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Animal Keepers' Forum

Special Issue on Prosimians

November/December 2015, Volume 42, Nos. 11 & 12

Pictured Above: Northern greater galago (O. Garnetii).
Photo by Matt Marriott

MISSION STATEMENT

American Association of Zoo Keepers, Inc.

The American Association of Zoo Keepers, Inc. exists to advance excellence in the animal keeping profession, foster effective communication beneficial to animal care, support deserving conservation projects, and promote the preservation of our natural resources and animal life.

About the Cover

This month's cover features Io Moth, a three-year-old (in this photo) male pygmy slow loris (*Nycticebus pygmaeus*) feeding on a frozen fruit enrichment treat on a hot summer's day at the Duke Lemur Center. At the time this photo was taken, Io Moth (now five-years-old) was living with a 27-year-old wild-caught aye-aye (*Daubentonia madagascariensis*) female, Ozma, and her three-year-old captive-born daughter, Styx.

Generally, captive adult pygmy slow lorises and adult aye-ayes do not seem to be compatible with their own species outside of the breeding season. Luckily, pygmy slows and aye-ayes do seem to be remarkably compatible, and hence make excellent mixed-species groups. At Duke, it is standard practice to have each of our pygmy slows sharing exhibit space with an aye-aye, with the only challenge being the prevention of lorises from gaining access to the aye-aye's food, which might result in undesirable loris weight gain. It would not be unusual during the period this photo was taken to read a technician daily entry indicating that Io Moth was sleeping in the same nestbox as both Ozma and Styx!

Special thanks to David Haring of the Duke Lemur Center for this month's cover photo!

Articles sent to ***Animal Keepers' Forum*** will be reviewed by the editorial staff for publication. Articles of a research or technical nature will be submitted to one or more of the zoo professionals who serve as referees for ***AKF***. No commitment is made to the author, but an effort will be made to publish articles as soon as possible. Lengthy articles may be separated into monthly installments at the discretion of the Editor. The Editor reserves the right to edit material without consultation unless approval is requested in writing by the author. Materials submitted will not be returned unless accompanied by a stamped, self-addressed, appropriately-sized envelope. Telephone, fax or e-mail contributions of late-breaking news or last-minute insertions are accepted as space allows. Phone (330) 483-1104; FAX (330) 483-1444; e-mail is shane.good@aazk.org. If you have questions about submission guidelines, please contact the Editor. Submission guidelines are also found at: aazk.org/akf-submission-guidelines/.

Deadline for each regular issue is the 3rd of the preceding month. Dedicated issues may have separate deadline dates and will be noted by the Editor.

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ANIMAL KEEPERS' FORUM

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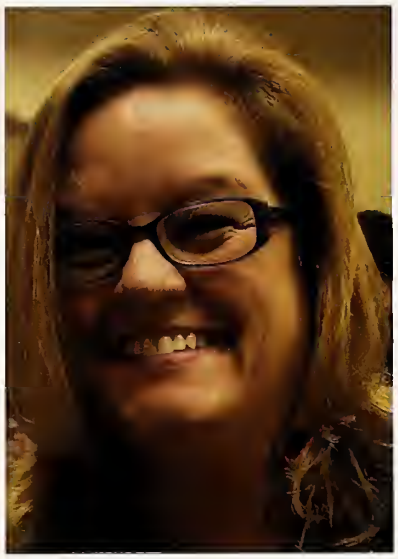
FROM THE PRESIDENT



I know this dedicated issue to Prosimians will help inspire you in your work to provide excellent care for all the animals in your care, as well as thinking about how you can care for our island in the universe. Our whole planet is feeling the same pressures Madagascar is with degradation of habitat and resources being stretched. Please take a moment to change something in your lifestyle that will reduce your impact.

I wanted to update all of you on the roles of your Board, Staff and agenda items discussed at the National Conference. Bob Cisneros will be continuing on in the role of Director of Professional Development for AAZK. He has been such a positive force, that he is going to help keep the momentum going as oversight of the Professional Development Committee, AAZK Online and Educational Partner management.

Wendy Lenhart will be oversight for Recognition (Grants Committee, Awards Committee and National Zoo Keeper Week), Mary Ann Cisneros for Conservation (Conservation Committee, BFR, TFYM). Bethany Bingham will continue as oversight for the Communication Committee and will also take on the role of Conference Manager to help facilitate communication, answer questions and assist where needed with upcoming conference hosts.

Bill Steele will be oversight for the Behavioral Husbandry Committee and our newly formed Safety Committee, which will provide resources and opportunities for safety and health training with continuing education in keeper safety.

I will be oversight for the reformed International Outreach Committee, which will provide resources and opportunities for training and continuing education in the international community, primarily Central and South America, as well as facilitating communication with our membership and professional associations.

Ed Hansen continues as CEO/CFO and manages the office administration, financial management and website for the Association. Shane Good and Elizabeth Thibodeaux produce your *Animal Keepers' Forum*.

I want to thank all of you for supporting your Association and to thank all the members who are volunteer project managers, committee chairs or members!

If you would like information or have questions/comments about any of the committees or programs, please feel free to contact me or any of the Board Oversights. Everyone's contact information can be found at aazk.org.

I look forward to hearing from you,

Penny Jolly
penny.jolly@aazk.org

COMING EVENTS

Post upcoming events here!
e-mail shane.good@aazk.org

March 19-24, 2016
AZA Mid-Year Conference
Omaha, NE
Hosted by Omaha's Henry Doorly Zoo and Aquarium
For more information go to: aza.org/midyearmeeting/

April 11-15, 2016
Practical Zoo Nutrition Management Course
Front Royal, VA
Smithsonian Conservation Biology Institute. For more info go to: http://smconservation.gmu.edu/programs/graduate-and-professional/professional-training-courses/nutrition/

April 17-22, 2016
ABMA National Conference
Tampa, FL
Hosted by Lowry Park Zoo and Busch Gardens Tampa
For more information go to: theabma.org/abma-annual-conference/

April 29 - May 1, 2016
Reconnecting with Elephants in Protected Contact Workshop (RECON)
Colorado Springs, CO
Hosted by Cheyenne Mountain Zoo, Steve Martin of NEI and Dr. Susan Friedman. For more information go to: www.cmzoo.org/index.php/recon-elephant-workshop/

May 9-12, 2016
The International Giraffid Conference
Chicago, IL
Hosted by Brookfield Zoo
For more information go to: https://www.czs.org/giraffid

May 12-17, 2016
Best Practices in Animal Keeping Course
Buffalo, NY
Hosted by AZA and Buffalo Zoo
For more information go to: https://www.aza.org/BPAK.aspx

June 12-16, 2016
24th International Conference on Bear Research & Management
Anchorage, AK
International Association for Bear Research and Management
For more information go to: www.iba2016.com

June 22-25, 2016
International Herpetological Symposium
St. Louis, MO
Hosted by Saint Louis Zoo
For more information go to the International Herpetological Symposium website.

September 7-11, 2016
AZA National Conference
San Diego, CA
Hosted by San Diego Zoo Global and SeaWorld San Diego
For more information go to: www.aza.org/annualconference/

AMERICAN ASSOCIATION of ZOO KEEPERS

September 19-23, 2016
AAZK National Conference
Memphis, TN

Hosted by Memphis Zoo AAZK Chapter and Memphis Zoo.

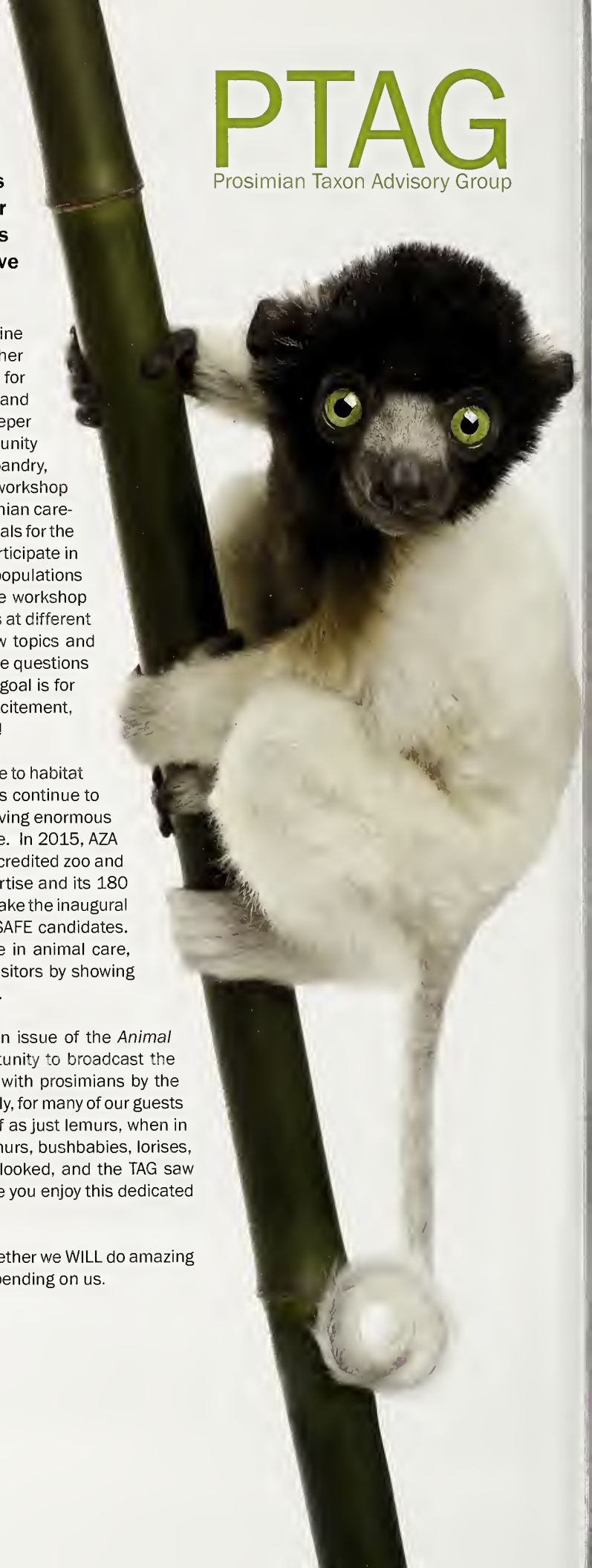
More details coming soon!

September 25-30, 2016
International Aquarium Congress
Vancouver, BC
Hosted by The Vancouver Aquarium Marine Science Centre
For more information go to: http://iac2016.venuewest.com/

PTAG

Prosimian Taxon Advisory Group

The mission of the Prosimian Taxon Advisory Group (PTAG) is to complement, promote and participate in the efforts to conserve prosimians in nature and to advance the highest levels of animal welfare for prosimians in human care. *Ex situ* populations may serve as an educational resource, as a stimulus for problem solving and fund-raising action for *in situ* conservation, as a genetic reservoir, and as a focus of scientific research. This is who we are and what we strive to achieve.



TAG members recognize the importance of being a resource for the front line prosimian care staff, and what better way to achieve this than to bring together the many years of husbandry and management experience as a resource for the keepers who care for prosimians on a daily basis. In 2008, the PTAG and Cleveland Metroparks Zoo organized and hosted the first Prosimian Keeper Workshop in conjunction with the annual TAG meeting. This was an opportunity for education and information exchange, with topics ranging from basic husbandry, behavior, veterinary medicine, to exhibit design. More importantly, this workshop served to set the stage for the future by providing an opportunity for prosimian caretakers to network and build relationships with those who share the same goals for the prosimians in their institutions. Workshop participants were invited to participate in TAG meetings, as well as receive exposure to the goals of managing our populations to maximize the genetic and demographic health for the long-term. The workshop received very positive feedback and has since been held every three years at different institutions with expertise in prosimian care. We have added many new topics and continue to innovate the focus of the workshop so that we can address the questions and topics that keepers are inquiring about. As leaders of the PTAG, our goal is for each participant to return to their own institutions with new ideas, new excitement, and having made new friends. If we reach that goal, we have succeeded!

Lemurs are considered one of the most endangered mammals on earth due to habitat loss and environmental degradation in Madagascar, and loris populations continue to suffer from the ongoing illegal wildlife trade in Asia. These threats are having enormous impacts on *in situ* populations, but we have the ability to influence change. In 2015, AZA rolled out Saving Animals from Extinction (SAFE), where the entire AZA-accredited zoo and aquarium community will focus its conservation science, its wildlife expertise and its 180 million visitors on saving species in the wild. Although prosimians did not make the inaugural list of ten SAFE species, all 10 nominated species are now considered SAFE candidates. It is an ability of zoos and aquariums to leverage not only our expertise in animal care, management, and science, but also to use our power to influence our visitors by showing them the world of biodiversity that exists through the animals in our care.

When the TAG was approached about developing a dedicated prosimian issue of the *Animal Keepers' Forum*, we didn't think twice. This would be one more opportunity to broadcast the amazing current projects and priority research that is being conducted with prosimians by the keepers who so passionately care for these diverse, unique primates. Finally, for many of our guests and zoo and aquarium management, prosimians are too often thought of as just lemurs, when in fact they are representative of a very large taxonomic group including lemurs, bushbabies, lorises, and tarsiers. Unfortunately, the small nocturnal species often get overlooked, and the TAG saw value in highlighting their uniqueness and important role as well. We hope you enjoy this dedicated issue and the articles within.

You are all amazing people with passion and drive, and when we come together we WILL do amazing things, because the prosimians in the wild and in our institutions are depending on us.

Christie Eddie
Chair, Prosimian Taxon Advisory Group

Gina Ferrie
Vice Chair, Prosimian Taxon Advisory Group

Thank You to our Sponsors!

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Creation of a Mixed-species Group of Red Ruffed (*Varecia rubra*) and Ring-tailed Lemurs (*Lemur catta*)

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Abstract

In August 2012, Mesker Park Zoo combined 1.1 red ruffed lemurs (*Varecia rubra*) with 1.2 ring-tailed lemurs (*Lemur catta*) to form a single mixed species group. Challenges included housing two species with breeding recommendations, individual lemur personalities, and special needs for separating ring-tailed lemurs for feeding. Following a four week mesh-to-mesh introduction, physical introductions were successfully done. By February 2013, the group hierarchy was firmly established and the group was relaxed enough to be locked on exhibit together.

Introduction

In 2012, Mesker Park Zoo (MPZ) in Evansville, Indiana was finalizing plans to acquire a bachelor group of Coquerel's sifaka (*Propithecus coquereli*). To make room for the incoming trio, it was decided to combine the zoo's 1.1 red ruffed (*Varecia rubra*) and 1.2 ring-tailed lemurs (*Lemur catta*) into a mixed species group that would share holding and an exhibit. The red ruffed lemurs were 1.0 Heath (born 2000) and 0.1 Little Dipper (born 2002). They had been paired up since 2008 with Heath dominant most of the time. The ring-tailed lemurs were 1.0 Jerry (born 2003), 0.1 Camille (born 2001), and 0.1 Denise (born 1998). The ring-tailed lemur group was relatively new and had only been formed in mid to late 2011. Denise had taken the dominant role and Jerry was at the bottom.

The lemur building at MPZ is divided into two sides with a keeper work area in the center. Each side has three stalls (see Figures 1 and 2). There are two exhibits (each several thousand square feet) connected to the building. Within the building and exhibits, the lemurs are always in auditory and olfactory contact and usually in visual contact as well. The decision was made to house the sifaka in the larger exhibit, which meant the ring-tailed lemurs would be moving over to the red ruffed lemur side of the building. Discussions with other lemur keepers made it sound like the success or failure of introductions was dependent upon individual lemurs' personalities, but that aggression did sometimes lessen over time[1].

Combining the groups

The three biggest concerns about combining the lemurs were making sure everyone got along, dealing with any infants since both species had breeding recommendations, and dealing with limited ability (two stalls for three animals since the red ruffed lemurs would be occupying a stall) to separate the ring-tailed lemurs from each other at feeding time, especially the pre-diabetic male.

The latter two concerns were easier to address. To be able to separate the ring-tailed lemurs from each other at mealtimes, the maintenance department created a stall within the largest stall. This task was completed before the ring-tailed lemurs moved over to the red ruffed

Figure 1. Mesker Park Zoo Lemur Building

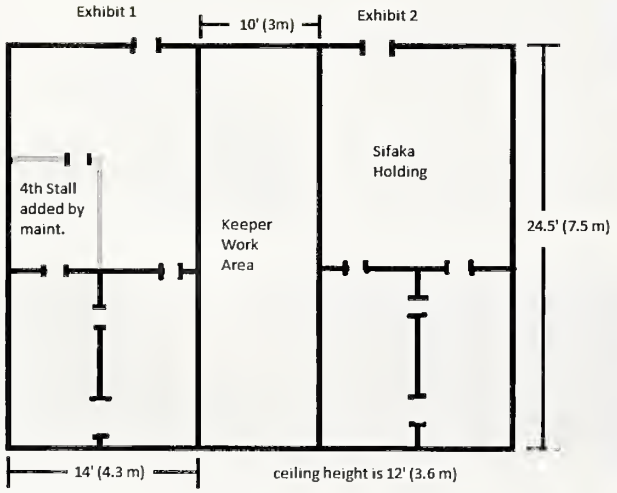

Figure 2. Photo of holding

side. The second concern of dealing with infants was categorized as something that could be dealt with later. We were doing introductions in August before the breeding season of either species and hoped to have a cohesive group before any babies showed up.

On 21 August 2012, the ring-tailed lemurs were moved into the back two stalls of the red ruffed lemur side for mesh-to-mesh introductions. There was immediate aggression by the red ruffed lemurs toward the ring-tailed lemurs, charging and attempting to grab through the mesh. Camille, the subordinate female, was also showing some aggression in response, attempting to grab and open mouth gaping/yawning. By the end of the day, Heath was continuing to patrol the mesh and attacking any ring-tailed lemur that came close. Little Dipper was not showing any more aggression toward the ring-tailed lemurs, but this lack could have been because Heath was displacing aggression toward the ring-tailed lemurs onto her. Denise and Jerry would run any time Heath approached. Camille would either ignore or back down from Heath's aggression.

Things quickly improved from there with lots of observations of lemurs appearing relaxed, although Heath continued to periodically patrol and displace aggression onto Little Dipper. The groups were switched within holding so the ring-tailed lemurs could have exhibit access. The sifaka were moved to the building on 11 Sep 2012. The red ruffed and ring-tailed lemurs seemed to enjoy watching them and their arrival did not change the routine or behavior of the resident lemurs.

The next step of physical introductions was done on 18 Sep 2012. The lemurs were given a roundabout in the stalls as well as access to the exhibit. There was a lot of chasing, but only three instances of physical contact were seen (two swats, one tail pull). The red ruffed lemurs seemed to be keeping the ring-tailed lemurs in the back stalls, but the group was relaxed enough to leave together overnight after a brief separation for feeding.

This power balance continued until November when the ring-tailed lemur females were observed chasing and slapping Heath. From that point on, they appeared to be dominant over Heath. By February 2013, the lemur dominance order was worked out: Little Dipper was on top (except with her conspecific) followed by the ring-tailed lemurs in the order previously mentioned and then Heath at the bottom. February 2013 was also the first time the entire group was voluntarily locked out on exhibit.

Discussion

As of writing (December 2013) the lemur group is still maintaining their established hierarchy. Breeding seasons did not produce a noticeable difference in behavior for the group, just some interspecific squabbling. We had been keeping the lemurs together overnight as recommended for ring-tailed lemur introductions[2]. However, when we entered into the birth window for the ring-tailed lemurs, we did start overnight separation. This practice has remained because it makes it easier to ensure the ring-tailed lemurs do not eat the red ruffed lemurs leftover food. There have not been any issues putting the group back together in the morning.

The creation of the fourth stall proved to be beneficial in two ways. We were able to separate all ring-tailed lemurs at feeding times, which over time led to Jerry getting down to a healthy weight and no longer requiring diabetic medication. The fourth stall also has a lower height making it ideal for lemur catch-ups.

We still have not had any lemur infants. Our plan is to separate the species for a duration of time as recommended by Duke Lemur Center and their extensive experience with mixed species breeding groups. Duke puts ring-tailed lemur babies back in mixed species groups as early as three weeks and red ruffed lemurs after a minimum of four to five weeks[3].

Figure 3. Little Dipper, Camille, and Denise forage together on exhibit in December 2013

When I was first told of the need to combine our lemurs, I felt very apprehensive. There did not seem to be a lot of written information out there regarding mixed species lemur groups. The Prosimian TAG Husbandry Workshop and Prosimian Keepers group on Facebook proved to be excellent sounding boards. If your zoo is going to attempt the same thing and wants more information, I highly recommend using these resources.

Acknowledgments

Thank you to the following MPZ staff: Dr. Sue Lindsey, Denny Charlton, Jackie Graybeal, and Katie Alexander (partner extraordinaire).

Endnotes

[1] 2012 Prosimian TAG Husbandry Workshop, discussion on mixed Varecia/Catta

[2] 2012 Prosimian TAG Husbandry Workshop, presentation on Handling Aggression (in Ring-tailed Lemurs) by Lynne Villers of the Indianapolis Zoo

[3] 2012 Prosimian TAG Husbandry Workshop, presentation on Parturition Management at Duke Lemur Center

Coquerel's Sifaka: Parental behaviors as observed in first-time parents

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Amy is enrolled in Miami University's Advanced Inquiry program. This program, a unique partnership between Miami University, Project Dragonfly, and the Cincinnati Zoo and Botanical Garden, focuses on developing inquiry-based teaching skills while encouraging students to affect positive social change in their local communities.

Introduction

Coquerel's sifaka (*Propithecus coquereli*) are a medium-sized lemur species endemic to the dry deciduous forests of northern Madagascar. These tree-dwelling prosimian primates are more closely related to bushbabies, lorises and tarsiers than to modern monkeys, apes or humans (Jolly, 1966). Currently, Coquerel's sifaka (pronounced: "she-FAHK") are listed as endangered by the International Union for Conservation of Nature mostly due to habitat loss from unsustainable agricultural and timber harvesting practices (IUCN, 2013). While eating lemurs was once considered taboo, a growing threat to their survival is hunting for the illegal bushmeat trade (Kinver & Gill, 2011).

Coquerel's sifaka move around on the ground by bipedal, sideways hopping, but most of their time is spent in the trees where they use a form of locomotion known as vertical clinging and leaping (Jolly, 1966). In the wild, Coquerel's sifaka eat mostly leaves, fruit, flowers and bark. In captivity, they receive a variety of vegetables, leafy greens, fruits, seeds, beans, mini leaf-eater biscuits* and fresh browse multiple times a day (Miller, personal communication, 2012). A diurnal species, Coquerel's sifaka are awake during the day and spend the night sleeping up in the trees to evade predators (Jolly, 1966). Coquerel's sifaka prefer to live in social groups ranging in size from a single adult pair to many individuals, with an average group size of five animals (Richard, 1978; Bastian & Brockman, 2007).

In lemur society, females are the dominant sex and males are submissive (Kappeler, 1991; Kappeler, 1993; Dunham, 2008). This social system is thought to have developed as an adaptation to the high cost associated with reproduction and childbirth and the limited availability of food resources in their natural habitat (Dunham, 2008; Grieser, 1992). Females get first choice when feeding and may initiate aggression if access to the food is threatened (Kubzdela et al., 2005). Most of the time, males submit to females and serve the social role of protecting and defining territories for their group. Male aggression, though rare, peaks during the breeding season when females are in estrus (Brockman, 1999).

In the wild, sifaka breeding occurs between January and March and following a 155-165 day gestation mothers give birth, typically to a single infant, in June and July (Bastian & Brockman, 2007; Miller, personal communication, 2012). This is the dry season when food resources are most scarce (Bastian & Brockman, 2007), so taking care of an infant is metabolically expensive (Dwyer, 2011; Grieser, 1992). Infants instinctually grip their mother's chest for the first few weeks of life and

Image 1. View from the Jungle Trails African Building lobby into the Coquerel's Sifaka exhibit. *Photo courtesy of Amy Thompson*

gradually transition to riding on her back for the next six months (IUCN, 2013). Infants reach mature size by one year of age (IUCN, 2013; Mittermeier et al., 2008).

As with most primate species, the female sifaka is the primary infant caregiver (Wright, 1990). Since wild sifaka females seem to be very intent on the business of survival, they rarely respond to an infant's desire to play except when resources are plentiful (Richard & Heimbuch, 1975). Some females will allow males to participate in childrearing activities such as holding and grooming, but these interactions are not presumed common because sifaka do not maintain pair bonds (Bastian & Brockman, 2007; Brockman, 1999; Grieser, 1992). Grieser (1992) was able to show that male Coquerel's sifaka display more paternal care behaviors than any other lemur species, which would seem to suggest that at least some males take an interest in caring for their offspring.

Based on the recommendation of the Sifaka Species Survival Plan (SSP) managed by the Association of Zoos and Aquariums (AZA), the Cincinnati Zoo acquired a pair of Coquerel's sifaka in 2011, a 3-year-old female ("Wilhelmina") and an 8-year-old male ("Rinaldo"), with hopes that the pair would breed (Johnson, 2012). For long-term survival of the captive population and maintenance of genetic diversity, these cooperative programs are essential.

On 03 September 2012, the female gave birth to a single infant with the sire present. The group size was 1.1 so no additional animals were present. Though the pair was observed breeding between 02 March 2012 and 01 April 2012, keepers did not suspect that the female was pregnant, however, during a routine check of the animals in their off-exhibit holding area, keepers discovered a newborn infant clinging to the female's chest (Ulrich et al., personal communication, 2012). During the next 24 hours, keepers watched the pair closely for signs of aggression or infant neglect (Miller, personal communication, 2012). Satisfied that things were going smoothly, zoo managers decided to keep the family group together and keepers were able to weigh the infant and determine gender (male) on 04 September 2012 (Miller personal communication, 2012). The weight, recorded at 98 grams, was within the acceptable range (85-115 grams) of a day-old infant (Dulaney, personal communication, 2014). This birth marked the first of its kind for the species at the Cincinnati Zoo and was also the first infant for the pair. At the time of his birth, the newborn and his parents were three of approximately 54 sifakas found in U.S. zoos (Johnson, 2012).

Image 3. Dam with infant. *Photo by Amy Thompson.*

Bastian & Brockman (2007) note that male-infant interactions can be difficult to assess in captivity because some institutions separate the dam and newborn from the rest of their social group for a short period of time post parturition to monitor the infant's well-being (Bastian & Brockman, 2007). Keepers at the Cincinnati Zoo and Botanical Garden did not find it necessary to separate the dam and her newborn from the sire following the infant's birth. This gave both parents uninterrupted and equal opportunity to interact with the infant.

Image 2. View of man-made branches and vines, natural bamboo poles, concrete floor, and painted walls in the exhibit. Photo courtesy of Amy Thompson.

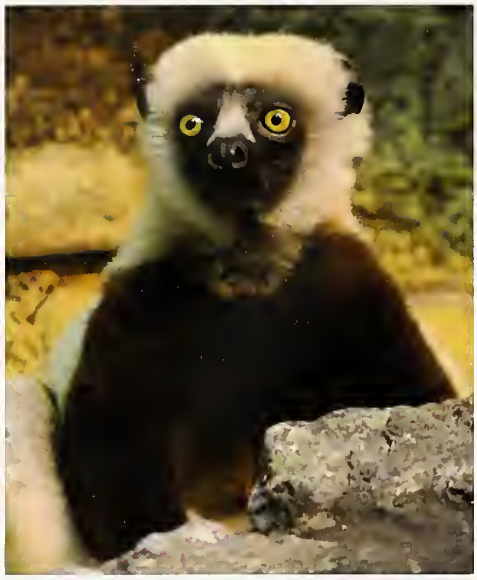
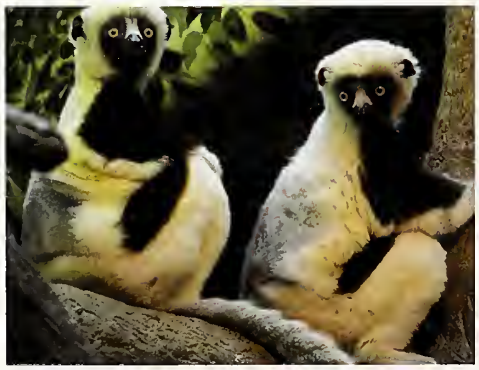


Image 4. Sire.

Coquerel's Sifaka.

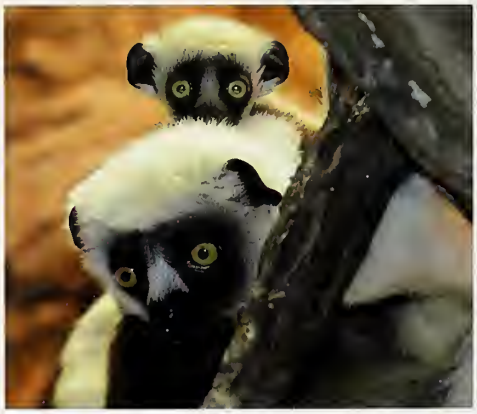


1.1 Coquerel's Sifaka.

Mother-Infant Eye Contact

Coquerel's Sifaka Family.

Dam and Infant.



