Of Meat Eaters: See How It All Adds Up. 27 June 2012. Retrieved 27 October 2014, from National Public Radio Web site: http://www.npr.org/blogs/thesalt/2012/06/27/155527365/visualizing-a-nation-of-meat-eaters
3. Center for Biological Diversity. How Eating Meat Hurts Wildlife and the Planet. 2014. Retrieved 28 October 2014, from Take Extinction Off Your Plate: http://takeextinctionoffyourplate.com/meat_and_wildlife.html
4. Salvo, M. Western Wildlife Under Hoof: Public Lands Livestock Grazing Threatens Iconic Species. Chandler: Wild Earth Guardians. 2009.

Deb Teachout is a veterinarian in Illinois, United States, whose practice serves both domestic and wildlife patients. She is a past member of the IWRC Board of Directors, an associate editor for JWR, and a long-time animal advocate.

CONTINUED FROM PAGE 6

ted to the facility each year are brought in by well-intentioned and largely compassionate members of the public who are simply trying to do the right thing by helping an animal they find. Yet, because none of these people is protected by an Illinois Good Samaritan law, each is similarly vulnerable to arrest and subsequent prosecution.

One could suggest that individual members of the public never rescue wildlife and always seek out and wait for the assistance of a municipal animal control officer or an appropriately permitted wildlife rehabilitation facility. Many municipalities have no animal control department that deals with wildlife. Given that few Illinois wildlife rehabilitation centers are funded, wildlife rehabilitation centers cannot assume the responsibility of rescuing all animals in the state currently brought to wildlife centers by members of the public.

Not only does the lack of a Good Samaritan law place well-intentioned and often unsuspecting individuals at risk of arrest, but also such arrest and subsequent prosecution uses scarce state resources that could be better spent on other issues.

[Update: On February 26, 2015, the rescuer was aquitted.]

Mexican Zoo Receives Wildlife Rehabilitation Award

CANCÚN, Quintana Roo, Mexico (December 1, 2014)—Mexican environmental authorities acknowledged the contribution of Xcaret Park of Cancún and the Riviera Maya to the rescue and rehabilitation of animals which have been stranded, injured, or confiscated from their owners for violations to environmental legislation.

The representative of the federal Environmental Protection Agency (PROFEPA) for the state of Quintana Roo, Ludivina Menchaca, said that there have been individuals and private-sector businesses who have helped to protect exemplars of wildlife in high-risk situations and that, thanks to this, these animals have had a chance to survive and return to the wild or remain in safe and healthy refuges. "Xcaret has been a major ally in the care of wild fauna in Quintana Roo," said the official during the event organized by the PROFEPA.

The park's wildlife manager, Rodolfo Raigoza Figueras, received the award on behalf of the park and expressed his gratitude for the distinction from the federal authorities. Over the last 10 years, the PROFEPA has asked Xcaret to safeguard 168 specimens belonging to over 45 different species, including their care, feeding, rehabilitation, and return to the wild where possible.

Of the animals entrusted to Xcaret, many have been returned to the wild, others have been assigned to refuges in accordance with instructions from governmental authorities, while still others have remained in the nature park, where they receive the care they need to thrive.

Among the species that have been entrusted to Xcaret are the ocellated turkey and the Yucatan black howler monkey, as well as species of crocodiles, deer, pumas, jaguars, falcons, turtles, and ocelots, among many others.

Unique Parrot Population on the Rise

TASMANIA, Australia (November 26, 2014)—Orange bellied parrot releases have bolstered a failing population in a Tasmanian World Heritage Site. The birds recently migrated back to the mating grounds months after release. November 2013's wild population of 18 birds has increased to 34 this year at the Melaleuca breeding grounds. The 2013 wild-fledged chicks have also returned to the breeding territory. With nesting well under way, there is hope for sustainable population growth in the coming years.

Tyson Shine of ABC reports, "The Melaleuca release was different to other [orange bellied parrot] releases because wild birds were also present, to teach captive-bred birds how to forage for food and migrate."

IWRC
International Wildlife Rehabilitation Council

Host a Class
it's easier than you think!

Basic Wildlife Rehabilitation

- Hands-on practical skills laboratory
- RACE approved

click here for details

call 866-871-1869 ext. 0
email julissa@theiwrc.org

RACE
REGISTRY OF APPROVED CONTINUING EDUCATION
AMERICAN ASSOCIATION OF VETERINARY STATE BOARDS

*The IWRC (provider number 896) Basic Wildlife Rehabilitation program was reviewed and approved by the AAVSB RACE program for 15 continuing education credits.

TAIL END



Don't be so glum, Charlie. Winter's almost here.

African penguins (*Spheniscus demersus).*

PHOTO © DUNNOCK_D AT FLICKR.COM, CREATIVE COMMONS LICENSE CC BY-NC-SA 2.0.

INSTRUCTIONS FOR AUTHORS

POLICY Original manuscripts on a variety of wildlife rehabilitation topics (e.g., husbandry and veterinary medicine) are welcomed. Manuscripts that address related topics such as facility administration, public relations, law, and education are invited as well.

Associate editors and anonymous reviewers, appropriate to the subject matter, evaluate each submitted manuscript. Concurrent submission to other peer-reviewed journals will preclude publication in the *Journal of Wildlife Rehabilitation* (JWR). The International Wildlife Rehabilitation Council (IWRC) retains copyright on all original articles published in the JWR but, upon request, will grant permission to reprint articles with credit given to the IWRC–JWR.

SUBMISSIONS All submissions should be accompanied by a cover letter stating the intent of the author(s) to submit the manuscript exclusively for publication in the JWR. Electronic submissions are required; hard-copy manuscripts are not accepted. The manuscript file should be attached to the submission letter (which can be the body of your email) and sent to:

Kieran Lindsey, Editor
jwr.editor@theiwrc.org

MANUSCRIPT Manuscripts should be MS Word documents in either PC or MAC platform (*no PDF files*).

Manuscript should be typed in Times Roman, 12 pt., double-spaced throughout with one-inch margins.

Include the name of each author. Specify the corresponding author and provide affiliation, complete mailing address, and email address. The affiliation for all authors should be included in a brief (maximum of 100 words) biography for each that reflects professional experience related to rehabilitation or to the manuscript subject matter rather than personal information. Biographies may be edited due to space limitations.

Include an abstract that does not exceed 175 words and choose several (up to 14) key words.

Templates have been developed for the following submission categories: case study, technique (including diets), research, and literature review; authors may request a copy of one, or all, of these templates from the editor (jwr.editor@theiwrc.org) before developing a manuscript for submission to the JWR.

STYLE The JWR follows the Scientific Style and Format of the CSE Manual for Authors, Editors, and Publishers, 8th Edition. The complete "JWR Author Instructions" document is available at:

http://theiwrc.org/journal-of-wildlife-rehabilitation/jwr-submission-guidelines

or by email request to the Editor. This document provides formatting guidelines for in-text citations and the Literature Cited section; provides the JWR textual requirements for tables, figures, and photo captions; and describes quality and resolution needs for charts, graphs, photographs, and illustrations.



PHOTO © TERRY ROSS, FLICKR.COM. CC BY-SA 2.0 LICENSE.

Kemp's Ridley sea turtle hatchling (*Lepidochelys kempii*).



IWRC

International Wildlife Rehabilitation Council

PO Box 3197
Eugene, OR 97403 USA
Voice/Fax: 408.876.6153
Toll free: 866.871.1869
Email: office@theiwrc.org
www.theiwrc.org