Dam and Infant

Upon initiating this study, the researcher conducted a review of literature focused on learning more about the interactions of both wild and captive adult Coquerel's sifaka with their infants. This information helped the researcher develop an observational study appropriate for collecting data on sifaka parental behaviors observed at the Cincinnati Zoo. The question that the researcher wanted to know more about was: Would the Coquerel's sifaka pair at the Cincinnati Zoo exhibit parental behaviors similar to those observed in the wild and in other captive situations, or would the dam and sire be unique in the way that they cared for their infant? The goal of this study was to assess, compare, and contrast male and female behaviors, targeting the occurrence of the four parental care behaviors previously identified by Bastian and Brockman (2007): grooming, holding, carrying, and playing with the infant.

It was anticipated that the findings of this study would be useful to zoo keepers and zoological managers who rarely have time in their busy schedules to personally conduct lengthy observational studies. By partnering with volunteers, students, and interns, keepers have an opportunity to capture important behavioral information about their animals that could be used to refine husbandry practices. This study will also expand upon our limited knowledge of paternal care behaviors in Coquerel's sifaka, particularly within zoos, and could be shared with other organizations interested in captive lemur management and species conservation.

Methods

The Coquerel's sifaka were housed in the Cincinnati Zoo's Jungle Trails African building. An observational study of this family group was initiated on 30 September 2012 and terminated on 10 November 2012. A total of seven observation dates were classified as observation periods I through VII (Figures 1-4). The infant was 27 days old at the initiation of the study and 68 days old at the completion. During the observational period, the group was housed exclusively in the indoor display of the Jungle Trails African building with access to off-exhibit holding areas during daily exhibit cleaning and maintenance by the keeper staff (Ulrich, personal communication, 2012).

For 60 minutes, once a week, the lemur family was observed by the researcher through the glass of the public viewing window in the lobby of the Jungle Trails African Building. The exhibit dimensions were 19 feet deep from the exhibit glass to the back wall by 26 feet wide from side to side by 16 feet high from floor to ceiling (Hutson, personal communication, 2012). For climbing, the exhibit featured floor-to-ceiling, man-made tree structures, branches, and vines inter-mixed with natural bamboo poles (Images

1 and 2). The floor of the exhibit was concrete. The walls and ceiling, also made of concrete, were painted with a forest mural. Pools in the exhibit, which may have been designed to hold water, were empty during the observation period. Food, including fresh browse, was offered in hanging PVC bowl-style feeders, scattered about the exhibit, or suspended from branches. Water was available *ad libitum*. Keepers provided the Coquerel's sifaka family group with daily environmental enrichment and conducted training sessions with the animals in their exhibit.

An ethogram was developed for capturing behavioral data. Instantaneous scan sampling of individual animal behavior was conducted every five minutes for periods of 60 seconds. Focal animal sampling documented occurrences of significant or interesting behaviors or interactions that occurred between instantaneous scan sampling data collection points. All instances of infant independent exploration, characterized by non-physical contact with an adult, were recorded. Out of thirty-four initially identified behaviors, only the four parental behaviors identified by Bastian & Brockman (2007) were targeted for further analysis. Those parental behaviors were: 1) infant grooming (licking or cleaning the infant's fur), 2) infant carrying (contact with infant while moving from place to place), 3) infant holding (contact with the infant while stationary), and 4) infant play (attention getting behaviors such as nudging, grabbing, pawing, or tugging). Microsoft Excel was used to analyze relevant data and produce figural representations of this information.

Results

During the observation period, which included seven separate observation dates, there was never an instance of male initiated aggression towards the female or infant. The female, however, was aggressive towards the male on one occasion when he attempted to reach for and groom the infant. This show of aggression (alarm vocalization and posturing) was very brief and the male was allowed to again approach the infant for grooming a few seconds later.

Of the targeted parental care behaviors (grooming, carrying, holding, and playing with the infant), only the female displayed all four (Figure 1). While the male held and groomed the infant, he did not play with the infant or carry it (Figure 2). Over time, the trend for infant grooming, play, and holding all decreased for the female, while infant carrying increased (Figure 3). When the four, targeted parental interactions are summed for both the male and female, both sexes show a decreasing trend in frequency of occurrence for parent-infant interactions over time (Figure 3).

During observation period IV, the male and female showed the most similar distribution of total time spent interacting with the infant. Thirty-six percent of parental interactions occurred between the male and the infant while sixty-four percent of parental interactions occurred between the female and the infant. During all other observations periods, the female overwhelmingly dominated the observed percentage of parent-infant interaction.

With increasing age, the infant spent more time independently exploring away from his parents (Figure 4). During these bouts of independent exploration, the infant was never more than approximately two feet away from reestablishing physical contact with either the dam or the sire. Distance ventured away from the adults ranged from a few inches to a couple of feet, but not more than that for the duration of the study. As the infant explored more independently, the data showed a general decrease in frequency of adult-infant interaction (Figure 4).

On average, the male had 1.7 bouts of infant grooming behavior per hour, 0.0 bouts of infant carrying per hour, 0.3 bouts of infant holding per hour, and 0.0 bouts of engagement in play per hour for the observation period (Table 1). The female averaged 3.9 bouts of infant grooming behavior per hour, 4.9 bouts of infant carrying behavior per hour, 4.3 bouts of infant holding per hour, and 0.3 bouts of engagement in play per hour for the observation period (Table 1).

Discussion

Some studies suggest that paternal care is rare in primates and even more so in prosimian primates including lemur species (Grieser, 1992; Sussman & Garber, 2007). Furthermore, Trivers (1972) suggests that paternal care should evolve only where paternal certainty exists. A general lack of pair bonding in the species would seem to predict the absence of male-infant care, but this is not always the case (Bastian & Brockman, 2007; Brockman, 1999; Grieser, 1992).

In this study, the male can be certain of his paternity because he was the only mate available to breed the female. Observations of the sire holding and grooming the infant show that two of the four, targeted parental care behaviors were met, which supports the findings of prior studies where paternal care was expressed in this species (Bastian & Brockman, 2007; Dwyer, 2011). The data collected as part of this study is consistent with research revealing that males are capable of providing at least a minimal level of infant care (Bastian & Brockman, 2007; Dwyer, 2011; Grieser, 1992). Even if the male's paternity were in question, he may be able to increase his odds of siring future offspring with the dam if he helps her care for the newborn infant (Grieser, 1992).

It is important to realize that the typical husbandry protocol following the birth of a captive Coquerel's sifaka would be to separate the dam and infant from other group members for at least one week post-birth to allow for infant monitoring (Bastian & Brockman, 2007; Miller, personal correspondence, 2012). Bastian & Brockman (2007) predicted that infant directed caregiver aggression is likely underestimated because of this separation. Since no separation period took place at the Cincinnati Zoo, opportunities for male-infant interactions were constantly available and, luckily, when these interactions did occur, they were all docile in nature. Data gathered as part of this study refute Bastian & Brockman's (2007) reasoning for the underestimation of infant-targeted aggression.

In the wild, female Coquerel's sifaka struggle to meet metabolic needs while raising infants in a resource poor environment and may require

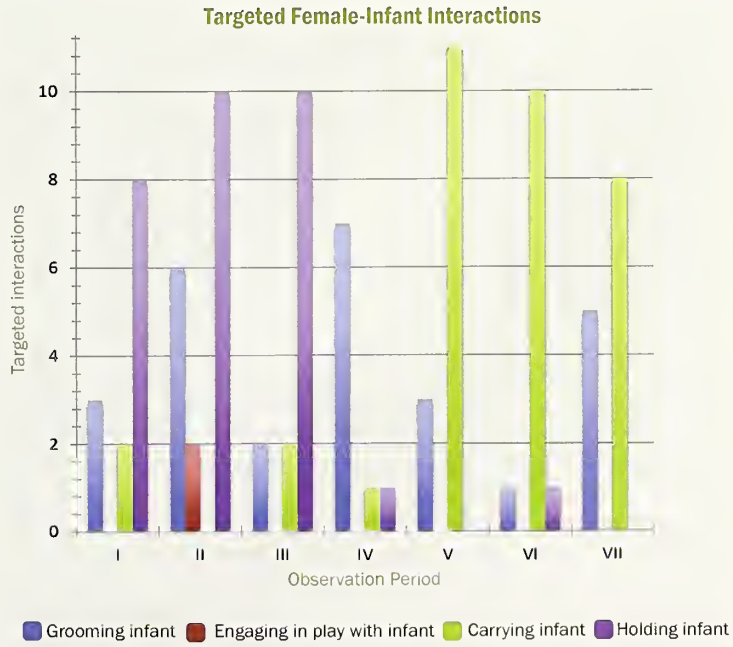


Figure 1. Occurrence of targeted female-infant interactions (grooming, play, carrying, and holding) as they occurred during each of the seven observation periods.

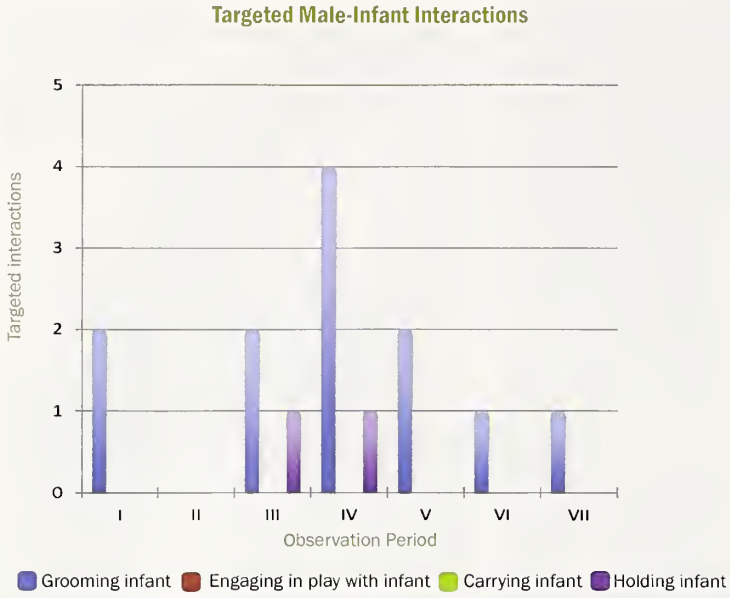


Figure 2. Occurrence of targeted male-infant interactions (grooming, play, carrying, and holding) as they occurred during each of the seven observation periods.

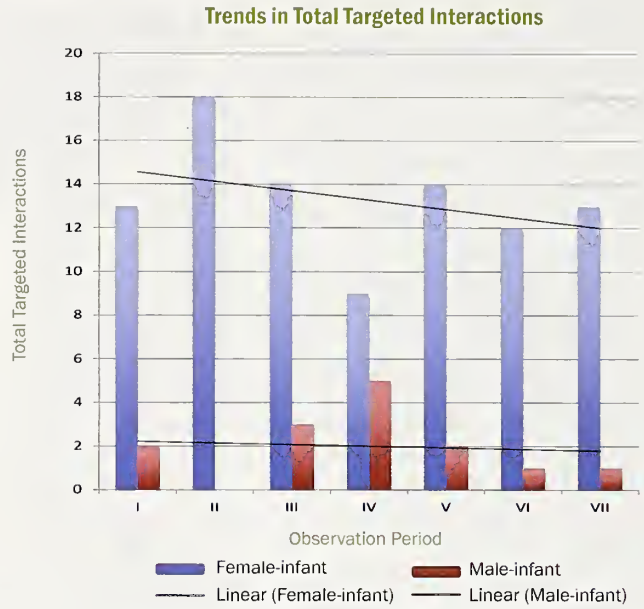


Figure 3. Total targeted female-infant and male-infant interactions for each observation period as shown with a linear trend line.

more help in general (Dunham, 2008; Grieser, 1992). In captivity, food resources are plentiful, predators are absent, and round-the-clock veterinary care is available. Though evolutionarily programmed to act a specific way, captive sifaka mothers are not taxed as heavily to meet their physiological demands. The influence of a "comfortable" captive environment should be taken into account when trying to explain observed differences in parental care as compared to studies done on wild populations where resource availability is undoubtedly more sporadic.

When comparing behavioral data, one might expect to see the expression of more similar behaviors when comparing day-to-day captive behaviors to behaviors observed in the wild during the wet season when food is plentiful. In other words, the resource-depleted environment of the dry season in Madagascar does not compare to the resource richness of captivity. Richard & Heimbuch (1975) reported that females only play with infants during the wet season when resources are plentiful. Thus, female play-based interactions, like those observed between the dam and infant in this study should be expected in the captive environment, but may not be seen as often in the wild.

Data collected in this study showed that mother-infant interactions were more frequent than father-infant interactions during the infant's first few months of life, presumably because the infant still needed to nurse, and only the dam could provide this service (Wright, 1990). Over time, mother-infant interactions decreased for the targeted parental behaviors of infant grooming, infant holding, and infant play. Infant carrying, however, increased over time. Perhaps less time spent nursing allowed for more mobility and should be examined in future studies.

Occurrences of targeted male-infant interactions, though existent, were not abundant. The only targeted behavior the male performed with any great frequency was infant grooming (Figure 2). Looking at observation period IV, the percentage of caregiver behaviors for the male most closely mirrored the expression of caregiver behaviors for the female (Figures 1 & 2). During this observation period, the family of lemurs sat together and had an extended grooming session in which the male held and groomed the infant for more than five minutes. Conspecific grooming in Coquerel's sifaka seems to reinforce social bonds and is a parental behavior worthy of tracking.

Previous research suggests that older males are more likely than younger males to hold, groom, and carry infants (Bastian & Brockman 2007). Future studies should explore this finding further, but the current study cannot support or negate this observation. From an animal care perspective this study is important because even though they were first-time parents, both sifaka exhibited appropriate parental care behaviors without the necessity of human intervention post-birth.

The relationship between individual interactions, group dynamics, and species persistence in the wild is currently unclear for Coquerel's sifaka. The pool of data containing information about parental care behaviors is also limited for the species. Questions about whether paternal-infant care is a male reproductive strategy should drive further research. Also, future research studies should track sifaka infant survival rates when males are known to have participated in parental care. When a sire's offspring survives, his genes continue in the population, so from a reproductive standpoint, anything males can do to ensure their infants survival has evolutionary benefits. In this study, the male spent a substantial amount of time grooming and holding the infant. Both are necessary but time-consuming parental functions. Also, any time a male sifaka assumes important parental responsibilities, it likely benefits the survival of the metabolically-taxed reproductive female. For the long-term survival of the species, parental investment benefits everyone.

An additional limitation of this study is that it only reports data following one birth and does not compare data from a larger sample. Also, the study began when the infant was 27-days-old and it would be nice to have observational data collected during the first month post-birth. Given the timeframe and scope of this particular study, further data

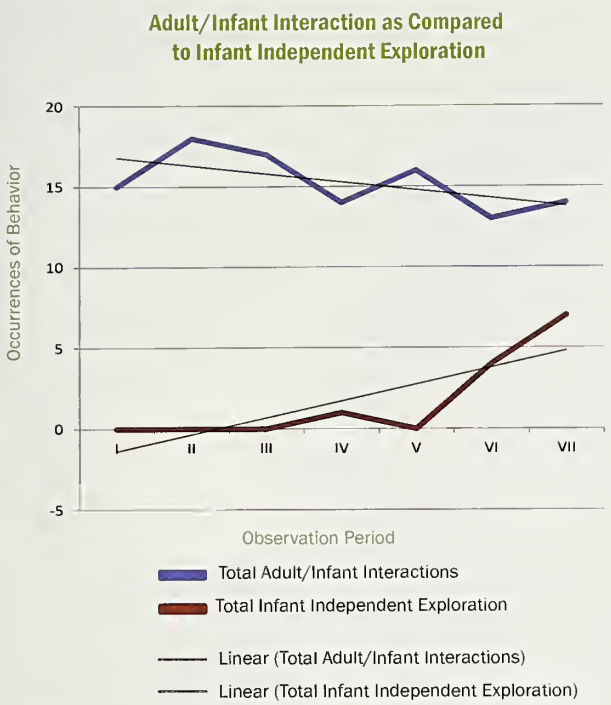


Figure 4. Comparison between total time that the infant spent interacting with an adult and the total amount of time the infant spent independently exploring, free of physical contact with an adult.

collection was not possible. In 2013, the Cincinnati Zoo's sifaka pair did go on to produce another infant, therefore it is hoped that other researchers might continue this project as long as the pair continues to successfully produce offspring. Any data collected could be used to supplement the current body of literature on the subject.

Conclusion

Much of the knowledge gained about this species has, and will continue to come from observations made of captive animals. Knowledge gained by studying captive sifaka should be applied towards the conservation of their wild counterparts in Madagascar. Overall, it is anticipated that this study will contribute to the pool of knowledge pertaining to Coquerel's sifaka behavior, and it will inspire further research as well. Clearly, understanding how all of these factors interrelate is key to the survival of the species in the wild, and essential to their continued success in the captive breeding program.

In addition to captive animal management strategies and ongoing research programs, habitat protection will also be vitally important for the long-term survival of Coquerel's sifaka in the wild. Most of Madagascar's original forests have already been cleared for agriculture and other developments (IUCN, 2013). The loss of Madagascar's biological diversity would be devastating. Madagascar is currently recognized as a world biodiversity hotspot and conservation projects aimed at saving lemur species should be amplified.

The results of this study should serve as a reminder for keepers about the many benefits of partnering with volunteers, students, and interns when you have questions about the animals that you care for. These arrangements provide opportunities for capturing important behavioral information and can be used to refresh and refine traditional husbandry practices.

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* Mazuri® Leaf-Eater Primate Diet Mini-Biscuit #5672. Catalog #: 0001448.

Sifaka photos by Author

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RH: Nutritional therapy and insulin resistance

Effects of insulin dose in combination with supplemental dietary SOLUBLE FIBER on the amelioration of blood glucose in an insulin-resistant collared lemur *(Eulemur collaris)*

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Abstract:
Obesity and associated diabetic disorders are not uncommon in captive nonhuman primates. Dietary manipulation including supplementation with food sources high in soluble fiber, has shown therapeutic potential with hypoglycemic effects in both human (*Homo sapiens*) and baboon (*Papio ursinus*) subjects. A female collared lemur (*Eulemur collaris*) approximately eighteen years of age presenting with hyperglycemia and pathology consistent with insulin resistance was supplemented via the diet with 7.5 to 10.0 g of purified soluble fiber (*Amorphophallus konjac*) per day in addition to conventional insulin therapy. Prior to dietary supplementation, blood glucose was highly unpredictable with only brief responses to progressively increasing insulin dosages. Between May of 2006 and March of 2007, the units of insulin required to elicit a hypoglycemic response had increased from five to eighteen units per 24 h period. Post dietary inclusion of supplemental dietary soluble fiber, in combination with insulin therapy and a low glycemic load diet appeared consistent with a numeric decrease in blood glucose without further increases to insulin dose. This reduction in blood glucose concentration appeared to be associated with an increase in consumption of soluble fiber, nevertheless due to the lack of appropriate scientific controls it is difficult to make a definitive conclusion as to which combination of factors indeed led to the improvement. Further research into the efficacy of dietary soluble fiber as a component of treatment for insulin resistance in nonhuman primates appears warranted.
Key Words: Diabetes, diet, fiber, glycemic, nutrition

Introduction

Improvements in veterinary and husbandry care have led to an increase in the longevity of captive primate populations. However, with increasing numbers of geriatric individuals, concern has developed as to the progressive treatment of common disorders that may be associated with an aging population and a lifestyle where nutrients can be plentiful and physical activity is often optional.[4,13,16] When the energy consumed by an animal exceeds the energy required, excess body condition and the pathogenesis of diabetes and insulin resistance are often the result.[5,11]

In the wild, predominantly frugivorous nutritional strategies are not uncommon to the primate order.[12] However, the free-ranging plant biomass that is naturally encountered and consumed by the majority of these species has been demonstrated to possess nutritional profiles that vary widely from the usual diets fed in captivity.[12] Wild-type fruits for example have been shown to contain much higher concentrations of neutral and acid detergent dietary fiber and lower levels of soluble sugar in comparison to the fruits and vegetables cultivated for human consumption.[6,12] Native fruit species commonly consumed by chimpanzees (*Australopithecus*) for example have been suggested to contain as high as 33% neutral detergent fiber as compared to approximately 10% for both fruits and vegetables produced by means of modern cultivation.[1] The high level of dietary fiber that appears to be associated with native feedstuffs, in comparison to those grown domestically for the human market, suggests that typical zoo diets formulated using farm-grown produce may not satisfy species-specific fiber requirements.

Significant among the many benefits associated with the consumption of soluble dietary fiber is its suggestion as a supplemental therapy to promote the regulation of blood glucose at the onset of diabetes and insulin resistance.[2,8,15] Specifically, fiber sources rich in β-glucans, e.g. β-D-glucose and β-D-mannose oligosaccharides, have been demonstrated to improve glycemic control within multiple species. Venter et al. (1990), studied the effects of *Amorphophallus konjac*, a tuber known to contain high levels of soluble fiber, when fed to a population of twelve male baboons as part (5% as fed) of a diet consisting of precooked whole soybean meal, refined corn meal, beef tallow and sucrose at 38.3, 38.3, 13.4 and 10.0 g per 100 g of as fed diet respectively. Animals receiving *Amorphophallus konjac* supplementation demonstrated a 9.4% reduction ($P < 0.05$) in mean fasting glucose (mmol/L) from non supplemented subjects.[15] Additional research utilizing biscuits enriched with soluble fiber, approximately 10% *Amorphophallus konjac* flour (AK) as dry matter, demonstrated a 5.6% reduction ($P < 0.003$) in serum fructosamine and a concomitant 13% decrease ($P < 0.0001$) in fasting glycemia as compared to a decrease of 0.39% with control.[17]

Molecular structure

The biochemical structure of the konjac oligosaccharide is composed of a tetrasaccharide, containing β-D-glucose and β-D-mannose sub-units linked via β-glycoside bonds with a reductive terminal α-D-mannose sub-unit.[7] Utilizing the ratio of neutral to acid detergent fiber, as determined via commercial laboratory, contained within the experimental diet (Table 1) it can be presumed that the elevated fiber concentration associated with the konjac formulation is due primarily to an increase in hemicelluloses, over fiber compounds of more structural significance such as cellulose and lignin. This indicates that the majority of the increase in total fiber concentration as a function of *Amorphophallus konjac* is due to the more biologically-active soluble rather than insoluble dietary fiber. However, it should be noted that lignin was not specifically determined and thus quantification of hemicellulose may be unreliable.

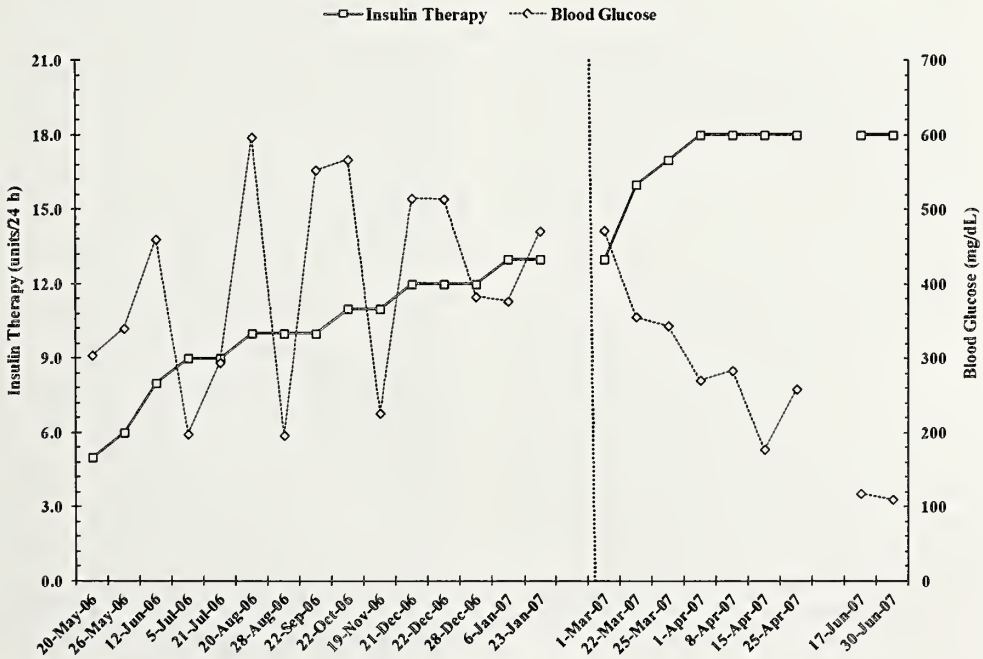

Figure 1. Insulin therapy (units/24 h) and associated blood glucose measurements (mg/dL) as related to all treatments over the course of a 12-month period. *Amorphophallus konjac* was included in the diet beginning 2 April 2007.

Mechanism of action

The regulation of blood glucose relies heavily on the recognition of insulin at the level of peripheral tissues[3]. Insulin resistance therefore, can best be described as the inability of these tissues to respond to insulin stimulation resulting in a reduced glucose intake to the tissues and increased hepatic glucose output[3]. In humans, the diabetic condition is characterized by recurrent, persistent hyperglycemia and can be diagnosed through the demonstration of random plasma glucose measurements at or above 200 mg/dL, fasting plasma glucose concentrations at or above 126 mg/dL or plasma glucose levels at or above 200 mg/dL two hours after a 75 g oral dose of glucose[18].

The theorized mechanisms, by which soluble fiber e.g. *Amorphophallus konjac* helps to regulate hyperglycemia, are many. One such conjecture suggests that the increase in circulating short chain fatty acids, specifically propionate that occurs with elevated levels of soluble dietary fiber, may inhibit fibrinogen synthesis in the liver, thus lowering the levels of circulating free fatty acids and inhibiting the hepatic insulin resistant state[15].

There is also mounting support within the literature correlating a reduction in glycemic response with consumption of highly viscous dietary polysaccharides[2,17]. Research conducted in 2001 suggests that the high viscosity, 12×10^{-1} cP, associated with various forms of soluble dietary fiber may be the cause for the amelioration of increases in plasma glucose concentrations.[17] The rheologic properties that are generated as a result of the digesta and soluble fiber combination slow the rate of glucose absorption in the small intestine and thus decrease postprandial surges of glucose and potentially improve peripheral insulin sensitivity.

In addition, the pathogenesis of diabetes has previously been correlated with oxidative stress of pancreatic islet β-cells.[14] It has been proposed that soluble fiber, specifically konjac oligosaccharides, may function in an antioxidant capacity with regards to free radical damage of these cells due to nitric oxide attack[14]. Research carried out in 2002, utilizing pancreatic islets isolated from 3-week-old mice to assess the antioxidant influence of contact with a gel forming fiber source during free radical challenge from Streptozotocin, concluded that islet function as determined by insulin secretion was directly correlated with nitric oxide level in the medium and that

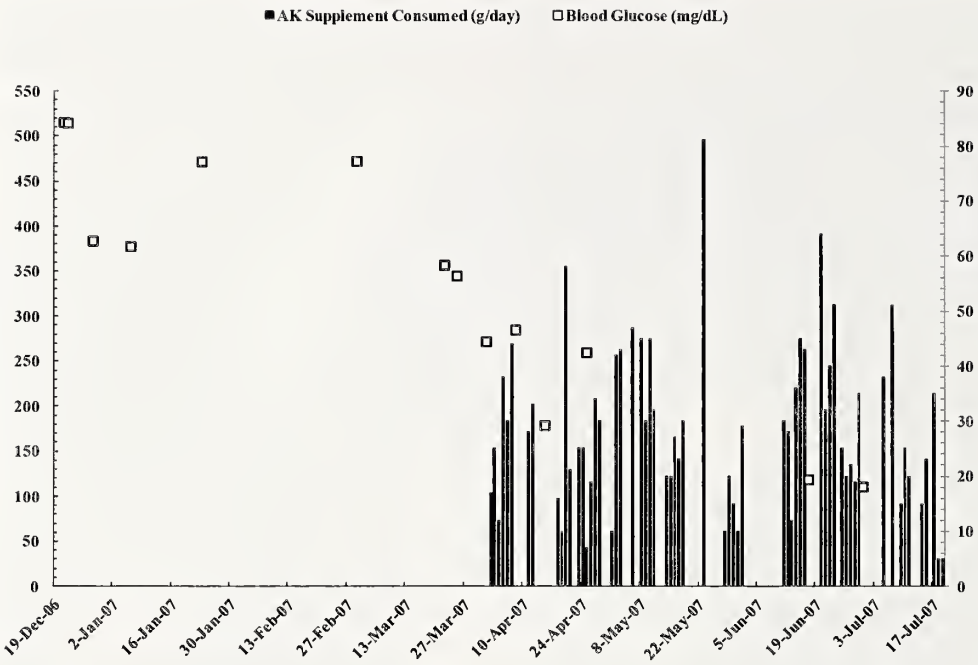

Figure 2. Measured blood glucose (mg/dL) and the associated consumption of the *Amorphophallus konjac* biscuit as fed from 19 December 2006 until 30 June 2007.

subsequent incubation with *Amorphophallus konjac* oligosaccharides from 1.5 to 1.5 x 10^{-4} mM down regulated nitric oxide formation and ameliorated insulin secretion within the test media[7].

CASE REPORT

Subject description and environmental parameters

In November of 2005 a geriatric female collard lemur (*Eulemer collaris*) approximately 18 years of age, presenting with weight loss, alopecia and general lethargy was admitted to the veterinary hospital at the Indianapolis Zoo. Upon completion of standard diagnostics, elevated serum glucose (311 mg/dL) and fructosamine (600 mg/dL) as well as significant glucosuria (>1000 pmol/L) were consistent with a diagnosis of poor glycemic control. Elevated serum insulin levels (357 pmol/L) were consistent with a diagnosis of insulin resistance. It is acknowledged that lemurs can demonstrate stress-induced hyperglycemia with associated glucosuria, however this individual maintained glucosuria even when urine was collected non-invasively. Consistently high fructosamine levels also support the diagnosis of *diabetes mellitus* in this case.

Following diagnosis, standard diabetic treatment protocols were instituted. Due to a consistently poor response to oral hypoglycemic therapies, insulin therapy and traditional dietary manipulation, an elevated level of soluble dietary fiber, in the form of *Amorphophallus konjac*, was incorporated into the diet as a therapeutic strategy to assist in the amelioration of hyperglycemia in this individual. During the investigation, the animal was maintained at the Winter Holding facility at the Indianapolis Zoo in a 9.0 x 6.0 m indoor enclosure that had direct access to an outdoor holding space of similar dimensions. Indoor temperature was maintained between 22 to 24°C year-round and a nine-hour photoperiod was provided daily between approximately 0800 and 1700 hours. The subject was housed with a single male conspecific of similar age making possible both hand-feeding of individual rations and daily approximation of feed intake by keeper staff.

Therapy prior to soluble fiber supplementation

Upon initial diagnosis in November 2005, the animal began treatment with the oral hypoglycemic medication Glipizide (Glipizide, Mylan Pharmaceuticals Inc., Morgantown, West Virginia 26505, United States) at a dose of 2.5 mg/day. Non-invasive collection methods were utilized to monitor urine glucose to avoid producing stress-induced hyperglycemia and subsequent glucosuria. The animal was manually-restrained for blood collection once per week for blood glucose determination and at least once monthly for serum fructosamine determination. Medications were adjusted to include insulin (Ultralente, Eli Lilly and Company, Indianapolis, Indiana 46285, United States and Glargine, Sanofi-Aventis, Bridgewater, New Jersey 08807, United States) based on blood glucose and fructosamine levels. The animal was observed daily by keeper staff who recorded mentation and activity levels.

Nutritional therapy including soluble fiber supplementation

Traditional diabetic dietary treatment protocols were instituted in Nov 2005 including the removal of a primate biscuit containing a moderate sugar concentration and the incorporation of a mixed diet containing significantly less fruit and increased fresh vegetables as a percent of total diet. Nutritional therapy was further modified 2 March of 2007 consisting of a transition to *ad libitum* access of a commercial primate biscuit[9] (Table 1), approximately 92% dry matter (DM) containing 6.1% soluble sugars (DM), value based upon independent analyses via commercial laboratory, and the incorporation of approximately 20.0 g *as fed* of low glycemic load produce items only per day.

On 2 April of 2007 the diet was modified once more to include 7.5 to 10.0 g of *Amorphophallus konjac* flour per 24 h period, formed into a biscuit (Table 1) by hand, using a combination of 20.0 g of high fiber commercial primate biscuit, ground to approximately 2 mm utilizing a Waring® Commercial 3.78 L, Professional Food Processor, with 40.0 g, by weight of unsweetened cherry juice obtained from thawed, individually quick frozen raw cherries. The biscuit was reconstituted using cherry juice due to the low glycemic load typically associated with this fruit[10]. The konjac biscuits were hand-fed by keeper staff to the diabetic individual only and consumption was monitored and recorded daily.

Glycemic control was not achieved with oral therapy and initial diet change. As blood glucose levels rose, keeper staff noted increased lethargy in the animal. In December 2005, insulin therapy was initiated at a dose of 0.50 units of Ultralente insulin (Ultralente, Eli Lilly and Company, Indianapolis, Indiana 46285, United States) delivered subcutaneously once per day. The dose was gradually increased based on serum glucose and fructosamine levels. In May 2006, Ultralente became unavailable and treatment with insulin Glargine (Sanofi-Aventis, Bridgewater, New Jersey 08807, United States) at a dose of 5 units, subcutaneous, was initiated daily. The dose was increased gradually over the course of 12 months based on serum glucose and fructosamine levels to a maximum of 18 units per 24 h on 2 April 2007. Serum glucose ranged from a low of 198 mg/dL as determined 5 July 2006 to a high of 597 mg/dL on 20 August 2006 (Figure 1). Fructosamine levels ranged from a low 339 µmol/L on 17 November 2006 to a high of 678 µmol/L on 19 August of that same year. From March 2nd to March 25th, measured serum glucose ranged from a high of 471 mg/dL to a low of 344 mg/dL. Insulin therapy progressed according to measured blood glucose and fructosamine elevations resulting in only intermittent amelioration of hyperglycemia (Figure 1). Mean as fed intake of the konjac biscuit from 2 April 2007 to 19

July 2007 was 28.3 g per 24 h. Consumption of the konjac biscuit during this time (Figure 2) ranged from 0.0 g per 24 h as a low to as high as 81.0 g per 24 h. Regular consumption of the konjac supplement appeared to be correlated with a normalization of blood glucose (Figure 2) and an improvement in keeper-monitored activity level.

Acknowledgements

The entire staff of the Forest's Biome and the Veterinary and Nutrition Department at the Indianapolis Zoo deserve acknowledgement for their diligence and professionalism throughout this process and without whom this investigation would not have been possible.

Conclusions

This lemur was eventually euthanized due to a severe hind limb fracture obtained from a presumed fall from perching within her enclosure. The diabetic condition appeared to be of no clinical significance with regards to the fracture and subsequent humane euthanasia. In addition, the available sections of pancreas showed marked interstitial fibrosis with histologically normal appearing islet cells. These histological findings support the clinical presentation of endocrine disease in this animal.

Although conclusions and a precise mode of action can only be speculated at this time, results from this investigation support a similar deduction, as observed with other species, that the consumption of elevated levels of soluble dietary fiber, e.g. *Amorphophallus konjac,* in combination with insulin therapy and a low glycemic load diet will aid in the amelioration of blood glucose in insulin-resistant individuals. It should be reiterated however, that due to a lack of appropriate experimental controls, definitive conclusions as to a specific cause and effect can only be theorized. Continued research does appear to be justified into the potential of *Amorphophallus konjac* as well as other highly viscous forms of dietary fiber for use as a therapeutic approach to the treatment of diabetic conditions in captive primates.

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Reproductive Management of Ruffed Lemurs (*Varecia variegata* and *Varecia rubra*) in Zoos

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Introduction

Managing reproduction in captive ruffed lemurs can be fairly simple to do, if one knows what to look for. Both male and female ruffed lemurs go through behavioral changes and physical changes during breeding season, and it is important for animal care staff to be able to recognize these changes in order to better manage reproduction of these species. The main purpose of this article is to provide information about reproduction in both black and white ruffed lemurs (*Varecia variegata*) and red ruffed lemurs (*Varecia rubra*) to help improve reproductive management in institutions that have these species, particularly those that are recommended to breed by the AZA (Association of Zoos and Aquariums) Ruffed Lemur SSP (Species Survival Plan). The second purpose of this article is to provide reproductive management information for those institutions that may be considering becoming a part of the AZA Ruffed Lemur SSP in the future.

Estrous Cycling Data Sheet

Female's Name

Date	*Code	Comments	ID

* DESCRIPTION OF VULVA CODE:
0: Vulva completely black and imperforate
1: Vulvar slit begins to separate, forming a visible pink line
2: Vulvar slit begins to evert & enlarge, forming a pink oval opening
3: Vulvar opening at maximum size and a deep pink color
4: Vulva begins to close and lose deep pink color

INSTRUCTIONS:
- During breeding season, visually examine female DAILY from October 1st through April 30th.
- Outside of breeding season, visually examine female 3X/week (Tuesday, Thursday, and Saturday).
- Note behavioral events/changes in Comments section.

Breeding Season in Captivity

Because breeding season for ruffed lemurs is photosensitive (Brockman et al., 1987), the breeding season in North America can range from early October through late April. Studbook data shows that the majority of births occur in April and May (76% for *V. variegata* and 84% for *V. rubra*), thus the majority of conceptions occur late December through February (Whipple, 2014).

Breeding Age

Females reach sexual maturity at around 1 year 6 months to 1 year 10 months (Foerg, 1982; Tattersall, 1982). The studbook data shows that for *V. variegata* the youngest dam was 1 year 2 months and 20 days old while the youngest sire was 1 year 8 months and 3 days old. The oldest *V. variegata* dam was 27 years 1 month and 26 days old while the oldest sire was 38 years 11 months and 28 days old. For *V. rubra* the youngest dam was 1 year 11 months and 7 days old while the youngest sire was 1 year 8 months and 9 days old according to the studbook. The oldest dam was 29 years 11 months and 5 days old and the oldest sire was 29 years 9 months and 29 days for *V. rubra* (Whipple, 2014).

Photo 1a. Lemur positioned for vulva check. *Photo by Mylisa Whipple.*

Photo 1b. Close-up of lemur positioned for vulva check. *Photo by Mylisa Whipple.*

Male Behavioral Changes During Breeding Season

Males show several behavioral changes during breeding season which include an increase in chin, neck and chest marking behaviors. They can be observed attempting to sniff or lick the anogenital area of a female, and they become less reactive to female aggression (Foerg, 1982). When observed attempting to mount a female, the male is usually seen approaching the female in a submissive posture with his abdomen lowered to the ground, making a whining vocalization with his ears flattened against his head (Pereira et al., 1988). Males may make several attempts to mount a female prior to her being receptive to him. Once a female becomes receptive to the male's mounting attempts, the male may become so focused on breeding the female that they physically exhaust themselves, as has been observed in a breeding male at Saint Louis Zoo. Both the male and female may refuse to eat or drink during this period of time (Foerg, 1982).

Female Behavioral Changes During Breeding Season

During breeding season, female behavioral changes include an increase in anogenital scent marking. If a female is not yet receptive to the male's mounting attempts, she may lunge at the male, chase him away, or cuff at him. When the female enters estrus, she usually becomes more solicitous of the male and more receptive to his mounting attempts (Foerg, 1982).

Male Physical Changes During Breeding Season

Males also go through physical changes during breeding season. They exhibit cyclical changes in testicular size. Testicular enlargement usually occurs two to three months prior to females beginning to cycle (Foerg, 1982). These changes correspond with seasonal variation in testosterone production (Bogart et al., 1977). Males housed in family groups with their fathers present usually do not show a comparable increase in testicular size (Foerg, 1982).

Female Physical Changes During Breeding Season

Ruffed lemur females are seasonally polyestrous and can experience up to three cycles during breeding season (Brockman et al., 1987). The female may cycle again if she did not successfully conceive during her first cycle; however Brockman et al. (1987) found that the majority of females conceived during their first cycle at San Diego Zoo (1987). The length of the estrous cycle varies in the research from 30 to 44 days (Boskoff, 1977; Bogart et al., 1977; Shideler et al., 1983; Foerg, 1982). Foerg's (1982) research showed an estrous cycle of 42 days and this is currently what the AZA Wildlife Contraception Center at the Saint Louis Zoo recommends as the cycle length for contraception. As females near estrus, they exhibit visible changes in vaginal morphology that make it easy for animal care staff to monitor.

Monitoring Estrus in a Captive Environment

At the Saint Louis Zoo, the animal care staff checks the vulvas of the females on a regular basis to monitor for estrus and keeps records of estrus on charts (Figure 1). Outside of breeding season the females' vulvas are checked three times per week (Tuesday, Thursday and Saturday). In the past, the animal care staff checked the females' vulvas three times per week until their vulvas started opening and then switched to daily checks, but at least two of the females at the Saint Louis Zoo have opened up so quickly that checks three times per week were not frequent enough to catch the early stages of estrus. Thus, during breeding season their vulvas are checked daily from October 1st through April 30th.

Not only is it very easy to do, but there are several reasons why it is important to monitor the vulvas of female ruffed lemurs. Monitoring

Photo 2. Vulva stage 0. *Photo by Joe Knobbe.*

Photo 4a. Vulva stage 2. *Photo by Alicia Marty.*

Photo 5. Vulva stage 3. *Photo by Alicia Marty.*

Photo 3. Vulva stage 1. *Photo by Joe Knobbe.*

Photo 4b. Vulva stage 2. *Photo by Alicia Marty.*

Photo 6a. Vulva stage 4. *Photo by Alicia Marty.*

Photo 6b. Vulva stage 4. *Photo by Alicia Marty.*

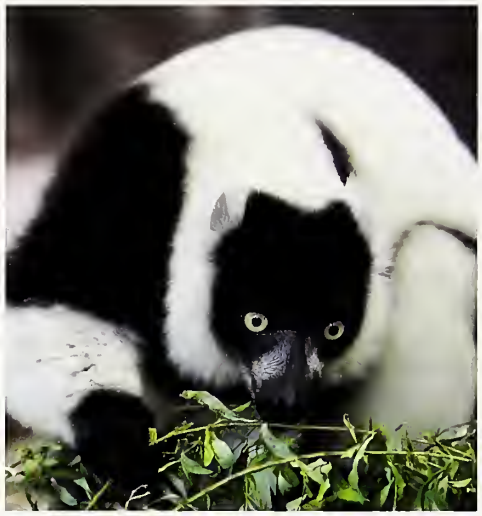

Photo 7. Mother gathering nesting materials. *Photo by Ethan Riepl.*

Photo 8a. Babies in a nest box. *Photo by Ethan Riepl.*

vulvas will indicate when a female is actually in estrus. Also, by monitoring vulvas closely, it can be used to indicate a possible pregnancy and help plan a due date. These vulva checks also help monitor reproductive health and reproductive status of a female. If necessary for animal management, monitoring vulvas can be used to indicate when to separate individuals when contraception is not in use and when a breeding recommendation has not been received. Lastly, monitoring vulvas can indicate if contraception is effective for females not recommended to breed.

Vulva Checks

Females must be positioned so that the vulva is visible for vulva checks (Photos 1a-1b). This can be accomplished in a variety of ways depending on the level of contact an institution allows their animal care staff to have with the species and also depending on the constraints created by the type of habitat enclosures and holding areas. For institutions with protected contact, the lemur could be trained to climb up on mesh or caging in front of a keeper to eye level so that the vulva is visible for vulva checks. Another possibility would be to train the lemur to station in an overhead tunnel above eye level so that the vulva is visible from below. If an institution allows free contact, then the lemur could be trained to station on branches or a platform above eye level so that the vulva is visible from below. The lemur might also be trained to station on branches or a platform and to allow a keeper to lift tail so that vulva is visible from behind. These examples are not an exhaustive list of the training possibilities to achieve proper positioning for lemur checks.

Stages of Estrus (Photos 2-6b)

Stage 0: When not in breeding season the female's vulva is black, closed, and may look deflated. However, the vulva begins to swell as the cycle begins.

Stage 1: The vulval slit begins to separate which can either give the appearance of a pink line along the entire vulval slit or a small oval opening at the distal end of the vulval slit.

Stage 2: As the vulva continues to open, the pink color of the vagina becomes increasingly visible. Over the next few days the vulval opening will continue to increase in size and depth.

Stage 3: Once the vulva reaches its maximum opening, it may stay open for as long as five days (Brockman et al., 1987). Both behavioral estrus and mating will occur at this point and is usually restricted to a 12-hour period or less (Foerg, 1982). Males produce a seminal plug which may sometimes be seen when checking the female's vulva after copulation and can provide an indicator that the copulation was successful.

Stage 4: The vulva will begin to close. Research has shown some variance in the length of time in which the vagina was open and visible from an average of 9.85 days (Shideler and Lindburg, 1982) to an average of 14.8 days (Brockman et al., 1987).

Birth

Monitoring estrus can help animal care staff better prepare for the birth of babies by allowing a more accurate estimation of due date. Ruffed lemur gestation averages 102 days (Boskoff, 1977; Foerg, 1982; Brockman et al., 1987). Ruffed lemurs are nesters so it is important to provide several nest boxes for the mother to have options for her level of comfort. Also, in the weeks leading up to her due date animal care staff need to provide a variety of nesting materials (branches, leaves, bamboo, etc.) on a daily basis for her to build her nest (Photo 7).

Once the babies are born, the mother may choose to move nesting sites several times and must carry each baby one at a time in her mouth to the new nesting location. In captivity, up to six young may be born, however twins are most common. The mean litter size for *V. variegata* is 2.1 babies and the mean litter size for *V. rubra* is 2.2 babies (Whipple, 2014). Because ruffed lemurs have nests, the females will leave their young to forage for food. This provides the animal care staff with the opportunity to check on the health of the babies on a regular basis because the female may be shifted off exhibit. Keepers can then safely enter the enclosure to check on the babies and take regular weights on them before letting the mother back with them. This also provides an opportunity to determine the gender of the babies (Photos 8a-10).

Photo 8b. Close-up of babies in a nest box. *Photo by Ethan Riepl.*

Photo 10. Babies in hand. *Photo Ethan Riepl.*

in order to determine the gender of ruffed lemur infants, the animal care staff must be able to get a close look at the genitalia of the infants. At this young age, the genitals look very similar, but upon close inspection the gender can be differentiated. The infant female will have a visible slit while the male will not (Photos 11-12).

Conclusion

Management of reproduction in ruffed lemurs can be improved upon by doing regular vulva checks to monitor estrus in ruffed lemur females. It is the hope of this author that the information and pictures provided in this article will help animal care staff better manage reproduction at institutions that currently house or potentially will house ruffed lemurs.

Acknowledgements

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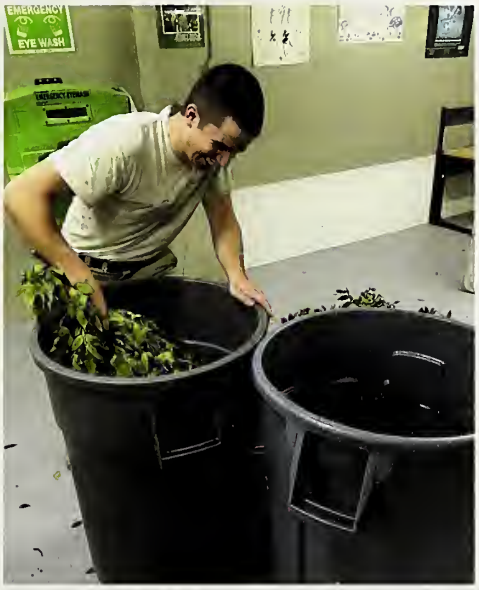
Photo 9. Taking a baby weight. *Photo by Joe Knobbe.*

Photo 11. Infant female genitalia – visible slit present. *Photo by Joe Knobbe.*

Photo 12. Infant male genitalia – no slit present *Photo by Joe Knobbe.*

Cultivating a Sustainable Browse Program for Coquerel's Sifaka



Browse is thoroughly washed and rinsed before it is given to the sifaka. *Photo by Shannon Farrell.*

Browse is stored in small batches so it can be thawed individually during winter. *Photo by Shannon Farrell*

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Leaf-eating primates are delicate animals that require specialized care and a strict diet. Coquerel's sifakas (*Propithecus coquereli*) have a unique gastro-intestinal tract that allows them to consume a diet of 40%-60% leaves in their wild home of Madagascar. They have a large cecum, long, large intestines and spiral colon that allow for intake of their highly fibrous diet. Their diets need to be high in fiber in order to keep their gut flora thriving. This can be difficult when this species is housed in captivity. Browse should be provided daily to keep these animals healthy. But where are keepers supposed to get all these leaves? Fortunately, this resource does grow on trees... get it? Growing a sustainable browse program is not only convenient for keepers and budget-friendly, it also benefits sifaka welfare.

The Saint Louis Zoo has been housing Coquerel's sifaka since 1998. There has been a long, varied history of browse collection in the last 17 years. The preferred browse species for the Saint Louis Zoo's sifaka is winged sumac (*Rhus copallina*). Sumac often grows along highways and so, for the first nine years, keepers collected sumac from the planted areas on roadsides. While there was plenty of browse to be had, the browse was of varying quality. It was unknown what kinds of pesticides and chemical residues from traffic these plants were exposed to. The plants were always thoroughly bleached and rinsed, but the condition was still questionable. This method of browse collection was very time-consuming for keepers. Finding browse patches with the appropriate type of plants, taking a vehicle out to said browse patches, and standing on the side of the road clipping branches was not just time consuming, it was dangerous and sometimes illegal.

After several years toiling on the side of the road, browse collection efforts were moved to a zoo-owned off-site farm. This provided a reliable and safe place for keepers to harvest the naturally occurring browse necessary to sustain the zoo's population of sifaka. However, the farm was located over 45 minutes from the zoo and going there was often a whole day ordeal. Multiple keepers would need to travel for the browse collection leaving those who remained at the zoo working under-staffed. When keepers returned, the browse would need to be washed and stored. All of this was time-consuming and needed to be completed in the same day. When invertebrate surveys were taking place, access to the property was often restricted.

In 2009, the Primate House staff determined that all these methods were inefficient and an alternative method needed to be found. Off-exhibit green space and the keepers' time was invested in an effort to create a sustainable source of fresh browse that could be fed fresh in the growing season and harvested and stored for the winter months. Through

Winged sumac has bright maroon berries. The berries should be removed before giving it to animals. *Photo by Shannon Farrell*

consultation with the Missouri Department of Conservation a source of sumac saplings was identified and purchased by the zoo. The Saint Louis Zoo's Horticulture Department was able to provide keepers with the training and knowledge necessary to grow and maintain a thriving browse patch. The goal was to grow enough browse for not only the Coquerel's sifaka, but also the other animals in the Primate Unit.

There are many forms of approved browse for sifaka and other primates. By the time a browse garden was ready to be planted, there was a good idea of what plants were the preferred form of browse. It was also clear which plants were appropriate for freezing. When some plants are thawed, they become slimy or just simply crumble into an unusable heap. Winged sumac and mulberry (*Marus* ssp.) were highly palatable, on the approved browse list, and retained their integrity when thawed. Mulberry was planted in a small satellite browse patch. However, sumac was the preferred plant and so the majority of the plants that were grown were sumac. Three large patches of unused off-exhibit space were dedicated to the sumac plants.

Sumac is easy to cultivate. It grows in USDA hardiness zones 5-10, which encompasses most states. The growing season will depend on climate. Saint Louis, Missouri is in Zone 6A/B and the growing season runs from late April to early September. Winged sumac is drought tolerant, although watering is sometimes required in the hottest times of the year to retain the quality of the plant for harvest. It can be grown successfully in poor soil and urban environments. It has very few, if any, pests. Winged sumac sends out "runners" that create new plants. While these "runners" should be left alone the year they appear, they can be harvested the following year to assure they branch out near the ground. It is easiest to keep these plants short and bush-like when growing them in a browse patch. This allows for a strong trunk and lots of leafy growth at chest height that is easy to harvest. This type of growth will happen with regular pruning, which occurs when the branches are harvested. As the plant grows, the branches will begin to droop under the weight of the leaves; this makes it possible to harvest the plant even as it grows taller.

The Saint Louis Zoo began its browse program in 2009, but it would be three more years until the browse patch would produce enough to sustain the seven Coquerel's sifaka. Each sifaka requires 75 grams of browse per day. That is over 420 pounds of sumac a year! To tide them over until the browse patches were capable of producing such a massive amount of browse, the Zoo partnered with the Missouri Botanical Garden and the Shaw Nature Reserve. They provided clean and accessible sites where keepers could harvest browse. The browse was of high quality, but it was challenging to coordinate. While this partnership was a solution for the interim, it was not a sustainable program.

In 2012, the Primate House sumac patch grew to be a sustainable source for year-round browse for the Coquerel's sifaka. Harvesting browse became something the keepers could do when time permitted, instead of having to devote a whole day to the process.

Several items are needed to carry out a successful browse harvest.

- Sharp pruning shears
- A scale that can read at least five kilograms
- A large container that fits on the scale
- Two large clean trash cans
- A drying rack
- Dilute bleach solution
- Wide tape that can be written on
- Permanent marker

Before removing the leafy branches, the berries are cut off with the pruning shears and discarded. These berries start out as light yellow flowers and become a deep red berry by mid-summer. They grow in large bunches at the ends of the branches. While the berries are edible, access is limited as loose stool can occur when too many are consumed by sifaka. Berries are not present until mid-summer and so harvesting early, after the main spring growth is over, is often less time-consuming. After harvesting, the branches continue to grow throughout the summer and are harvested several more times.

> Once the initial investment of plants and time was made, Mother Nature did the rest. It is well worth the effort in the long-run for these delicate and amazing primates.

When harvesting, sumac branches are cut with many compound leaves on a branch. Compound leaves are made up of several leaflets on a single stem. At least two buds (or two compound leaves) can be left under the cut to allow for more growth from that branch. New "runners" will need a whole season to grow before they can be harvested.

Even though pesticides and fertilizers are not used to maintain the browse patch, sumac is washed thoroughly for the safety of the animals. One of the two large clean trash cans is filled with a dilute bleach solution (one part bleach to 30 parts water). The second trash can is filled with plain water. Handfuls of freshly cut sumac are dunked into the bleach solution and swirled for about a minute making sure all leaves are washed in the solution. The branches are then removed and the excess solution is shaken off. The bleached browse is dunked into plain water and thoroughly rinsed. After shaking the branches one last time, they are placed on the drying rack for several minutes. This step is very important. If it is skipped, excess water will be part of the final weight and there will not be an accurate measure of how much sumac has been collected.

Sumac is frozen in small batches. The amount of browse needed for three days is calculated so that it can be bundled in that amount. At the Saint Louis Zoo, each sifaka consumes 75 grams of browse daily. There are seven sifaka and so bags of 1600 grams are frozen (this includes a buffer amount of 25 grams to account for potential loss). The sumac is weighed on a large scale that reads in grams. After the browse is mostly dry, it is placed in a large plastic container on top of the scale that has been tared. After weighing the desired amount, the sumac is placed into a large trash bag. All the air is squeezed out and the bag is rolled tightly around the browse so it creates a cylinder. Cylindrically wrapped sumac is easy to store and transport. The bag is then taped closed and labeled with the date collected and the area of animal division that it belongs too.

The Saint Louis Zoo has a large subzero walk-in freezer at the Animal Nutrition Center on grounds. This freezer is used to store the large amounts of browse that are collected throughout the summer. Room temperature bags should not be placed directly into walk-in subzero freezers. The bags are not water tight and if water leaks from the bags and hits the sub-zero concrete floor, the water will freeze instantly and create a hazardous area. Sumac is frozen in small chest freezers initially at the Primate House and then later it is moved to the walk-in.

The walk-in freezer at the Saint Louis Zoo Animal Nutrition Center has several fail safes and alarms if the freezer were to fail. Before the sumac was stored at the Animal Nutrition Center, three large chest freezers were used. Halfway through January of 2013 there was a freezer malfunction. Unfortunately, the mechanical issue was not caught until it was

too late. The sumac had already thawed and spoiled. Over half of the sumac was lost and alternatives had to be found, which was not an easy task in the middle of winter. The recommended daily browse amount was met by supplementing the remaining sumac with mulberry that had also been frozen. Once the sumac patch grew in, it was harvested right away. This was luckily not detrimental to this hardy plant and it grew like a weed all summer long. This lesson had been learned the hard way; freezers containing sumac should be checked daily!

When the summer winds to a close and the leaves on the sumac begin turning brilliant red, the sifaka are transitioned from fresh sumac to thawed. The transition assures that digestive upset does not occur in these sensitive animals. The transition takes place in quarters starting with 75% fresh and 25% frozen for one week. Then it moves to 50%/50% for the next week, followed by 25% fresh and 75% frozen. It takes a total of three weeks to complete the transition from fresh to thawed. This is taken into account when making the decision to begin transition. If the decision is made too late, the leaves may fall when fresh sumac is still needed. Frozen sumac is ordered from its long-term storage freezer at the Nutrition Center and it is delivered to the Primate House to be stored frozen for the short-term. One bag is taken out at a time and thawed overnight for use the next day. Thawed sumac is used within three days. After this, the quality of the sumac begins to decline.

These methods have led to a successful and sustainable on-site browse program at the Saint Louis Zoo. The animals have benefited considerably. They are enjoying fresh sumac that is always of high quality and free of toxic residues. The keepers have a safe and convenient place to collect browse when it fits into their schedule. The browse program is also budget friendly! Once the patch is established, browse is essentially free. The hours spent collecting browse off-site can now be allocated for other things. Once the initial investment of plants and time was made, Mother Nature did the rest. It is well worth the effort in the long-run for these delicate and amazing primates.

Planning on starting your own browse program? To help you determine which plants are most appropriate for your climate, find your zoo's USDA Hardiness Zone at http://planthardiness.ars.usda.gov. Special thanks to Primate Keeper Ethan Riepl for taking photos.

The AKO Project: The importance of storytelling in lemur conservation

Image 1

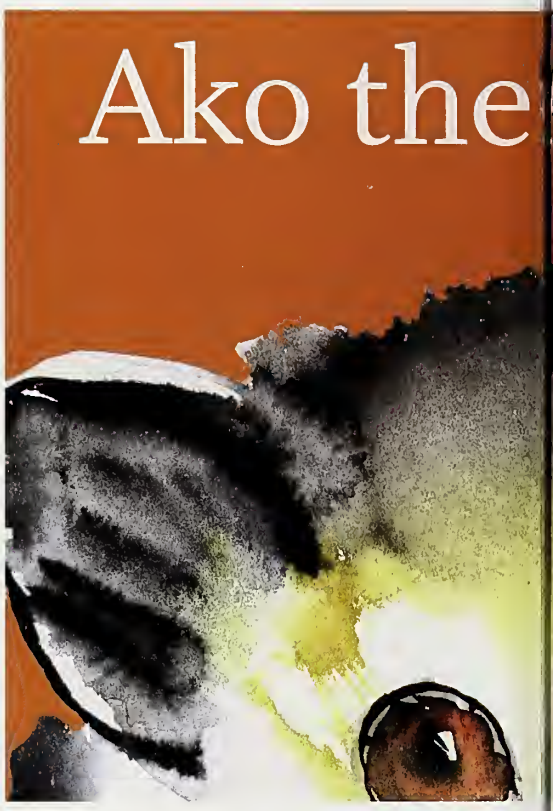

Image 2

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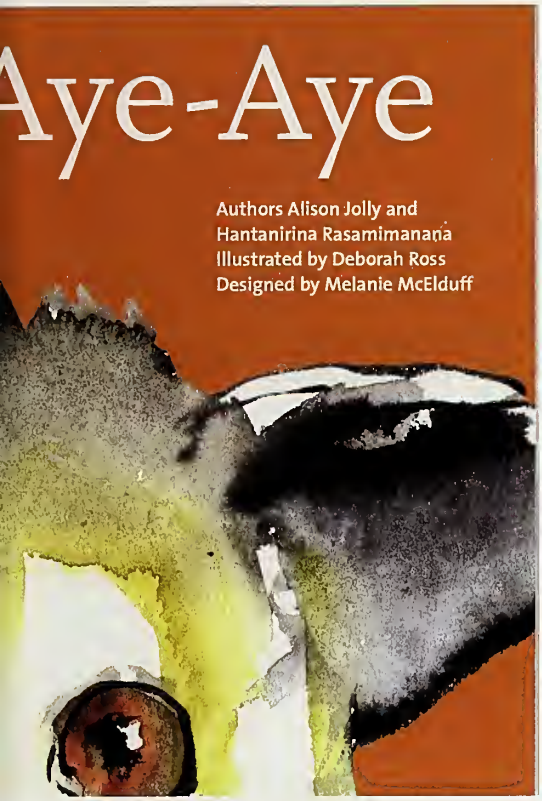
The Ako book series offers a convergence of art and fine storytelling to convey the lives and environments of different lemur species. More than just stories however, they inspire empathy and concern for the world around us. The books' illustrations and the posters are entrancing as well as instructive. The bilingual presentation fascinates children (English and Malagasy alike) and provides a unique language learning opportunity. The overarching message is that lemurs can be seen as representatives of all that is rare and beautiful in the world and that we have the responsibility to save them for future generations. (Image 1)

Within Madagascar, for historical reasons and as a result of overseas bias in biodiversity curriculum, there has been minimal teaching about this island nation's incredible biodiversity in their own, Malagasy primary schools. The colonial French curriculum imposed in the late 1880's onward led to the decline of primary school enrollment from 140-160,000

Caitlin Kenney, Acting Zoological Manager
Lemur Conservation Foundation
Myakka City, FL



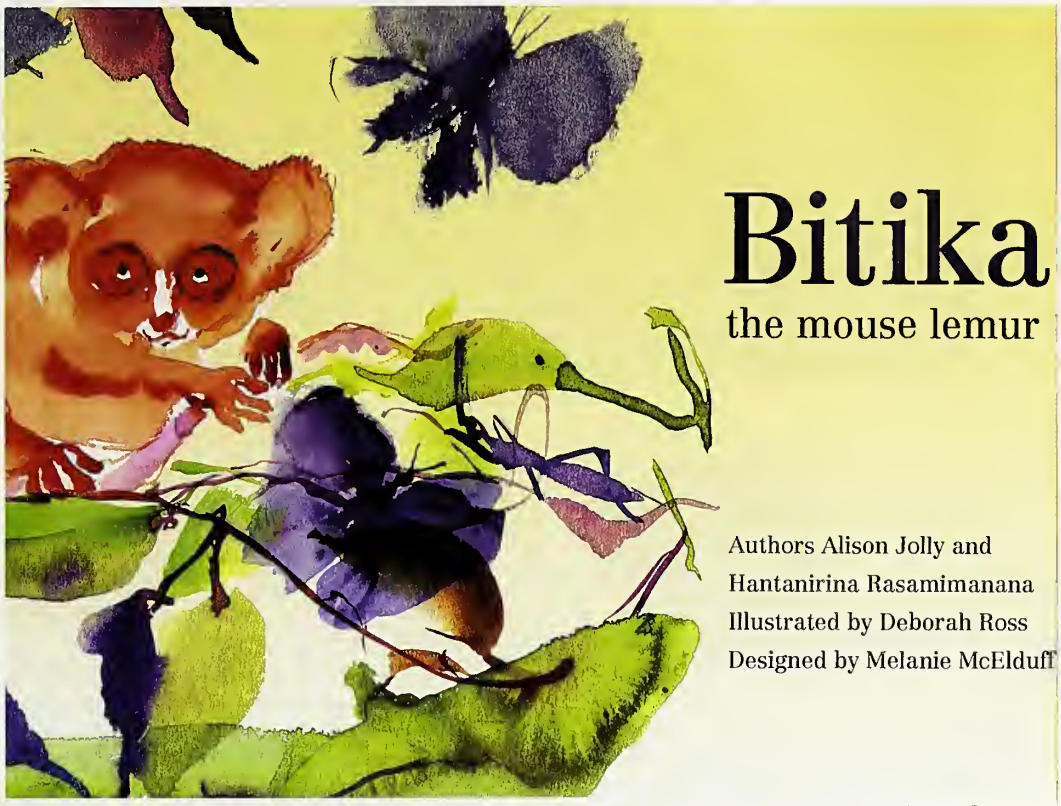


Image 3

children to just 40,000. Added to this, few Malagasy have ever seen a lemur or live near natural forest. While forest edge children do learn the medicinal plants and uses of the forest, they generally do not know about the richness of different habitats in Madagascar, or that most of the species they see do not exist in other parts of Madagascar let alone in different countries of the world. In addition, many rural teachers in villages near forests are often not trained with a depth of background knowledge about biology and ecology or environmental concerns. The Ako Project was developed to fill this void, aiming to produce children's storybooks on the lemurs of Madagascar, to involve and aid primary school teacher's professional development, and to provide teaching materials on conserving Madagascar's forest habitats.

The Ako Books

The Ako books are story picture books, each with a named endangered species lemur hero or heroine. While maintaining scientific accuracy, they are aimed to be fun and create empathy while also being educational in an indirect way. The accompanying posters are detailed painted portrayals of each of the six different habitats with information boxes on the edges of the poster. Each shows the differing landscapes with inset regional species of plants and animals. These are teaching tools with more and more to discover as children look closer.

Ako the Aye-aye (Ako means Echo) is a little aye-aye who really likes to play. His species is solitary so he plays with his food and his mother's tail. He finds and loses a brown lemur playmate. Finally he is so busy hanging by his feet that he forgets to be scared of humans. Visitors to the reserve see him playing and stop being scared of the ill-luck supposed to be brought by aye-ayes. (Image 2)

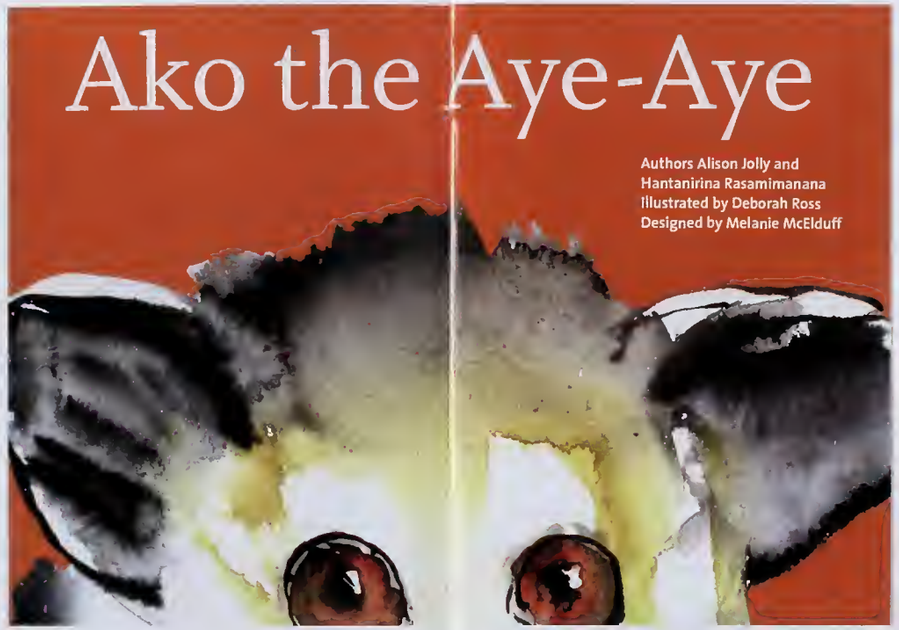
Bitika the Mouse Lemur is a baby lemur of the smallest species in Madagascar. (Bitika means Tiny.) She ventures out of the nest and meets all the larger lemur species of the baobab forest: the chorus is "Bitika felt small." Then she saves her mother's life from a white-browed owl. She ends up feeling like the biggest lemur in all Madagascar! (Image 3)

Tik-Tik the Ringtailed Lemur is an adolescent male ring-tailed lemur growing up as a species where females are totally dominant, and young males must emigrate to new troops. Tik-Tik means "Let's go!" in ring-tailed lemur sounds. He leaves his mother's troop to travel alone through the cactus-like spiny forest. He fights his rival, Longtooth, and wins the beautiful Feather-Fur. Ring-tailed lemur social calls appear in context so children can click, meow, purr, howl, squeak, shout war-cries, give alarm calls, and sing the male sunset song. (Image 4)

Fuzzy and Furry the Red Ruffed Lemur Twins live on the Masoala Peninsula where the rainforest goes down to the sea, and the trees are so tall that even their mother has never been to the ground. The branch where she parks them breaks in a cyclone. They fall by a forester's hut. The forester's wife wants to cook the baby lemurs, the twin children want them as pets, but the forester says "Suppose you were lost and the lemurs wanted to make pets of you!" (Image 5)

The AKO Project: The importance of storytelling in lemur conservation

Image 1



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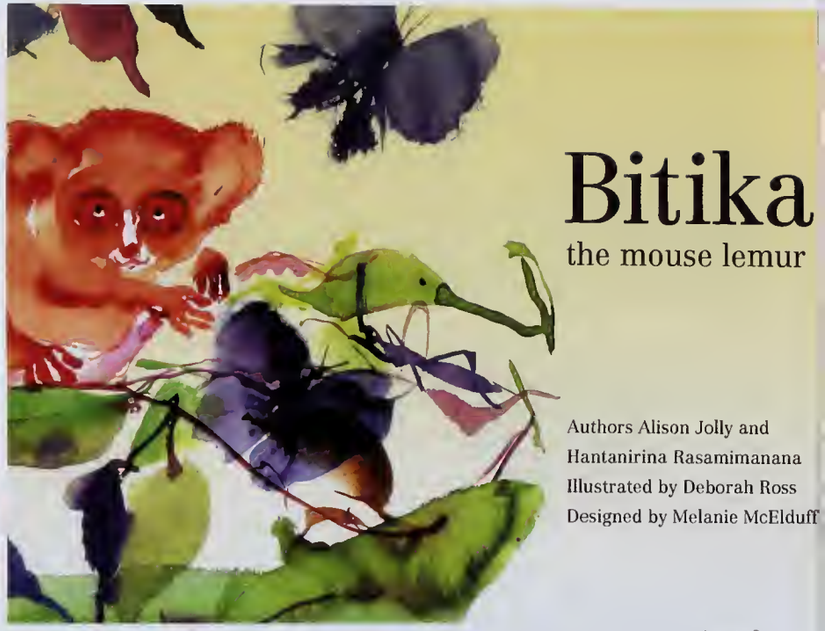

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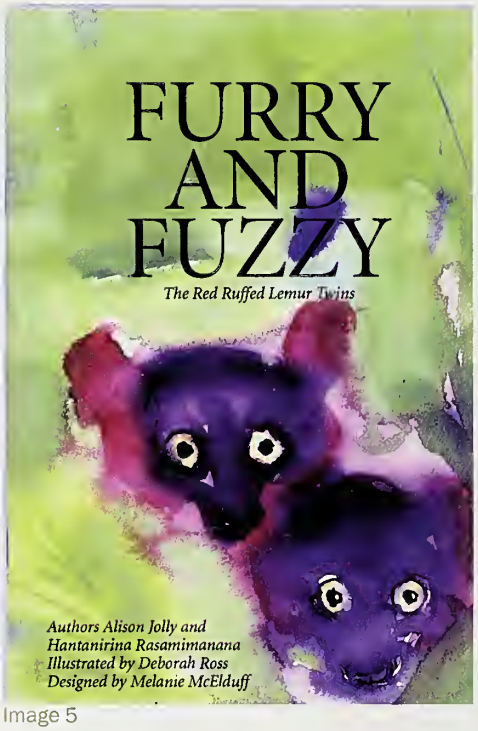


Image 5

Bounce the White Sifaka is a young sifaka lemur who lives among karst pinnacles, Madagascar's "stone forest." He falls down a crevasse where his family cannot reach him. He is frightened by bats, a snake, carnivorous cockroaches, and lastly a fossa, the largest predator of Madagascar. He finally leaps to safety on his mother's back. (Image 6)

No-Song the Indri lives in highland rainforest. Her family sings beautifully but she is too young to sing. Everything in the forest makes noises: trees, bees, birds, frogs, even a mosquito, but No-Song cannot sing. She finally understands what the indri songs mean during a territorial battle, and at last finds her own voice. (Image 7)

The History

The early initiative behind the Ako project came from artist Deborah Ross who, with the idea of story picture books, then approached Dr. Alison Jolly to work on the project with her. Dr. Hantanirina Rasamimanana joined the team, translating the books into Malagasy. After creating and publishing the first book, *Ako the Aye-Aye,* in 2005, two workshops were held in Madagascar in 2005 and 2006 with Dr. Jolly and professors from the University of Winchester.

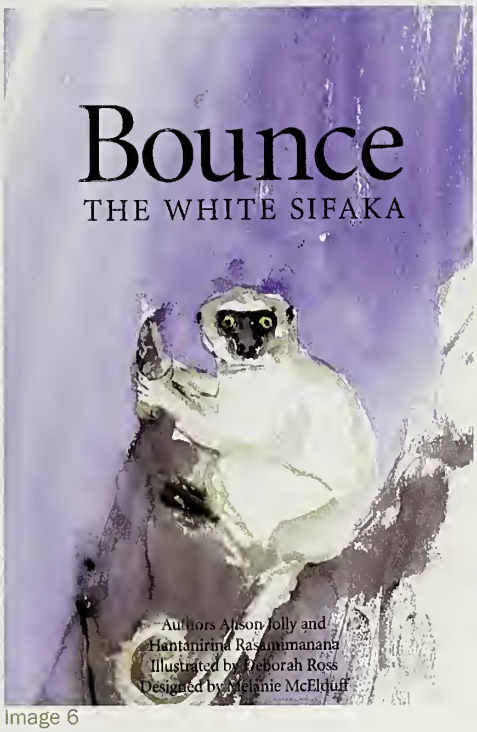
The McCrae Conservation and Education Fund (MCEF) joined with LCF and Dr. Jolly in 2007 to develop print materials to accompany the illustrated story-books. In collaboration with Ecole Normale Superieure of Antananarivo (ENS), Durrell Wildlife Conservation Preservation Trust (DWCPT), and GERP (Groupe d'Etudes et de Recherche sur les Primates, the Primatological Society of Madagascar), two thousand books of Ako the Aye-Aye were distributed in dozens of rural primary schools in six areas of Madagascar in 2007-2008. With continued support from MCEF, the following five story books were developed along with the accompanying poster series, leading to the distribution of 15,000 of each of the Ako books and 6,000 of each poster by UNICEF to 200 primary schools in 2010. Dr. Rasamimanana conducted a series of workshops in three rural areas to develop a teachers' handbook for primary schoolteachers using the Ako books and posters. (Image 8)

The first Ako Workshop in the United States was held in 2011 at the University of Michigan-Dearborn School of Education and College of Arts, Science and Letters. Presented by Drs. Alison Jolly and Francine Dolins, the workshop sought to design a comprehensive program that can help educators teach conservation education principles. The two-day pilot program focused on Detroit area school teachers, exploring environmentally-based online learning in the classroom, especially in connecting Michigan to the Madagascar rainforest. It combined the use of Ako materials and work on tele-conferencing from field sites.

In 2013, the project achieved a significant education goal by producing Ako-based lesson plans and teachers' guides and an 'Ako Certified' continuing education program for teachers, museums, and zoo educators in the US. LCF engaged Kris Whipple to produce education materials for the US-based portion of the project. Ms. Whipple produced a comprehensive curriculum based on the Ako Book Series and Posters, providing a K-5 Education Curriculum Framework. Ms. Whipple's work helps teachers identify which Ako book can be used in their classrooms to enhance standards-based learning in reading by suggesting which books are most appropriate for each grade and reading level. This curriculum based on the Ako Book Series and Posters allows LCF to deepen partnerships with Florida schools through many efforts including teacher continuing education credit programs, classroom materials, and the Teachers Institute for Conservation Ecology. (Image 9)

The Lemur Conservation Foundation introduced the Ako Conservation Education Program in 2014 to Zoo Educators. The full-day workshop, held at the Jacksonville Zoo and Gardens, focused on introducing the educators to the Ako book series and the accompanying educational posters and lesson plan. The workshop, led by Pattie Walsh, Kris Whipple, and Christina Dembiec (Jacksonville Zoo and LCF Institutional Animal Care and Use Committee Member), guided educators through the curriculum content and provided background information about lemur conservation and the history of the Ako Conservation Education Program. The interactive section of the workshop allowed attendees the opportunity to model, practice and evaluate the conservation lessons and activities from the Ako the Aye-Aye curriculum. Participants received conservation education materials including posters, books, and a teaching guide from the Ako Project to use in their zoo education programs. (Image 10)

In 2015, Dr. Francine Dolins (University of Michigan-Dearborn) implemented an initiative in the Detroit Public Schools to utilize Ako materials to connect Michigan students to



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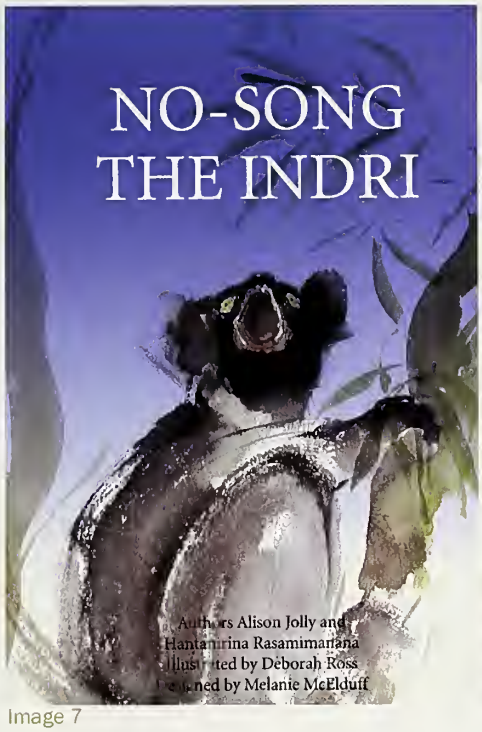

Image 7

Image 8

Madagascar and lemur conservation. LCF is currently partnering with Dr. Dolins to develop a pilot program to implement some of the new lessons at three primary schools in Madagascar. In partnership with the Prosimian Taxon Advisory Group (PTAG) Education Advisors, Christina Dembiec, Mandy Fischer, Corey Romberg, and Jessica Slater, a second workshop for zoo educators will be held at LCF in the spring of 2016 to introduce the Ako

Project to our local zoo partners. Our goal is that by working together we can help spread the conservation message about lemurs through the engaging tales of *Ako, Bitika, Tik-Tik, Fuzzy and Furry, Bounce,* and *No-Song.*

For more information about the Ako Project and how to get involved, please contact Caitlin Kenney at AkoProject@lemurreserve.org.

LEMUR CONSERVATION FOUNDATION

NATURE'S PATH ORGANIC

ENVIROKIDZ

Learning about Lemur Life

2nd - 3rd

A DAY IN THE LIFE OF A LEMUR

LEARNING GOALS: Students will understand the types of activities that ring-tailed lemurs participate in during a typical day and compare these daily activities to their own.

Grade Level: 2-3 | Subject Areas: Science, Math | Length of Activity: 1 hour
Background Information: See *Learning about Lemur Life*

STUDENTS WILL BE ABLE TO:

- Compare a day in their life to a day in the life of a ring-tailed lemur.
- Define an activity cycle.
- Describe how scientists use activity cycles to study animals.
- Determine how behavioral adaptations and activities help lemurs survive in the wild.

MATERIALS NEEDED:

- Day in the Life of a Lemur Activity Sheet (one per student).
- Pens/pencils or markers for each student to complete their activity cycle.

DESCRIPTION

Students compare their daily activities to the daily activities of a ring-tailed lemur. They create an activity cycle and graph it on a pie chart to show the differences.

LEARNING ACTIVITIES

SET-UP: Make copies of *A Day in the Life of a Lemur* Activity sheet (one per student.)

Create the Activity Cycle

1. Read Tik-Tik the Ring-Tailed Lemur to the class or instruct students to read the book independently.
2. Once the students have read the book, introduce the activity by asking students to describe the types of activities the ring-tailed lemurs participated in during the story. Use the following questions to guide the discussion:
   - How did Tik-Tik and the other ring-tailed lemurs in the sto-

(cont'd) Their troop provides them with protection from predators, companionship, and even warmth at night. For this reason they spend both their days and nights with their troop-mates.

3. Write their answers on the board. Tell students that they will now participate in an activity to learn how lemurs spend their day.
4. Distribute and review the A Day in the Life of a Lemur activi-

The Night is Alive with Nocturnals How about at your zoo?

Dean Gibson, Prosimian Taxon Advisory Group, Nocturnal Species Point of Contact.
Curator of Primates, San Diego Zoo, San Diego, CA

When most people think about prosimians, it's not surprising that the diurnal lemurs would come to mind. While the lemurs are a quite charming group of primates, the nocturnal prosimians are certainly no less appealing or noteworthy. With their many specialized nocturnal characteristics, such as large glowing eyes and rapid ear movement, along with their inquisitive personalities and copious ability to mix with other species, they are the ideal prosimians for exhibit.

A Little Taxonomy and a Few Interesting Nocturnal Species Facts

Prosimians first appear in the fossil record approximately 60 - 65 million years ago during the Paleocene Epoch. These early species evolved into today's array of primates including modern day prosimians which are found in Africa, Asia and Madagascar. Today, taxonomists recognize six families of strictly nocturnal prosimians and one family, the Indriidae, which is unique in that it includes both nocturnal and diurnal species. As a group, the nocturnal prosimians continue to present taxonomic challenges, especially in Madagascar, and as field work continues, additional nocturnal species will no doubt continue to be described. Table 1 lists the distribution, family and current number of recognized nocturnal species.

DISTRIBUTION	FAMILY	SPECIES #
AFRICA	Galagidae	18
	Lorisidae	5
ASIA	Lorisidae	8
	Tarsiidae	11
MADAGASCAR	Cheirogaleidae	31
	Lepilemuridae	26
	Daubentoniidae	1
	Indriidae *(Avahi ssp)*	9
TOTAL		109

There is of course much variety in the nocturnal prosimians and each of the seven families has unique and specialized characteristics which enable them to occupy a particular ecological niche. The largest family, Cheirogaleidae, of which there are five genera, are all arboreal and include the mouse lemurs. One species, Madame Berthe's mouse lemur *(microcebus bertha)*, is the smallest of all primates and has an adult weight of only 30g. Another, but lesser known genera are the phaner species or the fork-marked lemurs. These are the largest of the Cheirogaleidae and are specialized gum feeders. The dwarf or fat-tailed lemurs, store fat in their tails and use this source to survive seasonal periods of torpor which can last six months. They are distinct because they are the only known primate species to demonstrate the ability to hibernate. The Leplilemurs or sportive lemurs of the family Lepilemuridae are specialized nocturnal folivores ranging in size from 600 to 1200g making them the smallest of all the folivorous primates. Daubentoniidae of which there is only one species, is the largest of all the nocturnals, the most divergent and has the most unusual physical characteristics. The skeletal finger, large ears and ever-growing incisors are all adaptations for its specialized feeding strategy known as percussive and extractive foraging.

Whereas most nocturnals are found in tropical wet and/or dry forests, some of the Galagidae, which are the least studied of the nocturnals, are also found in drier woodland savannas. They, along with the tarsiers, are capable of turning their heads an amazing 180 degrees. The Lorisidae are the only nocturnal prosimians found both in Africa and Asia. They have specialized hands and feet for superior gripping capabilities and either lack or have only a vestigial tail. Some species have brachial glands that produce a substance that can be toxic under certain conditions when mixed with their saliva. The African species (pottos and angwantibos) similar to the many galago species are unfortunately very poorly studied in the wild. The Tarsidae are also much less known but often discussed among taxonomists due to having characteristics of both prosimians and simians. They are exceptional in that they represent a biological link between these groups.

Prosimian Taxon Advisory Group – Program Species

Not many of the 109 currently recognized nocturnal prosimian species have been in captivity and those species that are currently represented in our collections are struggling for sustainability. The American Association of Zoos and Aquariums' (AZA) Prosimian Taxonomy Advisory Group (PTAG) is working diligently to change this trend. The PTAG currently manages six nocturnal species of which four are SSP Programs (aye-aye, lesser bush baby, northern greater bush baby and pygmy loris), one is a candidate SSP (mouse lemur) and one is a studbook (potto). The PTAG also works with the European Association of Zoos and Aquariums' (EAZA) PTAG on population sustainability for the species we have in our collections. If you are looking for an unusual and active species or two to add to your exhibits or create a new exhibit – I encourage you to think nocturnal. Additional space for breeding and non-breeding animals will enable the PTAG to grow these populations to meet regional collection plan goals. To help with your decision, see the following species profiles and program manager contact information. Why not bring some night time activity to your zoo!

Aye – aye

(*Daubentonia madagascariensis*): SSP Coordinator/Studbook Keeper, Dean Gibson, Curator of Primates, San Diego Zoo. E-mail: DGibson@sandiegozoo.org

Aye-ayes are the largest (2-3kg) and most uniquely specialized of all the nocturnal prosimians. They are primarily found in tropical wet and dry forests along the east and west coasts of Madagascar, but also make use of secondary forests and cultivated areas such as coconut groves. The species is very adaptable and widely distributed; however, population density throughout its range is thought to be fairly low. The wild diet consists of seeds, especially the Ramy nut – *Canarium* spp., nectar, fungi and larvae. Wild aye-ayes are very active and spend approximately 80% of the

D. madagascariensis

time traveling and feeding. Males are known to travel long distances and have overlapping home ranges with females. Aye-ayes are listed by IUCN as Endangered and are a CITES I species. They have also been designated as an AZA S.A.F.E. species (Saving Animals From Extinction) program. Wild populations are declining and continue to be threatened by habitat destruction and hunting. In many parts of Madagascar aye-ayes face additional hunting pressure due to the belief that they are taboo and carry evil omens and bad luck.

Aye-ayes unlike most lemurs are not seasonal breeders, and can reproduce at all times of the year. In the wild, they construct large nests for sleeping utilizing leaves, tree forks and vines. Reproduction is unlike any other primate species with prolonged and upside down (dorsal-ventral) breeding events lasting over an hour in duration and with the female hanging horizontally and supporting the weight of the male. Females are receptive for a single night during the estrous period and unique "eeping" vocalizations from both the male and female correspond to receptivity. A single infant is produced after a gestation of 159-172 days. Infants remain in the nest for several months and have a long developmental dependency on the female. Infants begin to emerge from the nest at approximately two

months and start testing solid food at three months of age. When infants first emerge from the nest, their locomotion skills are not fully developed and as a result, the female will usually carry the infant (by mouth) back to the nest. Nursing can continue beyond year one if the female permits it. Sexual maturity is at approximately four years of age and longevity is 30+ years in captivity.

Aye-ayes do best if provided a minimum of 27.9 sq meters (300 sq. feet)/animal of space with complex climbing structures and heights ranging from 3.1-4.6m (10-15 feet). They are active explorers of their environment and must have access to natural wood materials for gnawing to maintain dental health. In addition, diet items should be provided to accommodate their percussive extractive foraging behavior. Nesting material and nest boxes are both required along with multiple enclosures and/or holding areas if housing multiple animals or a breeding pair. In warmer climates, aye-ayes can be housed outdoors as long as shelter and reliable heat sources are available. They also appreciate higher levels of humidity as dry conditions can result in sinus and dry skin problems. *For more details on aye-aye husbandry,* see *Management of Aye-aye on a Natural Photoperiod in this AKF edition.*

The aye-aye SSP began in 2000 and currently manages 26 animals in six institutions. For genetic health and long-term sustainability the SSP works closely with EAZA institutions and the Ueno Zoo in Japan. The first joint international aye-aye EEP-SSP meeting and husbandry workshop was held at the San Diego Zoo in 2013. Several exchanges were identified for sustainability purposes and seven international shipments were completed by mid-2015. Two of these international exchanges have resulted in pregnancies of which one has proven to be a record breaker, with the birth of twins at the Bristol Zoo in May, 2015. This is the first known occurrence of twinning in this species. The PTAG has set a population goal of 50 which cannot be achieved unless additional institutions commit space to this species. Aye-ayes are hardy and long-lived with very few health concerns. They mix well with other species (for example: bush baby, fruit bats, giant jumping rats, all loris species, mouse lemurs and fat-tailed dwarf lemurs) and when housed appropriately are very easy to work with. In addition, their naturally inquisitive personalities make them easily trainable and an ideal nocturnal addition. No nocturnal facilities – No problem! Although management on a reversed lighting system is recommended for those not familiar with this species, aye-ayes have been successfully housed on a natural photoperiod at several institutions in Europe, Japan, Madagascar and North America.

Lesser bush baby

(*Galago moholi*): SSP Coordinator/Studbook Keeper, Kris Arnold, Senior 1 Primate Keeper, Busch Gardens, Tampa Bay. E-mail: Kristen.Arnold@buschgardens.com

The lesser bush baby (*Galago moholi*) is a small nocturnal prosimian with grey to light brown hair that becomes lighter on the sides and stomach. They are found in Angola, Zimbabwe, Zambia as well as parts of South Africa, Tanzania, Namibia, Botswana, and Mozambique. The lesser bush baby inhabits woodland areas, often near Acacia trees, which provide the gum that is a staple in their wild diet. Their diet in the wild consists only of gum and insects. Lesser bush babies are listed by IUCN as Least Concern and are a CITES II species. They are preyed upon by eagles, owls, civets, genets and mongooses.

G. moholi

Lesser bush babies range 12 – 18cm (5-7 inches) in size with a tail length of 10 – 25 cm (4-10 inches). Males tend to be slightly larger than females. They have very large eyes which are incapable of movement within the eye socket, to compensate for this; the lesser bush babies can rotate their heads 180 degrees. The ears can be moved independently and folded flat. A toothcomb is present and can be used for grooming as well as scraping tree bark.

Lesser bush babies are polygamous, and the territory of one male may overlap that of several females. Sexual maturity is reached at about 10 months of age. Mating in this species occurs once or twice a year, typically births occur in the beginning of the calendar year and again in October/November. Gestation is approximately 121-124 days and weaning occurs around three months. Females care for offspring on their own, and typically give birth to singletons on their first pregnancy and twins on subsequent pregnancies. Parking is common and an offspring will stay in one spot for several hours, emitting a distress call if it senses a threat. The lifespan for lesser bush babies is approximately 16 years.

In the wild, lesser bush babies tend to rest in small social groups during the day, but forage alone at night. Many vocalizations have been recorded from this species, though they are difficult to track. Urine washing, which is used to mark territory, is another form of communication. Most movement is quadrupedal, but they are capable of bipedal movement and land hind-limbs-first when jumping.

Although they can be shy, lesser bush babies are great exhibit animals. They are curious and active during the day in a reverse lighting environment. Enrichment easily encourages them to be even more active and animated, showing off their impressive jumping skills. They can jump over 6.1 meters (20 feet) in a single bound and are capable of impressive vertical jumps as well. Multi-level branching throughout an exhibit offers ample surface area for climbing, jumping and scent marking. This species can be managed in a multi-species exhibit, having previously been housed with Rodrigues fruit bats, bay duikers, brush-tailed porcupines, elephant shrew, springhaas, potto, aardvark, aye-aye and pygmy loris. If housed with other primate species, non-breeding groups are recommended. Breeding is successful at a few facilities, however additional facilities are required to meet population growth goals. The lesser bush baby is a Red SSP and consists of 49 individuals at eight AZA institutions. Research is needed on contraception options within AZA facilities.

Northern greater bush baby

O. garnetii

(*Otolemur garnetii*): SSP Coordinator/Studbook Keeper, Kris Arnold, Senior 1 Primate Keeper, Busch Gardens, Tampa Bay. E-mail: Kristen.Arnold@buschgardens.com

The northern greater bush baby is a small, arboreal, nocturnal prosimian found in southern Somalia into Kenya and Tanzania, as well as the island of Zanzibar. They are listed by IUCN as Least Concern and are a CITES II species.

Also known as Garnett's greater galago and the small-eared galago, they are distinguished from other Otolemurs by their red or grey/brown coat and black tip on the thick, very long tail, as well as shorter ears. The ears may be small in this species, but they are capable of incredibly acute hearing and can move independently from one another, which aides in insect catching. In addition, this species can fold their ears down during rest and for protection. While insects are an enjoyable snack, the wild diet consists mainly of fruits found within the home range of an individual. Home ranges are marked by urine and with a scent gland found on the chest.

The territory of one male may overlap with that of several females, however home ranges do not overlap with same-sex or same-age individuals. Individuals of this species are promiscuous, with both males and females having multiple mates. In the wild, breeding takes place only once a year, but in managed care breeding occurs year-round. Gestation is approximately 125-130 days. Births typically consist of one offspring and twins are rare. Newborns are completely dependent on maternal care. Females will park infants while foraging. Offspring are weaned between four and five-months-old, and can be completely independent at about six months of age. Generally the male is separated from the female before birth and not reintroduced until the offspring has weaned, is independent, and has been separated from the mother. Additional research on reintroducing offspring within 30 days of birth to the paternal parent is needed. The lifespan for greater bush babies is approximately 15 years.

Working with greater bush babies is often a nice change of pace from an otherwise hectic day. They seem to enjoy attention from keepers and are motivated for training. Behaviors such as station, target, crate and scale, as well as some tactile and standing up for visual inspections have been easily trained and maintained. This species is very curious, especially if keepers appear different than normal, like wearing a hat, sweatshirt or different hairstyle. Enrichment is an important part of the bush baby husbandry program. They enjoy things like puzzle feeders, mirrors, bubbles, swings and hammocks.

Care and husbandry for greater bush babies can be elaborate or fairly simple. Several branches throughout the exhibit to provide plenty of surface area for climbing, jumping and scent marking is recommended. Most movement is quadrupedal, but this species is capable of bipedal movement and land hind-limbs-first when jumping. They use many levels of branches, but rarely go on the ground. Any substrate may be used if desired, but it is not necessary to do so. However, if the greater bushbaby is going to be part of a mixed-species exhibit and substrate is preferred for the habitat's co-occupant, substrate may be chosen based on the other species' needs. Species that have been part of successful mixed-species exhibits with the greater bush baby include aardvark, spring Haas, brush tail porcupine, prehensile tail porcupine, African crested porcupine, aye-aye, tree shrew, armadillo, Indian giant fruit bats, wombat, agouti, and potto. Due to their omnivorous diet, mixing with any small breeding prosimians is not suggested. Diet should be presented in three small feedings per day and training sessions a few times per week.

Northern greater bush babies are not threatened in the wild, but representation in zoos is limited. Currently the species is a Red SSP and the population consists of 30 individuals at nine AZA institutions. They make a great display animal as they are very active during the day in a reverse lighting situation. They are inquisitive and exploratory, which makes enriching them lots of fun- not to mention fun to watch! They have individual personalities—some are shy and less excitable, some are curious and brave, and they are cute-to-boot. If your facility is missing something, it is probably the northern greater bush baby!

Gray mouse lemur

(*Microcebus murinus*): Studbook Keeper, Bevan Clark, Technician II, Duke Lemur Center. E-mail: bevancclark@gmail.com for availability contact Andrea Katz at ASKatz@duke.edu

See species profile and husbandry information by Bevan Clark in the following article of this AKF edition.

Potto

(*Perodicticus potto*): Studbook Keeper, Michael W. Dulaney, Curator of Mammals, Cincinnati Zoo & Botanical Garden. E-mail: mike.dulaney@cincinnatizoo.org

Pottos are the largest member of the Lorisidae family. Found in the tropical rainforest of equatorial Africa from Gambia and Senegal to the west, the Democratic Republic of Congo and western Kenya where they prefer primary and secondary forest. It is the only species in the genus with at least four subspecies currently recognized. They are compact animals, roughly 30.5 – 38.1cm (12 – 15 inches) in length and weighing between 908 – 1361g (2 – 3lbs). Pottos are nocturnal and arboreal, cryptically climbing though the trees at night trying not to call attention to themselves. They mark their territory by urinating on their hands and feet, spreading their scent along the branches as

P. potto

they go. Omnivores, they will feed on fruits, tree gum, insects and numerous small vertebrates (lizards, nesting birds, bats, etc.). The insects that they often consume are those which are usually foul-smelling or have other forms of protection which causes them to be passed over by other animals.

Pottos have a strong grip, their thumbs and big toes are opposable and their index finger is vestigial which gives it the ability to grasp larger branches. It has flattened nails on all digits except the second toe on each foot which has a grooming or toilet claw as is found with other prosimians. Also, like other prosimians, they have a special set of teeth in the front of their lower jaw which are referred to as comb-teeth which are used to help keep the fur clean. Pottos also have a row of bony spines on the neck which is assumingly used for defense. If being bothered by another animal the potto will tuck its head down to its chest, exposing these spines, then attempt to neck-butt their opponent in hopes of persuading it to leave the potto alone.

Pottos are listed by IUCN as Least Concern and are a CITES II species. The primary threats they face are deforestation, predation and bushmeat hunting. They are considered solitary with the territory of a single male overlapping that of several females. Pottos usually have a single offspring after a gestation period range of 170 – 205 days. The female does not make a nest, rather the infant, from day one, will cling onto its mother, first gripping primarily onto her belly area (where the infant's light color blends in with the light color of the mother's abdomen), and then, as it gets older, larger and more brown in color the youngster will hitch a ride on mother's back. Also, from day one, the baby can be "parked" by mom onto a branch for hours at a time. The little potto remains there, basically motionless, until mom returns to claim her little one.

Though not an official SSP yet, there is a studbook for pottos and the population is being managed. There are currently 16 animals distributed between five AZA facilities. A major push was made in 2014 to bolster the genetics and recommend a number of new pairings

between facilities in hopes of both increasing overall breeding and the genetics of the population. Eleven of the 16 pottos were moved to create several new pairings as well as to pair up animals that had not been paired previously. As a result of those moves there are seven potential breeding pairs together. Although we are not yet looking for additional holders we are hoping that this is just a temporary condition and if several of our new breeding pairs are successful we will be able to provide others who wish to exhibit / breed this charismatic primate with the opportunity to do so.

If you might be one of those facilities interested in pottos for future exhibit / breeding they do best in a nocturnal environment with climbing opportunities (tree branches, vines, etc.) They can be mixed with many different nocturnal species and can be housed as male / female pairs (single sexed pairs usually do not work out well). They can live into their mid-20s and are relatively low maintenance. Pairs can become very attached to one another and though it is recommended to provide an elevated nesting box for each animal often times they can both be found occupying the same box during morning checks.

Pygmy Loris

(*Nycticebus pygmaeus*): SSP Coordinator, Dean Gibson, Curator of Primates, San Diego Zoo. E-mail: DGibson@sandiegozoo.org

Pygmy lorises are the smallest of the *Nycticebus* species, weighing 300 – 400g and have a more subtle dorsal body stripe. They are physically very appealing due to its small size and attractive clown-like face. Unfortunately, their small size and engaging appearance has resulted in high levels of illegal trade in the pet markets. Additionally, the body parts of this species are highly desired for medicinal purposes. Pygmy lorises are currently listed by IUCN as Vulnerable and have recently been up-listed from a CITES II to CITES I species. They have recently been designated as an AZA S.A.F.E. candidate species. Populations are decreasing in the wild due to habitat destruction and hunting pressures. They are found in China (Yunnan Province), Cambodia, Laos – Lao PDR and Vietnam in a wide variety of tropical wet and dry forest habitats and can make use of secondary, degraded and bamboo forests. Pygmy lorises feed on high levels of insects and gums but also small mammals, birds, flowers and some fruit. They will also consume small lizards, mammals, birds and eggs.

N. pygmaeus

For the most part lorises are solitary with male home ranges overlapping with several females. Communication is by scent marking but also through vocalizations during the estrous period. Unlike other *Nycticebus* species, the pygmy loris is a seasonal breeder and has a high rate of multiple births (50% of pregnancies produce twins). Gestation is approximately six months and infants are born fully developed. Pygmy loris females "park" infants on branches when they go off to forage or explore. One-day-old infants are capable of supporting themselves on the branch. Females increase their time away from the infant as the infant ages. Infant dependency is approximately six months with sexual maturity occurring at approximately one year.

Housing and husbandry requirements for managing pygmy lorises are fairly easy. They do not require significant space but it should be complex with varying and continuous pathways for locomotion – lorises do not jump or leap but climb from branch to branch. Pygmy lorises have primitive thermoregulatory capabilities, thus require warm environments. They can be housed outdoors in warm climates as long as they have access to heated sheltered areas. They should not be exposed to temperatures below 65*F or humidity lower than 40%. Sleeping sites can be provided with the use of vegetation, hollow logs/branches, nest boxes, tubes, shelving, etc. They can be maintained on a natural photoperiod or on reversed lighting systems. If housing a breeding pair, it is essential that there is suitable holding space available to separate the male prior to birth. Pygmy loris mix well and have been successfully housed with slender loris, bush baby, Coquerel's mouse lemur, potto, tree shrews, hedgehogs and others.

The pygmy loris SSP was established in 1995 and is the oldest and most successful of the managed nocturnal programs. Currently a Yellow SSP with 60 animals in 23 institutions (see Fitch-Snyder in this volume for historic loris population information). With continued population planning, additional institutional commitment/space and collaboration with EAZA's EEP, the pygmy loris population is likely to achieve long-term sustainability.

Summary

Hopefully this information has peaked your curiosity about nocturnal prosimians. They are the underdogs of the primate collections in today's zoos and will likely be lost to our collections without further institutional commitment. When you are considering adding to your exhibits or designing new exhibits, remember that nocturnal prosimians mix well with other species, are easily managed and take little space. Special attention to diet and holding space is required for breeding situations and mixed-species exhibits. Nocturnals can also be flexible as they can be maintained on a natural photoperiod as well as on a reversed lighting system. Please contact the program managers for additional species information and availability.

Acknowledgements

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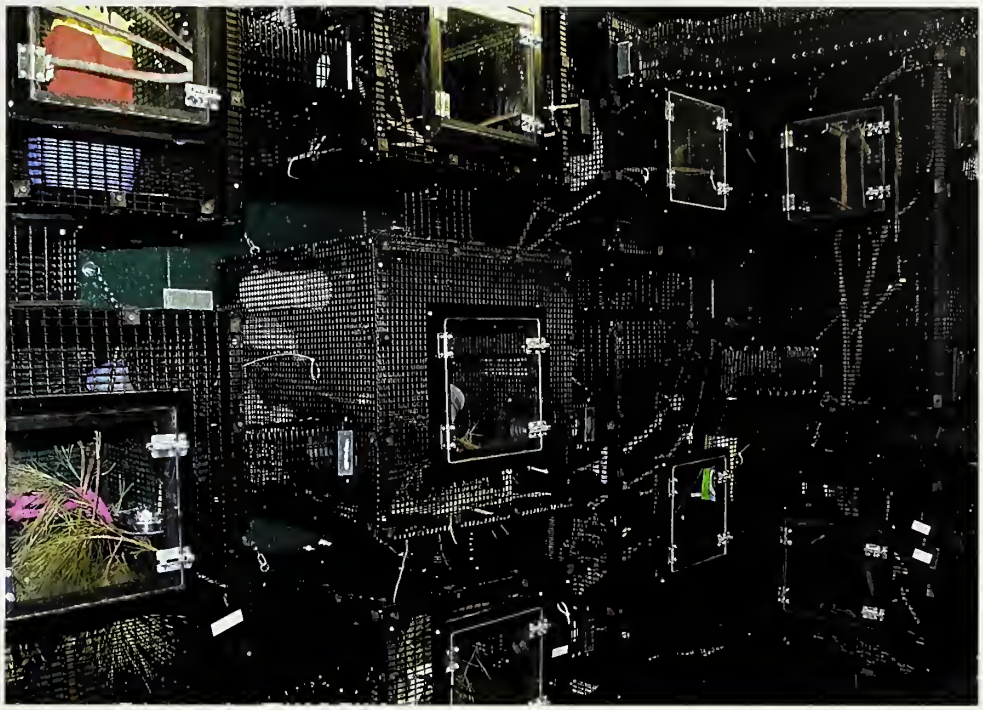
Mouse Lemur (*Microcebus murinus*) Husbandry at the Duke Lemur Center

Bevan Clark, DLC Technician II and Andrea Katz, Curator
Duke Lemur Center, Durham, North Carolina
Photos by David Haring

Mouse lemur eating persimmon (*Diospyros virginiana*)

The grey mouse lemur (*Microcebus murinus)* is a small nocturnal lemur found in Western Madagascar. Currently the captive population in North America stands at 57 individuals (28.28.1) at two institutions. Due to an aging captive population, reproduction was grounded to a halt between the years 1996-2009. In 2007, Duke Lemur Center began the process of importing mouse lemurs from a facility in France. Staff was educated on successful husbandry practices at the French facility. Husbandry techniques such as new housing and close management of breeding season were implemented. In the fall of 2009 Duke Lemur Center imported nine (4.5) individual lemurs from the Laboratoire d'Ecologie Générale, located in Brunoy, France. Included in this document are the guidelines Duke Lemur Center uses for successful mouse lemur management.



Example of a "condo" cage room. Tunnels allow for easy introduction and separation of animals.

Diet:

Following a North Carolina photoperiod, mouse lemurs are very active animals from late February to November when they begin to exhibit torpor-like behavior. Due to their varying levels of activity during different times of the year their diets change seasonally. Winter diet changes typically occur around mid to late October. Summer diet changes should be applied in March when the animals become more active. In the past, Duke made this change to the entire colony at once, however, with young animals in the population, diets are changed based on weights on an individual basis. Should the animal not maintain a steady weight on a standard diet, chow, fruit/veggie mix amounts will be increased by 25%.

Fruits and vegetable options change daily and typically mimic what is offered to the rest of the lemur colony that day. Technicians offer Mighty Mealies (Grubco© mealworms) to the animals as their insect option but have utilized crickets and waxworms. When the animals are rousing themselves for breeding season some animals may display hypoglycemic behavior. Mouse lemurs at the Lemur Center are fed on a BID basis. First feeding is offered at lights out, no more than 30 minutes after lights out. The second feeding occurs during the technician's PM checks. We do offer food as a part of our enrichment regime. Animals are given extra food enrichment 3 times per week.

Weights:

Weight range: 60-90 grams in the summer; 70-110 grams in the winter. Infant weights are collected 48-72 hours after suspected birth. After initial weight is collected and the infant appears healthy, weights are collected twice a week until the infant is four weeks of age. Animals between 5-8 weeks of age are weighed once weekly. When the mouse lemur infant is three months of age it is weighed as an adult mouse lemur. Adults are weighed every other week unless illness, age, rapid weight gain or loss occurs.

An example of mouse lemur diets at the Duke Lemur Center:

Standard winter diet:
¾ tsp. powdered Lab Diet Old World 5038 monkey chow, ¾ tsp. diced fruit/vegetable mix and 1 insect.

Standard summer diet:
1 tsp. powdered Lab Diet Old World 5038 monkey chow, 1 tsp. diced fruit/vegetable mix, 3 insects.

Mouse lemurs can lose or gain weight at an alarming rate. When animals become active for the breeding season they tend to lose weight rapidly. Animals are often found awake during the white light period and out of their nest tubes during the early stages of breeding season (March). They can appear frantic while searching for food or trying to "beg" for food from staff. The opposite is true for the non-breeding season. During the winter months, early November to late February, animals are extremely lethargic and often cold to the touch. Animals will still rouse themselves for their daily diets but typically go back to sleep afterward. If animals do become overweight, close observation of tail health is necessary. A nice fat tail in the winter is normal but a tail that appears to be buckling or has constrictions in fat rolls is a cause for concern as blood flow could be compromised. It is not unusual to have some adult animals exceed the weight range during the winter months. Many of our adult females can tip the scales at 130g! Weights over 100g are not a cause of alarm but should be monitored. If the diet is decreased be sure the animal does not drop weight too rapidly.

Housing:

The Lemur Center offers two types of animal rooms for nocturnal lemurs, free-range nocturnal rooms and caged "condo" rooms. Females are housed with related females year-round. Mothers and female infants from that year's litter form groups. Female offspring from previous litters can be reintroduced after their own infants are weaned. Males are typically housed alone but related animals (e.g. twin brothers) may do well together, although aggression can be seen closer to and during breeding season.

A mix of natural branching, fabricated supports, cloth, and plastic are used for cage structure. Ideally cages should have a good variety of vertical and horizontal perches for easy travel and breeding. During the breeding process males typically mount and hang onto the females as they move around the cage, so horizontal supports are needed.

Animals are offered PVC nest tubes with one

end open for easy viewing and capture. One PVC tube per animal allows for sleeping options should tension arise in the group. We also offer cardboard boxes, wooden boxes, plastic jugs, ferret or small animal sleeping bags, etc. for nesting options. Bamboo, bamboo grass, shredded paper towels, shredded newspaper, wood wool, and vet-approved browse are some nest material options. Females will begin to build nests very close to their delivery date and maintain them while they have their infants. Males may appreciate having the option but their nest building skills are lacking.

We have successfully housed mouse lemurs in the past with different species such as aye-aye, lesser bush babies, fat-tailed dwarf lemurs, and slender lorises. Mouse lemurs will take advantage of extra food if housed with other species and gain weight quickly.

Cage sanitation:
Daily basic husbandry and cage maintenance includes changing water, emptying food bowls and spot-cleaning newspapers or wood chip substrate on the floor under the cages. Bamboo, pine branching, shredded paper, etc. used for nesting is removed when soiled or at minimum of once a week. Every two weeks, newspapers and wood chips under the cages are removed and replaced with clean substrate.

For in-depth cleaning, animals are removed from cages along with all enrichment, nest material and nest tubes every 6-8 weeks. Sanitation is not as frequent during the breeding season and while mothers are with infants. Because mouse lemurs rely so heavily on olfactory cues, it is detrimental to their natural behavior to erase all odors. Prior to breeding season sanitation will be scheduled for early to mid- March and then one to two weeks prior to birth. Mothers with infants should not be disturbed for sanitation until the infant is at least one month of age. Daily cage maintenance may be performed as usual.

Lighting:
One of the most important aspects of mouse lemur husbandry! Animal rooms at the Lemur Center use a reverse light cycle so technicians can service the rooms while the fluorescent white lights are illuminated. North Carolina photoperiod is utilized but is altered every two weeks to mimic seasonal changes. Red lights are used to illuminate rooms when the animals are active. With dimmer switches technicians can bring red light levels up to 1 lux when in animal rooms. However, light levels should return to 0.5 lux or less when keepers are not in the room. Headlamps with a red light setting are very helpful for observations during the dark period.

Mouse lemurs are extremely dependent on photoperiod cues for breeding, white light during their exposure during their normal dark phase should be avoided. White light exposure will disrupt the animal's circadian rhythm and can affect health and breeding. We schedule all vet procedures, research use, etc., very early in the day to avoid disruption to the animal's normal photoperiod. If animals are removed from the cage or exhibit and are unable to be returned prior to their lights out time, they are kept in designated areas that have the same light cycle.

Breeding:
Mouse lemurs are extremely seasonal breeders. Peak breeding months at the Duke Lemur Center are April-June. In early March we make necessary moves to set up breeding groups. We do not introduce males to the females at this time. Females are however able to hear, see and smell nearby males.

We have successfully housed mouse lemurs in the past with different species such as aye-aye, lesser bush babies, fat-tailed dwarf lemurs, and slender lorises.

Males selected for the breeding program are introduced to each other in late February or March so dominance can be established. Typically two males are chosen to form a breeding duo to allow for competition and mate selection. Aggression is a normal part of these introductions. Some behaviors that have been observed when males are initially introduced include approaching each other, sometimes one with an erect tail, and sniffing each other. Interactions may be very quiet, leading up to both males balling up and possibly falling from perches. This can last for 1-2 minutes with both males appearing to bite each other's flanks and hind legs. They will separate after a vocal climax and usually dominance is then established. Typically once dominance is established minimal aggression is seen. However, it may be normal to see the dominant male "checking-in" with the subordinate male and scent marking branches by rubbing his muzzle along the branching.

Close to the vernal equinox, late March, we begin to check the females for estrus. Females are hand-captured in their nest tubes or boxes 2-3 times per week. Animals are visually inspected and the stage of cycling is documented. Females will exhibit genital swelling over several days. As estrus progresses, swellings will enlarge culminating in the vaginal seal opening. Male mouse lemur testicular size changes quite dramatically in late February and throughout March. They can appear to be as large as 1/5 of the animal's total body size! It is quite impressive and usually an indicator of the male's breeding condition.

Males can be introduced prior to the females being fully open, usually in early April. Mouse lemurs use sperm competition as part of their breeding strategy, so it is ideal to have multi-male, multi-female groups. However, it may not be an option if too much aggression is observed. We have had success with two males and two females but have seen higher rates of injury with larger groups. Chasing is normal if the female is not receptive but if it becomes excessive animals may need to be separated temporarily.

It is important to stress that aggression is normal for breeding season. Minor wounds on tails, noses, and ears are the most common injuries observed. However, more extreme injuries have been observed and have required veterinary attention. Often the injuries occur because the female is not open and ready to breed. If any of the animals are removed due to injury, continue close observation of the female's cycling progression. The injured animal may need to be placed back into a breeding situation per the veterinarian's approval. If it is the female's first cycle of the season, it is an option to allow the animal to heal fully and try again on the female's second cycle.

If possible it is very important to know the identity of the sire (the Studbook Keeper will thank you profusely!). This can be difficult because breeding sessions may or may not occur during observation time and of course they will most likely be in the dark! Our breeding animals are not on exhibit for the public so we rely upon tail shaves as a way to distinguish one male from the other.

When the female is fully open, usually only for 24-48 hours, she will allow the males to approach without protest. Males will tail wag and use an audible trill as a mating call. Some short-term chasing is typical. It has been observed that when the male and female are breeding the other animals in the cage, if any, may be aggressive towards the breeding male. Tail wounds may occur. If the breeding session was successful the animals will separate to groom their genitals. Females often appear to "drag" their genitals across branches,

Infant mouse lemur

caging, or available substrate. A sperm plug will be present after a good breeding session; however, it may or may not be visible. Sperm plugs may remain in the female for a variable amount of time. It is important to check the female to make sure the sperm plug has eventually fallen out of the female so no infection occurs. If the female still appears open and aggression is low, animals may be able to stay together for one more night. If vocal aggression, "chattering," is observed and the female does not allow the male or males to approach her, i.e. chasing, then it is best to separate the animals.

Gestation:
58-62 days. The upper end of the range seems to be the norm. Animals are palpated and given an ultrasound at ~30 days to confirm pregnancy.

Parturition:
Pregnant females are separated from all other group members at 58 days gestation. Females are moved to a smaller meshed "birth" cage within part of their housing cage complex. Nesting material is offered to the female along with one to two nest boxes. Care is taken to cause minimal disturbance to the female at this time. Females that stay on the nest at feeding times may have given birth. Documentation of possible birth is made and technicians will only enter animal rooms for basic husbandry. An increase in the female's diet by 50% on the day infants are discovered (or suspected) is recommended.

At 48-72 hours, infants are weighed and females are inspected by a veterinarian. If all is well the infant is returned to the nest box and the mother is placed back in the cage. It is typical for the mothers to transfer the infants from one nest box to another if disturbed. Adding additional nesting material after infant weight collection is recommended as the dam will most likely not use the disturbed material. Dams carry the infants in their mouths to transfer between boxes. If a dam is carrying her infant due to nest disturbance or human presence in the area, leave the area until she and the infant are in a nest box.

Infants will stay in the nest until approximately one month of age when they may be seen exploring. Infants will begin sampling adult diets in their second month and be fully weaned by four months of age. Male infants will remain with the dam until approximately four months of age. They may be separated and housed alone or with male siblings.

Lorises in Zoos: History, conservation, and management

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Introduction

Lorises are an amazing group of nocturnal prosimians with unique physical and behavioral characteristics. Their endearing appearance and stealthy movements make them very intriguing to the public. Despite the ability of some species to produce toxic bites (Alterman, 1995; Hagey et al., 2006), lorises are heavily sought by hunters for the illegal pet market trade, traditional medicines, and for tourist entertainment.

Lorises are divided into two genera, slow lorises *(Nycticebus sp.)* and slender lorises *(Loris sp.)* Slender lorises are only found in limited areas of India and Sri Lanka. As their name implies, these lorises have very slim torsos and limbs. Their altricial infants are born without fur and are carried by their mothers for the first month of their lives. In contrast, slow lorises are widely distributed throughout Southeast Asia and its bordering areas. These lorises are plumper in their appearance and their precocial infants can be parked on branches only hours after they are born.

Conservation Status and Captive History of Slender Lorises

There are two slender loris species, both of which have been exhibited in North American Zoos. One of these is the grey slender loris which was formerly known as "*Loris nordicus*" but is currently classified as "*Loris lydekkerianus*". These slender lorises are not considered to be at risk according to the current IUCN rating (IUCN, 2015). However, their survival is increasingly threatened due to habitat loss, use for medicinal purposes, and capture for the pet trade. The other species is the red slender loris *(Loris tardigradus)*. Unlike the grey species, these lorises are critically endangered and are found only in Sri Lanka. Thought to be extinct for 60 years, researchers now estimate that there are fewer than 100 remaining (Smith, 2010).

Grey slender loris from original German colony. *Photo by Helena Fitch-Snyder.*

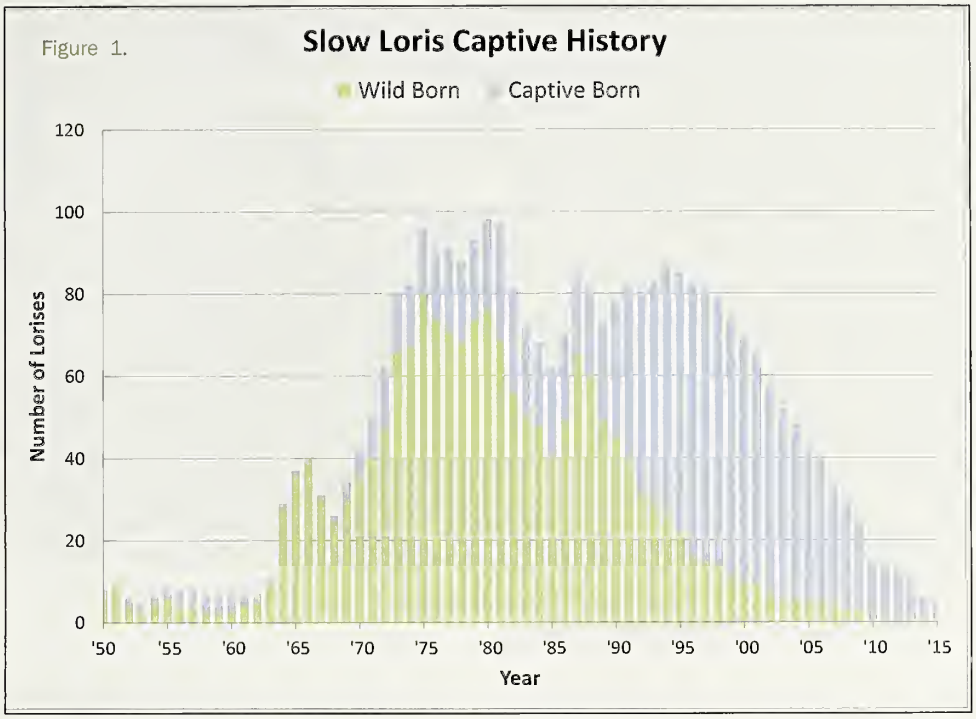
According to the data in the Slender Loris Studbook, the first grey slender lorises were two pairs of captive-born animals that were imported by Brookfield Zoo in 1987 (Fitch-Snyder, 2004). These lorises were born into a small research and breeding colony at Ruhr University in Germany. This founder group and their descendants produced a total of fifteen offspring (nine singletons and three sets of twins). The population grew to 13 animals before the last birth took place in 1995. As population numbers declined in both Europe and North America, three of the remaining lorises were exported to Europe to augment their diminishing population. There are currently twenty-seven remaining in six European zoos. The North American population became extinct when the last one died in 2004.

Studbook records show that the first record of a red slender loris in North America was a wild import in 1900 that survived less than a year (Fitch-Snyder, 2015). Several individuals and small groups were imported during the next eight decades and the first birth took place in 1982. By 1994, there were 42 living in North American zoos and 37 of these were captive born. The last of the wild caught lorises died in 1999 and the population gradually declined. The final successful births occurred in 2010 followed by two infants born in 2012 that did not survive. The remaining 2.3 (5) lorises are presently housed at Memphis Zoo.

Slow lorises

Slow lorises have an extensive distribution range in Southeast Asia from Yunnan Province in the north to Java in the south. Their eastern range includes the Philippines and their furthest western range extends as far as Bangladesh and Northeast India. All slow loris taxa were historically lumped under the *Nycticebus coucang* classification and geographic and morphological differences were therefore believed to be only subspecies variations. Considering their wide distribution and significant anatomical variations, it is not surprising that scientists have now verified eight valid species. These include the Sunda

Bengal Slow Loris with infant.
Photo by Helena Fitch-Snyder.



slow loris (*N. coucang*), Bengal slow loris (*N. bengalensis*, Javan slow loris (*N. javanicus*, and the smallest of this genus, the pygmy slow loris (*N. pygmaeus*). Additionally, there are four Bornean slow loris species: (*N. menagensis*), *N. bancanus*, *N. borneanus*, and *N. Kayan* (Munds et al. 2013).

With two exceptions, all slow loris taxa are classified by CITES as "Vulnerable". However, the Javan slow loris is critically endangered and is included on "The World's 25 Most Endangered Primates" list (Schwitzer et al., 2014). The Kayan slow loris from Borneo has only recently been identified and there currently is not enough data for CITES to assess their survival risk.

Despite legal protection throughout their distribution range, lorises are rapidly declining in the wild. This is primarily due to habitat loss and poaching for traditional medicine. More recently, the exotic pet trade has made a significant impact on wild populations due to numerous YouTube videos that portray lorises as cute and fun pets (Hance, 2011). Unfortunately, poachers often inhumanely remove the slow loris' teeth; with can lead to infection and death. This practice also makes it difficult for them to eat a healthy diet and they become unsuitable candidates for release back into the wild. Laos, Cambodia, and Thailand are reported to be the primary exporters of slow lorises along with Singapore and Malaysia. China and Indonesia are also involved, especially in local trade for traditional medicine (Nekaris et al., 2010). Over the past 20 years, both high demand and resulting high prices have fueled increased smuggling of slow lorises to additional countries, especially to Japan and Russia.

Baby Bengal Slow Loris in Vietnam.
Photo by Helena Fitch-Snyder.

The first known captive loris in North America was a slow loris that lived in the Philadelphia Zoo in 1876 (Fitch-Snyder, 2015a). At least 38 other slow lorises followed during the next 78 years, but they were kept in very small numbers and rarely given an opportunity to breed. It wasn't until 1950 that the first birth occurred after 13 wild-caught lorises were imported. During the 1960's and 70's, zoos and primate centers became more interested in lorises and exported them in larger numbers from throughout their native ranges. By the late 1970's, more than 100 individuals lived in zoos and primate centers. However, only about 24% of these were captive born.

By the 1980's these institutions began to develop breeding programs and they worked to identify the husbandry requirements for successful captive reproduction. While the birth rate increased during that era, there was unfortunately little known about loris taxonomy and the origins of many of the breeding lorises. At that time, all slow loris taxa were thought to be a subspecies of *Nycticebus coucang*, and dissimilar individuals were therefore commonly paired for breeding. Modern taxonomic classifications now acknowledge at least eight valid slow loris species. Therefore, many of the captive-born lorises are currently recognized as hybrids.

As shown in Figure 1, captive reproduction began to decline by the 1990's. This was partly the result of the emerging awareness of hybrids and uncertain origins of many of the founders. This made the population much less desirable for breeding in zoos. Additionally, groups of pygmy slow lorises (*Nycticebus pygmaeus*) were first imported into North America in the late 1980's. These lorises were much more exciting to zoos and primate professionals due to their taxonomic certainty along with the "newness" of this diminutive species. The Prosimian Taxon Advisory Group decided to classify all of the larger *Nycticebus* lorises as a "phase-out" population, partially to provide space to focus on the growing pygmy slow loris population. The last slow loris birth took place at the San Diego Zoo in 2001 and the population numbers continued to decline as older animals have died. There are currently only 2.2 (4) elderly individuals remaining in North America.

Pygmy Slow Lorises

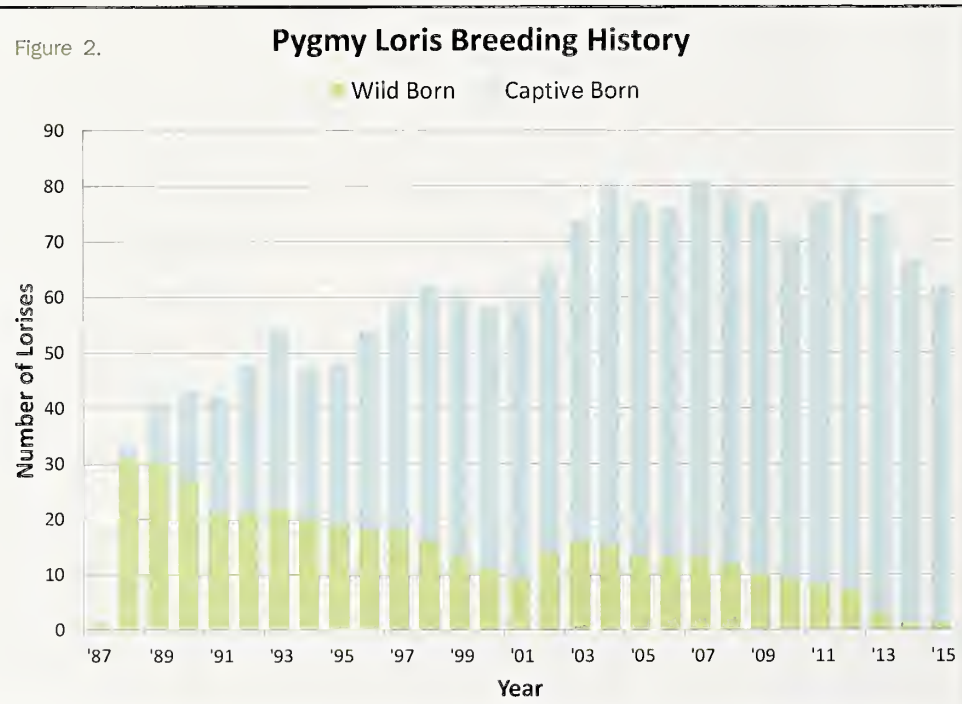
The smallest slow loris, (also known as the "pygmy loris") is found in Vietnam, Laos, Cambodia and southern China. Pygmy lorises are roughly 1/3 to 1/2 the size of their larger *Nycticebus* relatives and have more delicate physical features. Their reproductive patterns are also unique. Unlike other slow lorises which are fertile throughout the year, pygmy lorises breed seasonally (Fitch-Snyder et al., 2003). Additionally, multiple births (usually twins) are the norm for this species compared to singletons in all other *Nycticebus* lorises. It is

Young Bengal Slow Loris born at San Diego Zoo. *Photo by Helena Fitch-Snyder.*

also noteworthy that pygmy loris bites do not appear to produce the same toxic reactions to humans as do the bites from the larger slow loris taxa. This is likely due to significant chemical variations in the pygmy loris's brachial gland exudate, which is directly linked to the toxicity of loris bites (Hagey et al., 2007).

Pygmy lorises were unknown to the North American zoo community until 34 individuals were imported from Skansen Zoo in Sweden beginning in 1987 (Fitch-Snyder, 2015b). Skansen Zoo was the first to develop a relationship with the Vietnamese government and import groups of wild-caught founders. The arrival of these lorises sparked considerable interest in zoos and primate centers, and breeding and research programs were quickly established. The pygmy slow loris population grew rapidly (Figure 2) and reached a peak of 81 animals at 30 institutions in 2006. During that time, over 40% of the population was housed at four facilities with numbers ranging from six to eleven individuals. Two of these locations kept their colonies in off-exhibit enclosures and focused on research and breeding. Dozens of scientific and other publications were generated from this new captive population. Research focused on estrous cycles, reproductive endocrinology, pregnancy and birth, maternal behavior, infant development, seasonality, genetics, chemical communication, mate selection, and virology. Many of these publications remain significant references today. However, as breeding and research priorities have changed in North American primate centers and zoos, the population of pygmy lorises and their associated research has significantly decreased. Currently, there are 60 (28.32) pygmy lorises that are maintained at 23 different facilities. Nearly all of these lorises are kept in small numbers with a maximum of one breeding pair.

Figure 2.



Future Directions and Recommendations for Pygmy Loris Conservation

Pygmy lorises are the largest nocturnal prosimian population in North America and they are the last remaining loris species with any long-term potential. This population still has over 95% genetic diversity and does not have any inbred or hybrid animals. However, their population numbers are beginning to decline. There were 81 pygmy lorises in 2006 but now those numbers have been reduced to 60. According to the latest Pygmy Loris Masterplan (Gibson et al., 2015), reproduction must double the existing rate to maintain the current population size.

The existing population will need to be carefully managed to successfully maintain stable numbers in the future. Since females are usually only fertile once a year, pygmy lorises need to be actively monitored by their keepers to ensure that breeding opportunities are not missed. (A detailed protocol for documenting loris reproductive cycles and identifying estrus is available from the author upon request.) Artificial lighting can also affect and disrupt normal reproductive patterns making it more challenging to predict females' fertile periods and calculate possible birth dates. Since infant mortality can also be a substantial risk, it is essential to closely monitor pregnancies and births as well.

Mate choice can additionally play an important role in their reproductive success (Fisher et al., 2003). If a selected pair is incompatible, valuable breeding time is lost unless alternate partners are available on-site. It is therefore advisable to have more than one pairing option available for each female whenever possible. Maintaining pygmy lorises in small colonies will not only enhance reproductive prospects, but it will also provide more significant research opportunities.

Research and Conservation

During the first 20 years after pygmy lorises were imported, there were numerous studies and scientific publications. The majority of research was done at the San Diego Zoo and at the Duke Lemur Center. However, there have only been very few studies on this population since 2007. Continued research not only benefits the existing captive population, it can also provide essential information for field personnel who are working to protect and save lorises in the wild (Fitch-Snyder and Streicher, 2015). As previously stated,

all wild populations of lorises are declining. During the past fifteen years, rescue centers are receiving increasingly large numbers of confiscated lorises, most of them in very poor condition. (Streicher et al., 2008). These rescue centers must focus on the restoration of health in these animals and do not have the time, personnel and finances to conduct research. Rehabilitating these lorises and reintroducing them to the wild is the primary solution for the placement of these animals. But as long as many aspects of loris ecology are still comparatively unknown, successful reintroduction remains very difficult (Streicher, 1997). Topics that require further research include: vocal and chemical communication; pygmy loris toxins; social behavior; hormones and testis size; annual hormone patterns in males and females; thermoregulation and torpor; and the effect of light on reproduction. This information is urgently needed to better understand this species and to be able to improve the success rate of reintroduction efforts by rescue workers.

Along with conducting basic and conservation research, zoos can also help conserve lorises by informing the public that lorises do not make good pets and by discouraging "cute" YouTube videos. Additionally, zoos can help by supporting loris field projects and conservation organizations such as the Little Fireface Project (www.nocturama.org/).

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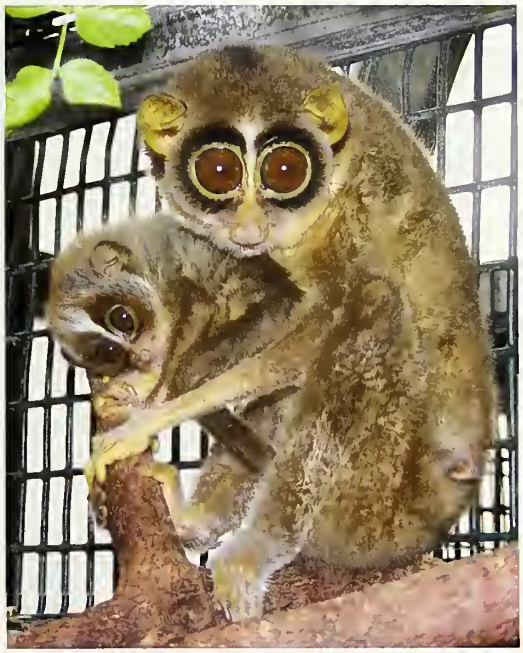

Red slender loris. *Photo by Helena Fitch-Snyder.*

Pygmy slow loris. *Photo by Rocky Winer.*

Managing Aye-aye (*Daubentonia madagascariensis*) on a Natural Photoperiod (NPP)

Dean Gibson, Aye-aye SSP Coordinator/Studbook Keeper, Curator of Primates; Mindy Settles and Joe Milo, Keepers, San Diego Zoo, San Diego, CA. Julie McKinney, Technician II, Duke Lemur Center, Durham, NC.

Aye-ayes (*Daubentonia madagascariensis*) have traditionally been managed in closed system nocturnal exhibits on reverse lighting systems. However, as an option to provide aye-ayes with additional sensory stimulation and a fresh air environment, a few institutions are experimenting with managing this species on a natural photoperiod (NPP) in outdoor exhibits and in indoor areas with access to outdoor exhibits. Of course there are pros and cons to both the traditional nocturnal exhibit and the NPP option. As the more traditional, reverse lighting system is widely known, we present our experience with a NPP management regime at the San Diego Zoo and the Duke Lemur Center.

Facility Descriptions

The San Diego Zoo (SDZOO) currently houses (1.1) aye-ayes in housing that consists of two indoor holding areas connected by an elevated chute system with an additional lower chute system connecting each area to a shared outside enclosure measuring 23.4 sq meters and 6.1 meters (20 ft) in height (Behlen type of caging, 252 sq ft and 20 ft high). Each of the two holding areas is constructed of concrete masonry units (CMU) and mesh wall panels. They measure 5.2 sq meters (56 sq ft) and 8.9 sq meters (96 sq ft) respectively, both with 2.1m (7 ft) in height. This space, while adequate for the short-term, is not recommended for long-term use for more than a single animal or female with young offspring. As we go to press, enclosure space is expanding to provide each aye-aye with 14.1 sq meters (152 sq ft) and 2.1m (7 ft) in height of indoor space and 23.4 sq meters (252sq ft) and 6.1 meters (20 ft) in height of outdoor space. All areas are connected with a chute/tunnel system or shift doors for easy movement from one area to another. The indoor area is thermostatically maintained at 24.4 – 25.6 Celsius (76 – 78 Fahrenheit), and due to the mild San Diego climate, the outdoor areas are not heated. See photos 1, 2 and 3.

The flooring indoors is concrete and each area has an operable skylight (opens for fresh air). There are a total of three permanent platforms (high density polyethylene) and additional movable furniture features, including wooden nest boxes. The nest boxes were designed with an easily attached wooden panel/door to place over the opening to secure the aye-aye inside the box. The boxes are fastened to the wire mesh utilizing a mechanism for easy removal resulting in very limited disturbance to the sleeping aye-aye inside. Natural wood perching is utilized throughout the indoor and outdoor enclosures. Substrate in the outdoor enclosure includes soil, mulch, rocks, and a grassy area as well as carrot trees, honey suckle, and hibiscus plants. Substrate is absent from the indoor areas unless an infant is present. In this case, either hay or pine chips are used. Large bamboo and acacia browse are cut frequently and added to both indoor and outdoor enclosures for nesting material and enrichment.

Aye-ayes have access to the outdoor enclosure at all times of the year. Average night time lows during the coolest months (Dec and Jan) can dip to 7.3 – 8.9 Celsius (45-48 Fahrenheit) for brief periods of time. During rare periods of unusually cold weather the aye-ayes may be held indoors for the night.

The Duke Lemur Center (DLC) also houses (1.1) aye-ayes on a NPP with a similar design of connected indoor and outdoor housing. The current outdoor aye-aye holding areas are constructed of 2.5 x 2.5 cm (1inch x 1inch), 11 gauge chain link. Total outdoor square footage for the pair (including four connected cages) is approximately 62.7 square meters (675 sq ft) with a height of 3.66 meters (12 ft). The outdoor caging connects to an indoor area which is made of CMU and measures 24.2

Photo 1: Outdoor Behlen

Photo 2: Indoor holding

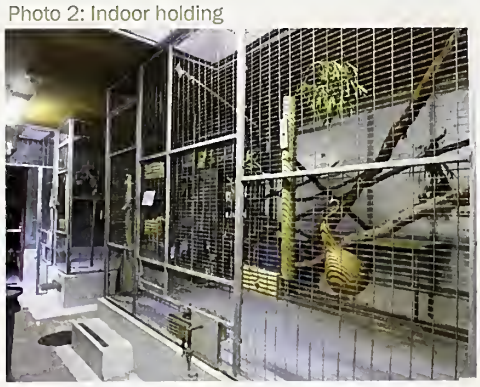

Photo 3: Chutes/tunnels

square meters (260 sq ft) with a height of 3.66 meters (12 ft) via a shift door.

Current practice is that aye-ayes are provided access to the outdoor housing in the spring when nighttime temperatures are consistently predicted to be above 12.8 Celsius (55 Fahrenheit). In Durham, these temperatures are typically reached in April and continue through October. Short periods of colder temperatures, 1-2 nights of 8.9 - 10 Celsius (48-50 Fahrenheit) have been well-tolerated with a heat source. Due to the Durham weather patterns, outdoor radiant heaters are installed approximately 18" above small sections of the chain link with the thermostat set point at 18.4 Celsius (65 Fahrenheit). In these cases, the aye-ayes can choose to move in and out of the heated part of the outdoor cage or enter the thermostatically controlled heated indoor holding room (25.6 Celsius, 78 Fahrenheit).

Historically at the DLC, a total of seven aye-ayes have been successfully housed either outdoors or indoors on a NPP for varying amounts of time. Outdoor caging included Behlen caging, similar to what is now being used at the SDZOO, equipped with vermin exclusion mesh, natural branching, shelving and a nest box. With this caging, aye-ayes were housed outdoors for the spring and summer months only. Indoor housing on a NPP consisted of a sizable chain link enclosure within a heated wooden barn structure which permitted NPP housing during both the winter and summer months.

Photo 4: Foraging behavior

Husbandry Routine

The husbandry routine for aye-aye managed on a NPP varies from that of a traditional nocturnal exhibit. Whereas on a reversed lighting regime the keeper schedule would overlap with the dark phase of the photoperiod, this is not the case when managing on a NPP unless the institution has an evening or night time keeper shift. The aye-aye's activity period varies slightly with changing sunrise and sunset but could be roughly generalized to extend from 1900-0430 hrs. (7:00PM-4:30AM). At both the SDZOO and DLC, the primary keeper shifts cover the daylight hours ranging from approximately 0600-1630 hrs. (6:00AM - 4:30PM). While this makes husbandry slightly more difficult, with staff, institutional commitment and creative scheduling, it is not impossible!

Health checks

At the SDZOO, morning aye-aye checks are completed at 0615- 0630 hrs. (6:15-6:30AM). While the aye-ayes are already settled into their nest boxes for the day, they are not yet sound asleep. Both aye-ayes are frequently willing to rouse and participate in training as well as provide keepers with the opportunity for a good visual inspection. Through a few simple trained behaviors and hand-feeding, keepers can quickly conduct an estrous cycle check and inspect body condition (fingers, eyes and teeth) in addition to general health condition, appetite and behavior. Since observation time may be limited, it is helpful to have consistency with animal care staff as subtle changes can be identified and addressed more quickly. Non-natural lighting is not utilized during these sessions. Keepers rely on red overhead lights, a red light flashlight and/or a red headlamp for a light source. Additional animal care staff conducts evening behavior and activity observations once or twice weekly along with breeding introductions and health observations as needed.

At the DLC, keepers arrive a little later in the morning (8:00AM) and the aye-ayes, who are likely sleeping more soundly, may be more reluctant to come out of nest box at this time. As a result, training and obtaining visual inspections can be challenging. With the schedule at the DLC, the aye-ayes on a NPP are handfed to come out of the nest box late in the afternoon at 1600 hrs. (4:00PM) for a full-body visual check daily (the female) or at least once a week (the male).

When managing on a NPP, the ability to regularly and fully monitor behavior, health and reproductive condition must be met. There are certainly several ways to achieve this goal. Rousing the aye-ayes for inspection as early as possible in the morning or as late as possible in the afternoon is ideal and the animals do become conditioned to this. In addition, observing the aye-ayes during their nocturnal activity period is the best way to ensure overall health and well being.

Cleaning

Exhibit cleaning and maintenance is conducted later on in the day at both institutions with keepers attempting to limit noise and commotion as much as possible. Both indoor and outdoor areas are raked or hosed and spot cleaned daily with full sanitization occurring as needed. As aye-ayes are very sensitive to chemicals, they are temporarily relocated while their enclosures are fully sanitized. Sanitization is completed with quaternary ammonium disinfectant, water and bleach. Branching and other materials are spot cleaned daily and replaced as needed.

Diet – it's all about the gruel!

Diet and enrichment preparation is similar to that for animals managed in traditional nocturnal exhibits. The critical exception is that keepers are not able to provide multiple feedings or stretch out the diet presentation time. As a result, the less desirable but nutritionally important items may not be adequately consumed.

Diet presentation is unique with aye-aye as they have a very unique foraging behavior referred to as percussive extractive foraging. Their diet must be presented in such a manner to be somewhat challenging and require the use of their third finger for extraction. Additionally, aye-aye are easily bored with routine presentation and consistent food items. The diet items and presentations should be

rotated on a daily basis and presented in a manner to encourage consumption.

One of the main components of the captive aye-aye diet is "gruel". This is a mixture of cracked old world monkey diet (Lab Diet® Old World Monkey 5038), Mazuri® leaf eater biscuit, a flavoring (such as vanilla extract, honey, peanut butter, apple sauce, etc.) and water. As with many animals, primate chow – no matter how it is presented, is not always readily consumed. The aye-ayes are no different.

At the DLC, when the diet is provided to the outdoor aye-aye too early in the day, it attracts insects and wildlife. If the gruel is refrigerated or frozen for several hours to keep it fresh for feeding out at the end of the day, consumption decreases. To ensure adequate gruel consumption, the keeper feeds right before they leave between 1600 – 1630 hrs. (4:00 - 4:30PM). Every piece of diet is individually wrapped in paper bags, newspapers or in a box with wood wool. Under these conditions, the aye-ayes eat most of their diet quite well. This technique also helps deter some of the local wildlife and vermin (e.g. squirrels, mice). Rodents in the area can attract snakes (e.g. copperheads in North Carolina) to the enclosures, which can cause serious injuries to the aye-ayes. Wrapping the food also serves as enrichment as the aye-ayes have to spend more time working to obtain the food.

At the SDZOO, diets are normally prepared in the afternoon and fed out by 1330hrs (1:30PM) in the indoor areas. Indoor presentation is used to deter the local outdoor wildlife which is all too aware of the possibility for low risk plundering of unprotected food scraps! Feeding at this time provides an additional opportunity to interact with the male aye-aye. In anticipation of food, he will wake up and approach the keeper, eager to take nuts and worms from the hand and to consume one or two of his more desirable enrichment/food items before going back to bed. During the summer hours, the SDZOO extends its operating hours and there is a daily late keeper available to feed at 1730 (5:30PM).

There has been some difficulty with gruel consumption and attempts are now being made to make the gruel a more desirable food item. This is being accomplished by continuing to try different methods of preparation to determine which are most palatable and to increase variability. Methods utilized include freezing the previous day, preparing fresh daily, mixing with a blender or hand-mixing. Keepers continue to try new flavorings as well as mixing in variable solid food items in order to increase the novelty of the different gruel mixtures. Presentation methods are also variable each night. Some of the most frequently utilized methods for gruel presentation include boxes, bamboo cups, paper cups, and paper bowls. Additional diet items include several varieties of fruit and vegetables, soft-boiled eggs, mealworms, coconut, sugar cane, tamarind pods, nuts, seeds.

Enrichment

In the wild, aye-ayes have extensive home ranges and spend the majority of their time and energy searching for insect larvae and excising them from their protective wooden burrows. Since captive aye-ayes lack the opportunity for long-distance travel, and in general do not have access to naturally occurring insect larvae populations, it is incredibly important that husbandry protocols include providing them with an extensive amount and variety of enrichment on a daily basis. As with all primates, enrichment encourages natural behaviors, assists in maintaining mentally and physically healthy animals, and aids in reducing and preventing stereotypic behaviors.

Aye-ayes utilize their ever-growing rodent-like front incisors to chew into just about anything. Given this behavior, it is extremely important to ensure a safe environment. This can be accomplished by limiting what they have access to in their enclosure as well as limiting what is provided for enrichment and ensuring that materials being used are not toxic if accidently ingested. The aye-ayes front teeth have the ability to move independently which also makes it important to make sure they do not have access to any materials that could possibly become wedged between the front teeth (example: zip ties). For these reasons, aye-aye enrichment is largely limited to paper and wood products but don't let that defeat you, the world of wood and paper is quite extensive and there is a lot of room for creativity! Some of the most successful enrichment items include smashing avocado, peanut butter, or honey inside of pine cones, using peanut butter boards, manufacturing any kind of bamboo sections into worm feeders, drilling deep holes for worms in lateral tree sections or lumber, providing metal puzzle feeders and attaching paper cups with any number of food enrichment items to the back of a large piece of cardboard and hanging it on the outside of the enclosure. All kinds of paper, boxes, paper plates, paper bags, cardboard tubes, hay and gourds can be used and manipulated in dozens of ways as well. Paper tape/masking tape and fleece strips can be used with aye-aye and are ideal for providing flexibility for hanging and securing enrichment items. Wood wool, fleece, cardboard boxes, rotten logs and a variety of scents can also be used. Fresh cut acacia, bamboo and/or pine not only provide enrichment but are also a good source of nesting material. To promote incisor use, aye-ayes are provided with a minimum of one chewing/gnawing enrichment item a day. See photos 5, 6 and 7.

The aye-ayes front teeth have the ability to move independently which also makes it important to make sure they do not have access to any materials that could possibly become wedged between the front teeth (example: zip ties).

Training

At the SDZOO, keepers rotate schedules to extend their shifts to 1730-2100 hrs. (5:30-9:00PM) pending the sunset hour, to conduct more extensive training. This is in addition to the maintenance training that occurs during the morning health checks. These more intense and specific training activities are scheduled a minimum of twice per month. Currently, the aye-ayes at the SDZOO are scale, kennel and chute trained. They both eagerly participate in training and are in the process of learning target and a hanging behavior. The aye-ayes on the NPP schedule at the DLC are not currently involved in a training program but have had successful experience with training while housed on a reversed lighting regime.

Managing Reproduction

Conducting estrous cycle checks is critical for successfully managing reproduction in this species. For breeding aye-ayes on a NPP, a commitment must be made to monitor estrus and conduct breeding introductions. This can be accomplished by rousing females during the day or by checking estrus status in the evening/night hours after the aye-aye is awake and active. At the SDZOO, given that the female will come out of the nest in the early AM, estrus checks can be done daily by keeper staff. When estrus begins, additional PM checks are conducted by animal care staff to verify marking behavior and estrous vocalizations. With this information it is very easy to determine when to schedule evening introductions for breeding.

Generally, adult male and female aye-ayes are housed separately. However, in some cases, females will tolerate the presence of a male outside of estrus. For breeding aye-ayes housed

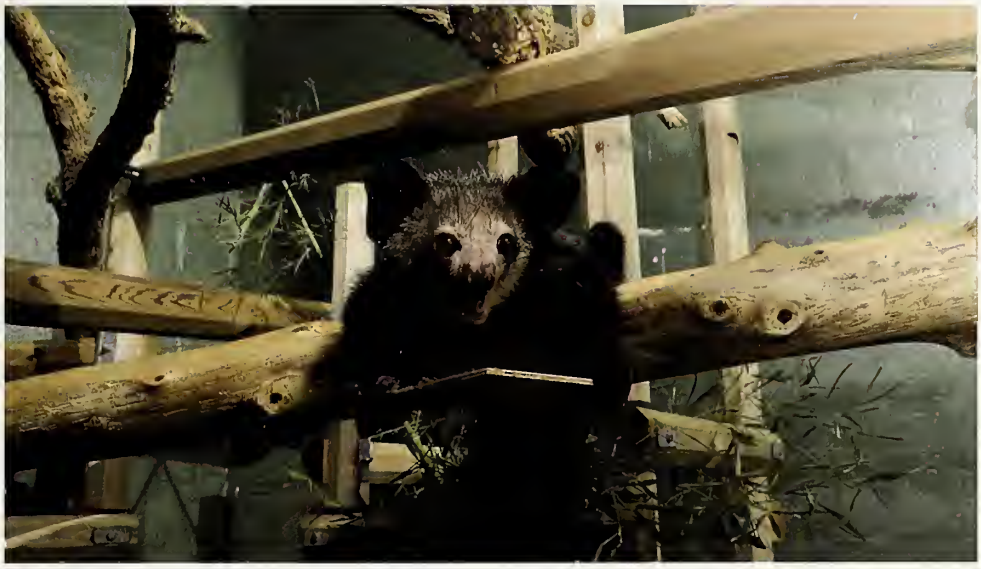

Photo 5: (Top left) Enrichment assortment
Photo 6: (Bottom left) Cardboard and cups
Photo 7: (Above) Peanut butter board

together, estrous cycle monitoring is still critical for predicting a breeding date, delivery date and managing infant care. If the aye-ayes are not housed together, for successful reproduction, introductions must occur when the female is receptive during the estrous cycle (usually only one night). The current aye-ayes at the DLC on a NPP are a non-breeding pair. In addition, the aye-ayes housed at the DLC historically on a NPP were also non-breeding animals.

Surveillance Monitoring

At the SDZOO, in addition to early AM and evening visual checks, the keepers are able to monitor activity and concerns that may have occurred overnight through a video surveillance system. The current system retains approximately one month of video footage which has been sufficient for current needs. The infra-red cameras are motion sensitive and set to record during the hours the aye-aye are active. While checking video footage is very time-consuming, when the aye-aye first arrived it was a very helpful tool for keepers to acquire a good understanding of each animal and to monitor their behavior as they adjusted to their new environment.

At the DLC, overnight video recording of the aye-ayes is done at least once a week for routine monitoring and as needed in case of special behavior concerns. The camera is set up inside the building and directed towards an observation window in the indoor enclosure. The memory card holds 13 hours of HD video. The following day, a quick review of each tape is done to alert the husbandry staff of any concerns. A more detailed tape review and analysis noting indoor/outdoor use, stereotypies and enrichment processing is completed later by DLC students.

Summary

When aye-ayes are housed in traditional nocturnal exhibits on a reverse light cycle, all aspects of husbandry and management can be easily provided with the highest standards. When managed on a NPP, certain aspects of husbandry and management are more challenging simply because the aye-aye's activity period does not fully overlap with that of the keepers.

One concerning aspect of maintaining aye-aye on a NPP is conducting consistent observations for general health and reproductive success. Late shifts or flexible keeper hours can address these concerns. Furthermore, pending the personality of the animals, aye-ayes may rouse during the day to participate in training and for estrous checks. At the SDZOO, the aye-ayes have become conditioned to the presence of the keepers in the morning as well as in the afternoon and respond favorably. Obviously, there may be individual aye-ayes with sleep patterns that are better suited for the NPP management regime. However, maintaining a breeding pair on a NPP requires evening scheduling commitments to monitor estrous behavior (marking, presenting and vocalizing), conducting physical introductions and recording breeding events. In all cases, aye-aye should be routinely visually inspected while fully alert and active during the night phase to monitor overall activity and well being.

Another important husbandry concern is ensuring sufficient amounts of gruel consumption. On traditional nocturnal systems, gruel can be made fresh and immediately fed when aye-ayes first awake and other diet items held back to be fed later in the day. On a NPP, there is less opportunity to stagger feeding times thus aye-aye are less likely to consume less favorable food items such as gruel. Presentation, freshness and flavor all become extremely important to encourage the aye-aye to choose gruel over other high value, more delicious options. The SDZOO has plans to experiment with automatic feeders triggered to engage throughout the night. This may provide a solution to increase gruel consumption while also introducing another enrichment tool. Additionally, local wildlife and vermin are problematic when food is left out unattended. Pending the enclosure/exhibit type, vermin can easily be controlled by securing the area with vermin exclusion mesh.

Finally, depending on an institution's operating schedule, management on a NPP limits public viewing and exhibit opportunities. As aye-ayes are large and active, evening viewing is definitely possible if there are night time zoo events or guided evening VIP or educational tours. The SDZOO has a small public following

of night time zoo visitors to the aye-aye exhibit. In addition, to accommodate the majority of the day time guests, the possibility of installing an aye-aye video loop at the exhibit is being considered along with housing diurnal lemurs to occupy the exhibit space during the day.

So, with the known obstacles, why bother to manage aye-ayes on a NPP? Outdoor housing and fresh air provides nightly environmental stimulation not available in closed nocturnal systems. As aye-ayes are known to exhibit stereotypic behavior (pacing, flipping and looping behaviors) while housed in traditional nocturnal exhibits, management outdoors is being explored by the SSP as an option to reduce/eliminate these behaviors and improve overall welfare. Additionally, outdoor housing options may also permit the SSP to grow the population as many institutions do not have nocturnal facilities. The SSP continues to monitor aye-ayes on NPPs and the associated management difficulties in an effort to develop appropriate solutions and recommendations to ensure that husbandry practices remain of the highest quality.

Nirina: A Case Study on stereotypic behavior, exhibit design and the value of enrichment

Nirina, an eleven-year-old male aye-aye arrived at the SDZOO in 2014. His records indicated that he was separated from his mother at sixteen months of age, which is younger than is typically recommended and upon being separated, began exhibiting stereotypic flipping and pacing behaviors. He had been housed both on a NPP and a reverse light cycle prior to his move. His stereotypic behaviors peaked during a time when he was exhibited on a NPP in an indoor enclosure with a nest box situated close to public viewing where visitors could disturb him by tapping on the glass and/or yelling. As he was housed on a NPP, the daily public disturbance was during his sleep cycle.

Nirina arrived at the SDZOO with a reputation of being aggressive and exhibiting severe stereotypy. While in quarantine, he exhibited extreme stereotypic flipping and pacing throughout the night and only very minimally interacted with enrichment items. Once evaluated by SDZOO staff and compared to other aye-ayes, it was determined that his aggressive behavior could be better defined as agitation, nervousness and tension.

After clearing quarantine, Nirina was transferred to his current exhibit and continued to be managed on a NPP. His behavior was monitored directly through typical husbandry and indirectly through evidence from enrichment and diet as well as analysis of video footage from surveillance cameras. Nirina was given access to both aye-aye holding areas but chose to remain in the smaller room for two weeks. During this time, he continued to exhibit significant stereotypic flipping, utilizing the skylight and area just below it. When he finally began exploring the larger room (14 days after the move), he would investigate some of the enrichment but would spend no more than three minutes at a time in the area. Not until week three (day 26), did he finally venture outdoors. Unfortunately, as the sun began to rise, he was unable to find his way back indoors. As a result, he spent day 27, completely exhausted, sleeping approximately 15' up, on only a log in broad daylight. He also spent the following night on exhibit as keepers found him still outdoors early the following morning. Fortunately he was still awake and was successfully baited indoors through the lower chute system using an apple. While we worried about his transition to his new environment, he appeared to suddenly hit a developmental milestone after the outdoor adventure. On day 28, he finally interacted with all of his enrichment during a single night. And, finally, on the 32nd day he was able to go outdoors on exhibit and find his way back indoors with relative ease. Progress was slow but continued in the right direction. After 36 days he finally made his first hole in a piece of bamboo. Prior to that, he would only utilize the holes that keepers had already drilled into the bamboo in order to insert worms. Not until day 67 did Nirina successfully chew into all of his bamboo enrichment over a single evening.

At present day, Nirina is a changed aye-aye. He is calm, curious, hand-feeds, participates in training, chews through every piece of bamboo nightly and utilizes every piece of enrichment. He has gone from agitation to curiosity. He is still easily stressed by noise but has a great appetite for all but his gruel, of course! While his stereotypic flipping and pacing will likely never be fully extinguished it has been much reduced since his arrival. The greatest reduction in stereotypic behavior was a direct result of having him utilize the larger indoor room. Through analysis of the video footage and evening observations, Nirina has almost completely stopped the full body flipping and pacing in the inside larger holding room. On occasion, we see very short segments of a subtle head toss. Keepers continue to monitor behavior and at this time report that the availability of bamboo to chew into has been a very successful distraction from the stereotypic behavior. While we believe having access to the outdoor exhibit is providing positive stimulation for him, we have to date not been able to place much enrichment or food there. Nirina utilizes the space and is very active at going in and out throughout the night, but unfortunately he continues to complete stereotypic loops with relatively high frequency in the outdoor area.

To address Nirina's outdoor stereotypy he will be provided with access to additional space (indoor holding and exhibit) and enrichment. Exhibit changes will provide him with 14.1 sq meters (152 sq ft) and 2.1m (7 ft) in height of indoor space and 23.4 sq meters (252sq ft) and 6.1 meters (20 ft) in height of outdoor space with access every night. Additionally, the outside exhibit will be secured with vermin exclusion mesh to keep out vermin and local wildlife. This will enable keepers to introduce food enrichment outdoors, thus providing additional stimulation and distraction in an effort to continue to reduce stereotypic behavior.

Further Reading

Feistner, A.T.C., and E. Sterling eds. 1994. Folia Primatologica, *The Aye-Aye: Madagascar's Most Puzzling Primate*. Karger, Switzerland.

Products

Behlen® caging http://www.behlencountry.com/index.aspx?ascxid=behlenCatalogProduct&i=928

Lab Chow® 5038
Lab Diet
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St. Louis, MO 63144
info@labdiet.com

Mazuri® Leaf Eater Biscuit
Purina Mills, LLC.,
St. Louis, MO 63116
http://www.Mazuir.com

Professional Development Committee

The American Association of Zoo Keepers

First Call for WORKSHOP Abstracts for the 2016 National AAZK Conference!

This is the first call for workshop abstracts for the 2016 National AAZK Conference in Memphis, TN, September 19-23rd. Abstracts should be no more than 250 words and submitted as a Microsoft Word document via e-mail to pdc@aazk.org. **Abstracts are due no later than FEBRUARY 1st, 2016.**

Diagnosis and Treatment of Lice in Black-and-White Ruffed Lemurs (*Varecia variegata*)

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Kelsey Miller, Keeper
Judilee C. Marrow, DVM
Binder Park Zoo, Battle Creek, MI 49014

Abstract:
A twenty-three-year-old male black-and-white ruffed lemur (*Varecia variegata*) was evaluated for progressive hair loss after behavioral, environmental, and enrichment changes had failed to curb clinical signs. Unidentified chewing lice were detected upon physical examination. Through medical management and environmental modification this animal was successfully cleared of lice.

Introduction:

Ectoparasites are an uncommon finding in captive lemurs in North American Zoos (Personal communication C. Williams and R. Junge). Clinical signs of disease can be asymptomatic or manifest with hair loss, excessive grooming, or weight loss. As these signs can occur with other conditions; including behavioral conditions, which can occur more frequently in captivity, it is important to closely evaluate animals with these clinical signs for medical and non-medical causes of hair loss and excessive grooming.

Case Report:

A twenty-three-year-old male black-and-white ruffed lemur (*Varecia varigata*) house name "John" presented with hair loss on his left forearm and side. This animal is housed at Binder Park Zoo (BPZ) in Battle Creek, Michigan, USA. John has been housed at BPZ for four years prior to the hair loss. He is housed directly with a female black-and-white ruffed lemur (*Varecia varigata*) house name "Phin". Other animals housed in this building are collared brown lemurs (*Eulemur collaris*), another black-and-white ruffed lemur (*Varecia varigata*), a ring-tailed lemur (*Lemur catta*), and a sulphur-crested cockatoo (*Cacatua galerita*). Lemurs at this institution have an indoor heated holding area, access to an outdoor chute system, and two large outdoor exhibits. The lemurs have access to outdoor exhibits when the temperatures are above 40F. During the winter months when temperatures are not warm enough for the lemurs to have access to the outdoor exhibits, some of the lemur groups are rotated through the indoor heated stalls to add variety and change to their daily routines. They are also offered a variety of daily enrichment items, diet changes, and holding furniture is rotated weekly to help prevent boredom.

On 22 January 2015, keepers noticed that John had some significant hair loss on his left forearm. By 31 January, he was also missing hair on the left side of his body. Over the next two weeks, keepers observed John and Phin grooming those areas. The initial assumption was they were over-grooming due to boredom and their daily enrichment was increased to at least three times a day. Keepers increased foraging by splitting up their diet into multiple feeds, hiding their diet in various locations, and presenting diets in different ways with every feed. Kongs® (www.kongcomnpany.com) and other puzzle feeders were used to help encourage puzzle solving techniques, which allowed the lemurs to be active and engaged for a longer period of time. Keepers also increased the use of perfumes or spices in their holding area to encourage natural scent marking behaviors. Although Phin is contracepted, nesting material was given to stimulate any natural maternal instinct.

On 10 and 11 of February, keepers found possible regurgitation that contained some hair. John's clinical condition started to decline and by 12 February, John was becoming more subdued and was not eating as well. An evaluation was scheduled with veterinary staff.

On 16 February, John underwent anesthesia for examination and diagnostic evaluation. Examination revealed a thin body condition. Radiographs and ultrasound obtained during the exam confirmed a depletion of fat stores in the abdomen. Blood samples did not reveal any significant clinical abnormalities and the rest of the examination was unchanged from previous exams. There were areas of thinning hair over his front arms, the left knee and the left lateral body wall/flank (figure 1). On close visual inspection with the naked eye numerous

Figure 1: John's left side showing the hair loss

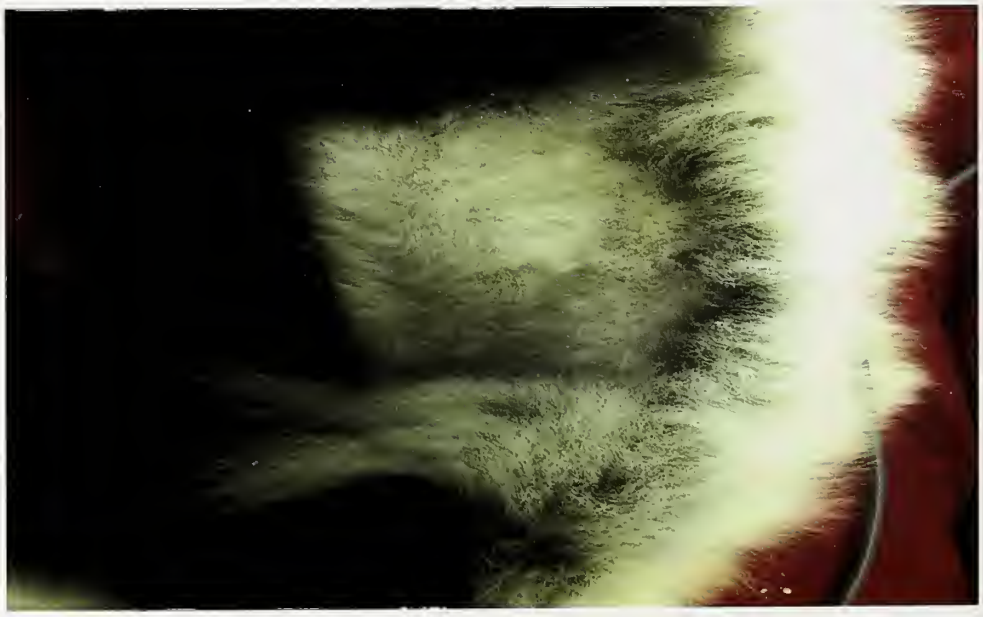

Figure 2: Picture of John's face while under anesthesia showing the small brown spots (lice) around his eyes.

Photograph of louse.

small, brown, mobile structures were noted (figure 2). Microscopic evaluation of these structures revealed unidentified chewing lice. Ivermectin was given subcutaneously at the time of his immobilization to treat the lice. Samples of the lice were collected for further characterization to try to determine the taxonomy and possible origin of the lice.

John returned to his holding area with Phin. On 24 February all lemurs in the building were evaluated for lice. Mild numbers of lice were confirmed on John's mate Phin and our two collared brown lemurs. Vet staff contacted other facilities and experts in lemur medicine to see if other facilities had experienced a case like this and possible treatment protocols. No other cases were reported (personal communication C. Williams and R. Junge).

On 3 March, John was immobilized to recheck for lice and for us to collect additional samples. At this time, he still had live lice and his body weight was down 8.73% from his previous examination. John was thoroughly groomed to remove lice and was treated with Ivermectin subcutaneously and topical Frontline® (Fipronil) (www.frontline.com) was applied. Samples of the lice were submitted to several entomologists for identification (figure 3).

A comprehensive plan for individual animal treatment and environmental modification was initiated to treat the lice. All other lemurs in the building were treated topically with Frontline®. We used a combination of operant conditioning and hand-restraint to apply medications to minimize the need for anesthesia. All organic substrate and propping were removed from holding spaces and lemurs were no longer permitted to have any hay beds or stuffed animals. Only plastic furniture was provided to try and eliminate places for the lice to hide. Lemurs were not permitted to share indoor holding areas with the other lemur species. Holding areas were disinfected every day with Brulin Maxima 128® (www.brulin.com), Spartan HDQ Neutral® (http://m.spartanchemical.com), or bleach throughout treatment. Although temperatures permitted outdoor access, it was determined the lemurs could not have outside access until the lice were gone.

On 26 March, John was rechecked for lice under hand-restraint. Although he still had signs of eggs, we could not see any signs of live lice at the time. During this examination it was noted that his hair was returning to normal. John's weight had also increased at this time; keepers added ZuPreem Primate Diet® (www.zupreem.com) to his diet to help continue the increase of his caloric intake. Treatment continued with Frontline® applications at 28-day intervals and was rechecked monthly for lice. John remained positive for lice eggs through June. On 17 June, zoo staff determined that John and Phin could go outside on exhibit since he had only showed signs of lice eggs during his last two monthly checks. On 20 July, John was rechecked and showed no signs of lice eggs. The final dose of Frontline® was administered at this time and John was cleared from lice. Frontline® treatment continued for all other lemurs in the building through 20 May. At this time, all other animals were determined to be free of lice.

Discussion and Conclusions:

This report describes how an outbreak of lice was treated in a group of lemurs using medical and environmental modifications to minimize spread and reduce clinical signs. Although the species of lice has not been determined at this time, zoo staff is currently working with two other facilities to try to determine taxonomy of the lice. The original source of the lice is still unclear. Lice are generally highly species-specific and have modifications of their grasping pinchers that allow them to parasitize certain types of animals or hairs. There have been no additions to the collection for the four years prior to this outbreak. It may be possible that John always had low levels of lice present on him and stress or underlying disease may have triggered the outbreak. The zoo's treatment and management strategies prevented lice from being spread to the male ring-tailed lemur or female black-and-white ruffed lemur housed in the same building. These strategies also prevented all other affected lemurs from developing clinical signs. This was a great learning experience for all the staff at the zoo. The staff looks forward to finding out what type of lice was involved in this case, which will allow everyone involved to better understand the impact of these ectoparsites on captive lemurs.

Acknowledgements:

The authors would like to thank Dr. Cathy Williams (Duke Primate Center) and Dr. Randy Junge (Columbus Zoo) for their assistance with treating these cases. The authors would also like to thank Mr. Daniel Kish (Hillsdale College) for providing some of the photographs and electromicrographs used in this manuscript.

When Tactile Training Comes in Handy: Helping a red-ruffed lemur *(Varecia rubra)* recover from four metacarpal fractures

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Abstract

Red-ruffed lemurs (*Varecia rubra)* are a critically endangered species, approximately six hundred of which live in human care worldwide. Within North America, the species is managed as an SSP (Species Survival Plan) under the auspices of the AZA (Association of Zoo and Aquariums). As with all animals included in such programs, each is a valued representative of its species and their care is a high priority. The San Antonio Zoo and Aquarium housed 1.1 red-ruffed lemurs in hopes of breeding the pair. Tactile training by positive reinforcement was implemented so that trainers could perform various tasks consistent with physical examinations to determine pregnancy. However, after the discovery that one lemur had broken four metacarpals, the tactile training shifted its purpose towards a previously unexplored use: the rehabilitation of the injured hand. This paper discusses the training processes, successes and challenges of training a twenty-one-year-old female red-ruffed lemur to accept muscle therapy.

Introduction

By 2014, the number of species and subspecies of lemurs recognized had increased to 103; of these, the IUCN classified 23 as Critically Endangered, 52 as Endangered, 19 as Vulnerable, two as Near Threatened, three as Least Concern and four as Data Deficient (Andriaholinirina, 2014). Red-ruffed lemurs are one of five ruffed lemur species. Like all lemurs, they only occupy the island of Madagascar. Red-ruffed lemurs are found in the rainforest of Masoala, in the northeastern part of Madagascar. Population numbers are in sharp decline due to a rapid upsurge of illegal logging in addition to hunting pressure, frequent cyclones and fires (Andriaholinirina, 2014). They live in matriarchal groups of 2-16 individuals and live in the same area as Black and white ruffed lemurs (*Varecia variegata);* however, the different species do not associate with each other. Their large group size, along with alarm vocalizations, help alert the groups against predators.

Figure 1a. Red-ruffed lemur hanging upside down in exhibit.
Figure 1b. Red-ruffed lemur utilizing the platforms for sleeping off the ground.

Their natural diet consists mostly of fruit, nectar and pollen; they are considered the most frugivorous of all the lemurs. Small amounts of leaves and seeds are also consumed, primarily during the dry season when fruit and nectar is scarce or nonexistent. When appropriate flowers are available, the lemurs eagerly feed on nectar by sticking their long noses deep into the flower. During this feeding, the flowers are not harmed, but the lemurs' snouts become coated with pollen, which is then transported to other flowers. Thus, for certain species of plants in the tropical forests of Madagascar, the ruffed lemur is an important pollinator. Unfortunately, many of the larger fruit trees essential for the survival of the ruffed lemur are also regarded as the most desirable hardwoods by logging interests, and are often the first to be cut down when a forest is selectively cut. Thus, the presence of healthy populations of ruffed lemurs is considered an important indicator of the health of a tropical forest. Females are the driving force in group dynamics and are always dominant to males. Ruffed lemurs will form larger groups during the wet season when food is plentiful, and disperse during the dry season in search of scarcer fruit (Duke, 2014).

In 2013, the San Antonio Zoo and Aquarium housed a total of six red-ruffed lemurs of which 1.1 were designated for breeding. A

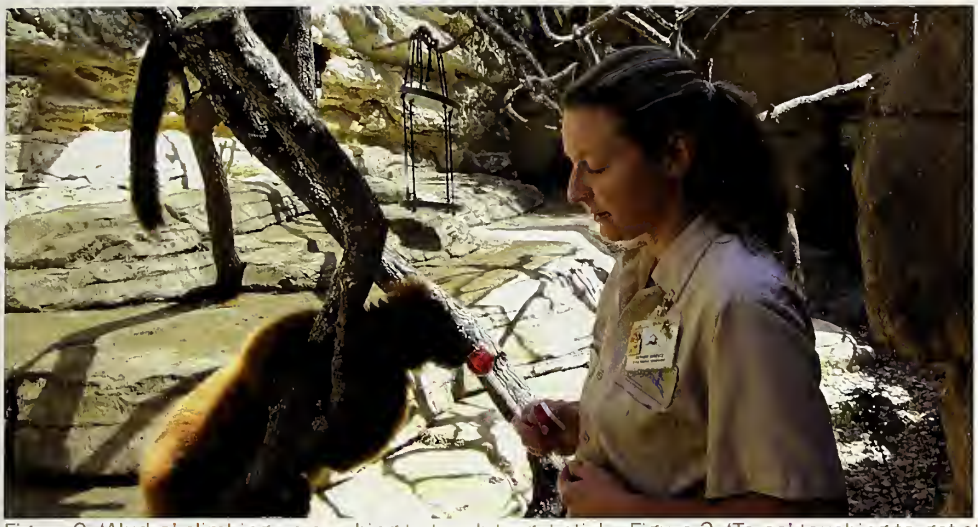

Figure 2. 'Aludra' climbing on perching to touch target stick. Figure 3. 'Toros' touching target stick with his mouth.

non-breeding sibling group of 3.1 comprised the balance of the individuals housed. The main enclosure provides lots of climbing structures and logs positioned at various angles to provide both horizontal and vertical moving space. Also, numerous horizontal pieces of rope are hung to increase grasp and balance (Figure 1a-b). With the intended breeders, a training program utilizing positive reinforcement was implemented. The goals for the pair had been focused on desensitizing the animals to close trainer proximity, accepting tactile contact, and ultimately allowing trainers to touch the female's abdomen.

Training Plan

The training with the pair began in 2007. The male that we had at that time was being sedated weekly for blood draws due to iron overload, or hemochromatosis. The training plan was to start working with the pair so animal catch-ups would be facilitated and weights could be obtained regularly, as well as to allow for monitoring the female for pregnancy. The animals were both already accustomed to free contact cleaning, but would not get close to keepers.

Step one: Desensitize animals to approach keeper by offering food reward and/or showing interest. Criteria for a reward increased as animals began focusing on and moving toward trainers.

Soon after training started, the female 'Aludra' would approach; however, the male 'Toros' took much longer to approach keepers. Due to his weekly catch-ups, 'Toros' had come to expect keepers approaching him in a negative way and thus trainers had to gain his trust by positive interactions.

While feeding 'Aludra;' food would be tossed behind her to encourage 'Toros' to get closer. Training times were also variable in order to experiment with what time of day they were more comfortable working for food. During these sporadic events the trainer would sit still and remain quiet to give them an opportunity to explore in close proximity.

Once 'Toros' appeared comfortable at a certain distance, the criteria for desensitization increased and the distance from trainer decreased for reinforcement.

Step two: Incorporate the bridge – a clicker – as the animals were rewarded.

As the red-ruffed lemurs became comfortable enough to eat from trainers and were beginning to approach on their own accord, a clicker was introduced as a bridge. It was clicked as the animals were given their food reward, but 'Toros' was found to be very sensitive to the normal sounding clicker and would vocalize and become distracted, so a soft clicker sound was then used.

The animals were conditioned over a one-month period (November-December 2007) to accept keeper and trainer presence as well as the clicker bridge. During this time, sessions were only conducted a few times a week with no specific plan instated. In the first week of November, a training plan was drawn up and initiated, and sessions (five to ten minutes long) were held at least three times a week before the animals received their diets. Formal documentation was kept on training steps and progress.

Step three: Introduce animals to a target stick (lollipop target stick), and train them to touch the target with their mouth. Once comfortable with the target stick, the increased criteria required the lemurs to move around exhibit for reward (Figures 2 and 3).

'Aludra' was stationed some distance away from 'Toros.' This gave 'Toros' easier access to the target stick. It was difficult keeping 'Toros' involved in the training sessions. He became easily distracted even with sounds outside of trainers' control. Also, taking into account that females are the dominant gender of this species, it was necessary to make sure 'Aludra' was trained at a distance away from 'Toros' to prevent any food-based aggression she might display towards 'Toros' when he earned his reward—yet still maintain enough proximity so that the pair was still close enough to interact with the trainer. This step was completed in January 2008.

Step four: Desensitize to scale. The target stick was used to get animals in close proximity to the scale. Once comfortable touching the scale, the increased criteria required the lemurs to sit up on scale.

There were many setbacks; their attention was often lost. When 'Aludra' would get distracted and move away, 'Toros' would end session as well. The training sessions needed to be re-evaluated to see why the pair was not staying engaged. Was the training session too long, was there an outside distraction, and was there any miscommunication from trainer to lemurs?

'Aludra' would get a rub down when the session ended-- mainly just touching and scratching behind her ears or underarms. When this was done her body completely relaxed and

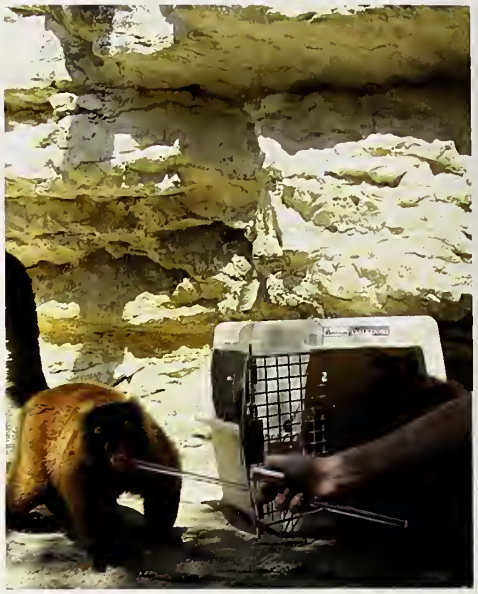

Figure 4a. 'Aludra' entering kennel without having to be targeted into kennel. Figure 4b. 'Aludra' entering kennel while 'Toros' is being desensitized targeting near kennel.

she would position her body to get scratched where she wanted. It was decided to change her primary reinforcer from food reinforcement to tactile reinforcement, due to her relaxed body language. After the reward was switched, 'Aludra' became more willing to work, and in turn 'Toros' stayed engaged in the sessions as well. It was also decided to cancel scale training at the time; we didn't have any flat scales that they could easily fit on, and the scale used was a My Weigh® MBS-2010 (www.myweigh.com) which had a trough top so it became unstable as animal attempted to get onto scale. The scale was even modified to prevent tipping, but even the slightest movement prevented both animals from getting on it.

Step five: Desensitize animals to a kennel. Again, the target stick was used to get animals in close proximity to the kennel and train them to touch target near kennel.

In order to desensitize the lemurs to the kennel, food rewards were placed near it. Once acclimated to the kennel they were targeted around, on top, and eventually inside. As the individuals became more comfortable, criteria changed and required the lemurs to enter the kennel. Afterwards, they were targeted inside the kennel. Once the animals were comfortable following the target and became proficient with the behavior, trainers required them to target through the kennel mesh and towards the back of kennel and shut the door (Figure 4a-b)

This step was completed in February 2008 with 'Aludra', but it took many months for 'Toros' to get comfortable with the kennel. He would reach all the way inside to touch the target to get the reward, but while his body was completely inside the kennel, he stretched so his rear paws remained outside the kennel, preventing the door from closing.

Step six: Train animals to remain calm while being weighed in kennel.

'Aludra' had no issues with the kennel moving while she was in it, so we were able to easily get weights when we needed to with her. After this we had her on a maintenance training schedule to keep the behaviors consistent.

Shortly after being able to get 'Toros' into the kennel, we received word that the SSP had plans to transfer him to another zoo for a breeding recommendation. We were able to successfully crate him up without having to restrain him for his transfer.

Figure 5. Radiographs of the right hand with metacarpals II-V fractured and the associated soft tissue swelling.

Setbacks Experienced

There were many setbacks to overcome along the years. Gaining trust in an animal that was caught up every week proved to be a greater task.

1. It became necessary to keep in mind each animal's specific needs during training. The lemurs were trained using positive reinforcement; food was used as the primary reinforcer for both until realizing that a tactile reward would be a better reinforcement for the female. For the male, it was also necessary to select the right bridge (softer sounding clicker was needed).
2. The lemurs would get easily distracted by noises outside the exhibit, so it became necessary to constantly change the time of day of the training sessions to deal with outside factors.
3. After completing some of the goals for the training, it became necessary to change

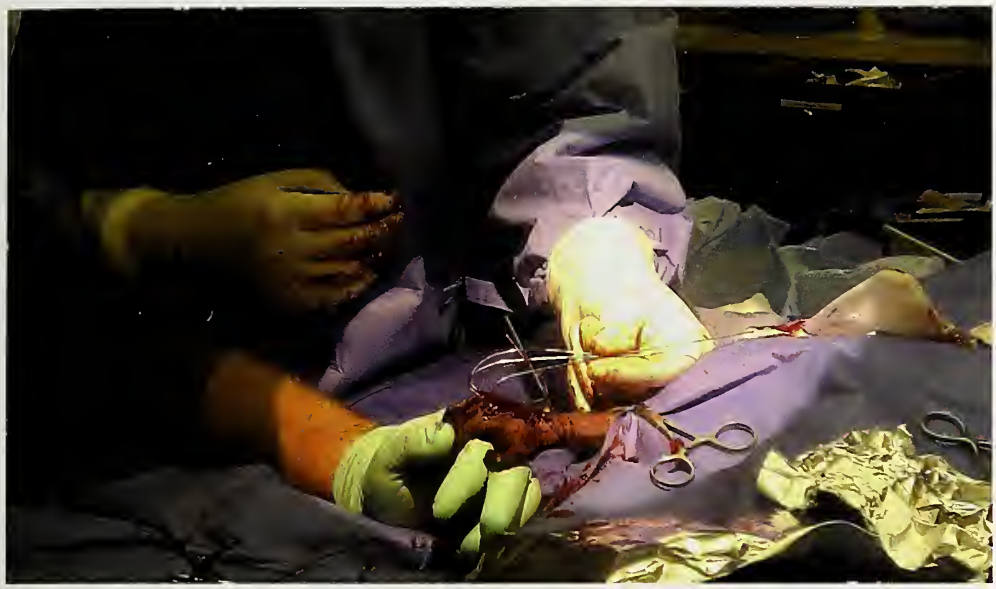

Figure 7a- Doctors adjusting the wire pins back to join them together with acrylic to form an external fixator.
Figure 7b- Image of hand with the completed acrylic external fixator.

gears in order to make an animal transfer possible. The SSP set out new breeding recommendations, and we had to prepare to ship out our male and to receive a new male.

Free contact ended when we discovered how aggressive our new male would be towards keepers, particularly when the female was in estrus. The new pair was now going to be trained separately. While the female could still be trained free contact, the new male could only be trained through protected contact.

Ultimately, the newly established pair was transferred successfully from their current exhibit to a different exhibit that had been renovated for the lemurs.

Figure 6. Radiograph of the three pins inserted in metacarpals II,IV,V and one wire pin inserted in wrist. A bone plate with screws was placed in III metacarpal.

'Aludra's' Accidents

In 2011, 'Aludra' had been in a new exhibit with her new mate for seven months when an accident occurred wherein her tail was broken four inches from the tip, and had to be amputated. Twelve days later she was noted not using her right front hand. A few days passed and she continued to not use her hand. 'Aludra' was sedated on 29 December 2011 to remove her tail sutures and change her bandage, so it was decided to take radiographs of her hand at this time as well. The radiographs showed that she had managed to break all four of her metacarpals on her right hand (Figure 5).

On 3 January 2012 an outside orthopedic surgeon came to the zoo to perform surgery on 'Aludra's' hand. She had four pins inserted and a bone plate was screwed on the worst break, on her III metacarpal (Figure 6). All four of the wire pins were curved upward and connected with acrylic to form an external fixator (Figure 7 a-b). She was placed at the animal health center to recover under veterinary supervision and was in a small cage without perching to prevent climbing; however, 'Aludra' still attempted to climb the cage so wood had to be added to the bottom of the mesh cage to inhibit climbing. After eleven days she began to form wounds on her fingers because of the heaviness of the acrylic fixator. 'Aludra's' trainer began working with the vets on a daily basis to assist in applying topical ointment on her fingers (Figure 8).

Figure 8. Ulcer on finger. *Photo by Bethany Wall*

Before her bandages were removed, an athletic trainer, B. J. Lough, came to assist zoo staff in developing a therapy regimen that could be incorporated into her training. The athletic trainer, vet staff, training and enrichment coordinator, and 'Aludra's' trainer came up with a training plan to start post-surgery. The main goals were to start her extending her fingers, and to have her wrist back to full rotation. Twelve weeks post-surgery she had surgery again to remove all the wire pins. The bone plate in her III metacarpal remained in place and radiographs showed healed fractures. However, even though her fractures were healed, she had gone twelve weeks without moving or using her right fingers and hand; as a result, her muscles had tightened. Our Associate Veterinarian, Dr. Shannon Cerveny, described her mobility post-surgery, "After implant removal, the lemur was using the manus minimally, but it had moderate reluctantance to extend the phalanges beyond approximately 50% of normal extension or to flex the carpus." (Cerveny, 2013)

When post-surgery therapy began, 'Aludra' was first trained to accept warm compresses. During the compresses she would grip her trainer's fingers, so small-sized balls were going to be used to aid in opening her hand. It was then decided to use her lollipop target stick since it was a familiar object, but with no success. Although she would set her hand on top of the target, she would not grip her target like she would fingers. Next, she was tested to see if she would allow physical manipulation of her fingers. She did really well. Her fingers would get extended for about 10-30 seconds several times in a training session. The vet staff also added perching and ropes to her cage to encourage climbing. She was rewarded for descending on the perching and using the rope.

Conclusion

There was progress within four weeks of starting 'Aludra' on a therapy routine of heat compresses, manipulating her wrist, and beginning to slowly stretch out her fingers. One month after removing the pins, the radiographs showed she had completely healed. Her range of motion had improved significantly; however with the plate remaining intact on third digit, full range of motion would only reach about 80%. Without tactile training her fingers would have healed, but without the ability to grasp, climb or even move. It is possible 'Aludra' might have had a greater range of motion if therapy would have been started sooner. Tactile training was a huge asset because it allowed the trainer to be able to physically manipulate her wrist and fingers within her limits and while using her primary reinforcer of tactile stimulus as a reward. 'Aludra' does really well moving around in her exhibit and it is an amazing feeling for her keeper and trainer to see this (Figure 9).

Figure 9. 'Aludra' eating in her exhibit, post-surgery.

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Cerveny, S., Harper, J., Voges, A., and R. Coke. 2013. Surgical and Medical Management for Fractures of the Second through Fifth Metacarpals in a Red Ruffed Lemur. *Journal of Zoo and Wildlife Medicine* 44(1):215-219.

Duke Lemur Center. 2014. Red Ruffed Lemur. http://lemur.duke.edu/discover/meet-the-lemurs/red-ruffed-lemur/. Downloaded on 17 November 2014

Looking at Lemurs: Confirming pregnancies in ring-tailed lemurs (*Lemur catta*) via voluntary ultrasound

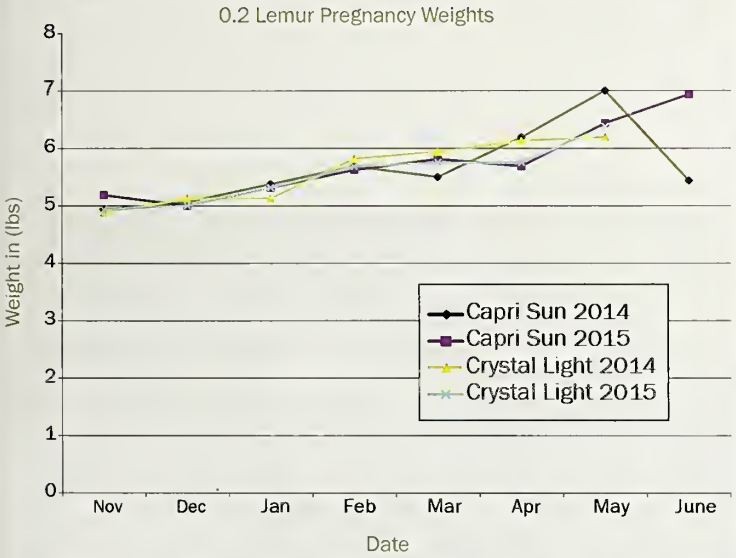
Emily Ellison and Laura Laverick, Primate Keepers
Cameron Park Zoo
Waco, Texas

Abstract

Cameron Park Zoo in Waco, Texas currently houses 4.3 Ring-tailed Lemurs (*Lemur catta*). In 2014 and 2015, staff was able to confirm three separate pregnancies in the twin ring-tailed lemur females via voluntary ultrasound training. This was a valuable asset as both females were first time moms in 2014. This training was accomplished by keeper staff having positive relationships, utilizing a target behavior, and desensitizing the lemurs to touch.

Need for Training

For the 2014 breeding season both ring-tailed twin females, Capri Sun and Crystal Light, received their first breeding recommendation from the SSP. Keeper staff had observed breeding with Crystal Light and an estimated birth window was calculated for her. Consistent weights were collected on both females. (See Graph 1) Even though breeding was not observed with Capri Sun, she was gaining the same amount of weight as her sister, leading the keepers to believe she was also pregnant and due to give birth around the same time.



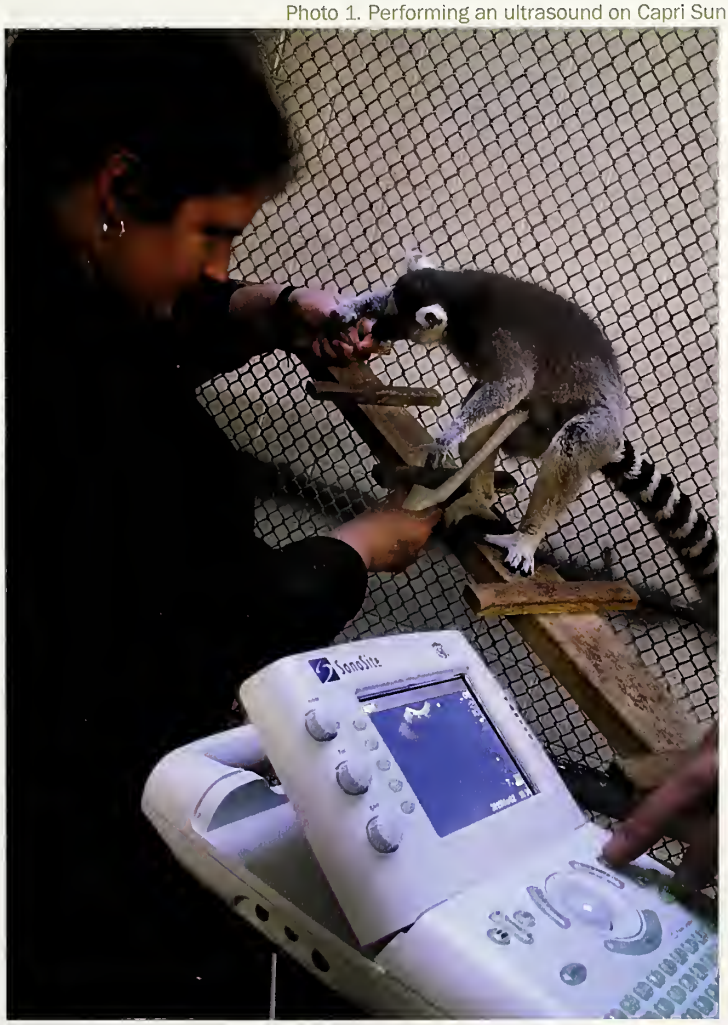
On March 18, 2014 Capri Sun gave birth to twin boys. Both males appeared smaller than a normal-sized infant and even one of the boys was roughly half the size of the other. The smaller male was born virtually hairless and had a weaker grip. Even though there was medical intervention of oral fluids and heat supplementation and then a successful reintroduction to the mother, the infant was found deceased the next morning. Capri Sun continued to thrive with the larger male infant, named Snickers, and was a phenomenal mom.

As the next weeks progressed, keepers became concerned about Crystal Light and her potential infant, considering the facts that she was continuing to gain weight and her birth window was questioned with a possible miscalculation. Therefore, a plan was then implemented to begin voluntary ultrasound training in hopes to gain more information. The first session was on March 27, 2014. Images were obtained on March 28 but pregnancy was not confirmed until a session on April 4 where a single infant's spine and a heartbeat were observed. On April 16, 2014 Crystal Light gave birth to a healthy baby boy, named Twix.

Method of Training

Given that the lemurs were already trained to target and desensitized to touch, training of voluntary ultrasound went rather smoothly and quickly. A belly behavior and desensitization to a "fake" ultrasound probe were the first steps. Then small amounts of gel were worked into the sessions. The machine and veterinarian were introduced as the final steps prior to performing a complete ultrasound. A continuous reward (usually raisins or Craisins®) while holding on their target, proved to be most beneficial when performing ultrasounds on the lemurs. (See Photos 1 and 2)

Photo 1. Performing an ultrasound on Capri Sun.



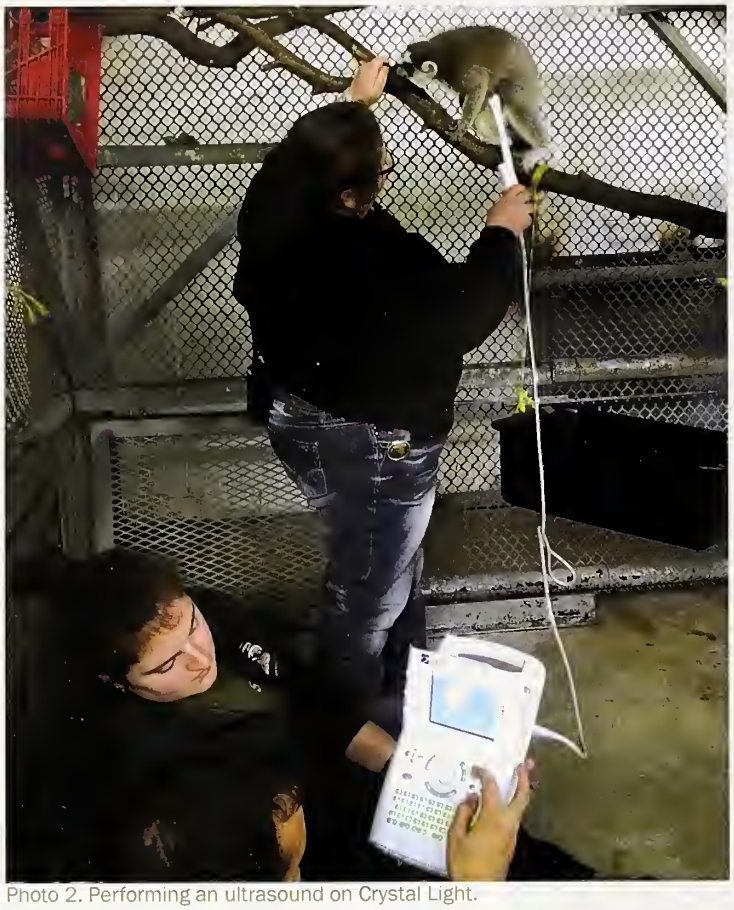


Photo 2. Performing an ultrasound on Crystal Light.

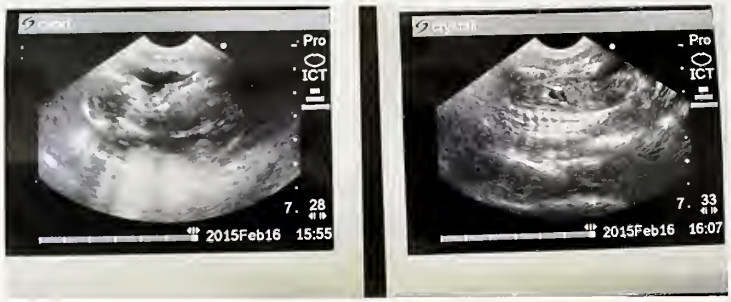
Maintaining the Behavior

Both Capri Sun and Crystal Light received another SSP recommendation for the 2015 breeding season. Voluntary ultrasound training was maintained and applied to prepare them for confirming pregnancies. Frequent visits from the veterinarian, continuing practice sessions with the real and fake probes, and training of an "up" behavior all added to the success keepers had in maintaining this important behavior.

Breeding with both females was observed, sperm plugs were found in holding, and birth windows were calculated for each. Crystal Light's window was March 7 through the 17th and Capri Sun's window was April 8 through the 18th. The voluntary ultrasound training was utilized and pregnancies were confirmed for each female. (See Photo 3)

Crystal Light gave birth to a healthy infant boy, named Rolo, on March 8, 2015 and Capri Sun gave birth to twin girls on April 3, 2015. One infant was found to be a stillborn. Similar to Capri Sun's previous infants, both girls appeared to be smaller than a normal infant with the stillborn one being more underdeveloped than the healthy one. The second female infant, named Skittles, continues to develop at a natural rate.

Photo 3. Ultrasound images of Rolo and Skittles.



Moving Forward

Currently, Cameron Park Zoo is doing a fundraiser to be able to purchase an ultrasound machine. The zoo has been using an older, smaller, portable ultrasound machine that is on loan from a local OB-GYN. This machine has its limitations and even though pregnancies can be confirmed, it has been difficult to identify the number of infants in the womb. The hope with the new machine is that much more data and information can be collected while doing ultrasounds.

Since funds are not secured yet for the new machine, keeper staff is beginning to train the lemurs for voluntary x-ray. This will ultimately confirm the number of infants and can be a beneficial tool during future pregnancies.

Keeper staff has begun infant assessment training with Rolo and Skittles. The continued trusting relationship between the keepers and Capri Sun and Crystal Light has allowed for stress-free medical examinations. Currently, an otoscope and stethoscope can be used on both infants in aiding veterinary staff to obtain respiratory rates and heart rates as well as perform ocular inspections. Tactile manipulation of the infants is also performed while they remain on their mom; this has resulted in confirming gender, dehydration tests, and body condition scoring.

Conclusion

Cameron Park Zoo is excited to have a proactive and productive training program for their ring-tailed lemurs. This voluntary training has proven to be successful and helpful in the last three pregnancies. Keeper staff is looking forward to continuing and advancing the lemur training program in the future. (See Photo 4)

Acknowledgments

Cameron Park Zoo Management
Dr. James Kusmierczyk, Staff Veterinarian
Theresa Larson, Primate Keeper
Ring-tailed Lemur SSP

Photo 4. Capri Sun with Snickers and Crystal Light with Twix.

Using Operant Conditioning to Manage Reproduction in Coquerel's Sifaka *(Propithecus coquereli)*

Mylisa A. Whipple, M.S.
Keeper/Primates, Saint Louis Zoo, Saint Louis, Missouri

Introduction

Using operant conditioning with Coquerel's sifaka *(Propithecus coquereli)* can allow animal care staff to manage reproduction in a non-invasive way. Without the need to use hand-restraint or immobilization methods, the stress of an ultrasound procedure should be reduced for the animal and, in turn, the animal care staff. The training can be done through protective contact with a training panel for safety, reducing the risk of injury to the trainer and the animal being trained. Using the methods in this article, the animal care staff at the Saint Louis Zoo was able to do multiple ultrasounds on a female sifaka.

Currently, the Saint Louis Zoo houses two groups of Coquerel's sifaka. One group consists of a male named Caligula, a female named Almirena, and their three daughters Sophie, Martine, and Kapika. The pair was last recommended to breed in 2013. Almirena is the subject of the training in this article; however, Sophie is also in the process of being trained for these behaviors. The other group consists of a male named Constantine and a female named Irene. This pair is currently recommended to breed and Irene is now participating in training for these behaviors as well.

Training Goal

The goal is to train a sequence of several behaviors that would ultimately allow for the trainer and veterinarian to palpate and perform an ultrasound on the abdomen of a female sifaka in order to confirm whether or not she is pregnant. If pregnancy is confirmed, this training will also be used to monitor the health and development of the fetus throughout the pregnancy.

Tools

The training discussed in this article is through protective contact. A training panel was put in place for this purpose, allowing the animal to be on one side of the training panel and the trainer on the other. So that there is secondary containment, the training panel is located inside a holding area cage. The training panel opening is 27.94 cm tall and 27.94 cm wide (11 inches tall and 11 inches wide), with a hinged door that opens toward the trainer and a latch to secure it when not in use. There is a shelf on the animal side so that the animal being trained can sit directly in front of the opening. The top of the shelf and the bottom of the opening are 101.6 cm (40 inches) from the ground, with a horizontal bar 60.96 cm (24 inches) above the shelf that the animal will target their hands to. The dimensions used were based on the general size of our female sifaka and how we needed their bodies to be oriented during an ultrasound, taking into consideration the females' comfort (Photos 1a and 1b).

In addition to the training panel, there are several other tools needed for this shaping plan. These include a station marker, target stick, ultrasound gel, paper towels and "dummy" ultrasound training equipment. The "dummy" ultrasound training equipment consists of an old laptop and a "dummy" ultrasound wand with cord made out of a deodorant stick with a USB cord taped to it. Training rewards are also needed; for the Saint Louis Zoo sifaka, peanuts are the preferred training reward. Shelled peanut kernels are used as the regular reward and whole peanuts are given as the jackpot item (Photo 2).

Shaping Plan

A shaping plan was created for training the series of behaviors needed to accomplish the training goals. These behaviors were separation, station, bar, door, touch, wand ("dry" and "wet"), and wipe. In order to shape each behavior, successive approximations were used. During all training sessions, the

Photo 1a. Trainer-side of training panel. *Photo by Mylisa Whipple.*

Photo 1b. Animal-side of training panel. *Photo by Mylisa Whipple.*

Photo 2. Tools. *Photo by Mylisa Whipple*

Photo 3. Bar behavior. *Photo by Shannon Farrell.*

Photo 4. Touch behavior. *Photo by Shannon Farrell.*

Photo 5. Wand behavior. *Photo by Shannon Farrell.*

"dummy" ultrasound training equipment was set up so that the subject could be desensitized to its presence. The plan also included steps to include additional people during the training session. All of the steps progressed toward the ultimate goal of performing an actual ultrasound. Also, the plan included being prepared to have to do multiple separate sessions with actual ultrasound equipment in order for the subject animal to become comfortable enough to allow an ultrasound that produced a clear image.

Behaviors

- Separation – Separate the subject from the others in the group into the enclosure where the training panel is located.
- Station – The subject will sit on the shelf in front of the training panel when asked to "station" until released.
- Bar – The subject will target both hands onto a bar above the door of the training panel (verbal cue "bar") and hold them there until released. The purpose of this behavior is to get the subject in the position needed to perform palpation and an ultrasound. It also keeps their head and hands away from the area where the trainer will be contacting them through the training panel door (Photo 3).
- Door – The subject will stay in position when the training panel door is opened following the verbal cue "door."
- Touch – The subject stays in position and allows the trainer to palpate her abdomen. The trainer will say "touch" for the beginning palpation but then continue to bridge and reinforce throughout for the duration of palpation (Photo 4).
- Wand – This requires two steps, "dry" and "wet" (Photo 5).
    - "Dry" - First the verbal cue "wand" will be used without the ultrasound gel. The subject should stay in position and allow the wand to be placed against her abdomen with light pressure applied and allow for the wand to be moved around gently along her abdomen. The trainer will say "wand" for the beginning of this behavior but then continue to bridge and reinforce throughout for the duration of the behavior.
    - "Wet" – Second, the trainer allows the subject to see that ultrasound gel is being put on the tip of the wand. The verbal cue is still "wand" and the criteria are the same as above except that ultrasound gel is being used.
- Wipe – The verbal cue "wipe" is used for this behavior. The subject allows the trainer to wipe off excess ultrasound gel from her abdomen after training using a towel (Photo 6).
- Additional steps are needed for a veterinarian to palpate the subject and to be present for the real ultrasound. Once all of the behaviors are all done reliably, then trainer must work towards including other people during the training session.
    - A second person the subject is familiar with watches the training sessions.
    - A second person the subject is less familiar with watches the training sessions.
    - A person that the subject is more wary of, but not a veterinarian, watches the training sessions.
    - A second person works towards palpating the subject with the trainer present to cue, bridge and reward.
    - The veterinarian works towards palpating the subject with the trainer present to cue, bridge and reward.

Real ultrasound: Veterinarians will come with the real ultrasound equipment. This should be treated as a normal training session going through the same steps, but this time there is a veterinarian present using actual ultrasound equipment. Again, this may not be successful the first time because the equipment is slightly different than the "dummy" equipment. Because of this, the trainer should work with the veterinarians to come back on a regularly scheduled basis, at least once a week would be ideal. If a pregnancy is confirmed, then veterinarians may want to schedule regular follow-up ultrasounds to monitor the pregnancy (Photos 7).

Results and Discussion

In November of 2013, pregnancy was confirmed in our female, Almirena, using ultrasound. Though both the trainer and veterinarian were able to palpate the subject, it was not the best method to confirm pregnancy because the fetus was not easily felt in the abdomen until much farther along in the pregnancy. The subject allowed for several ultrasounds to not only confirm pregnancy, but also monitor the development of the baby. The behavior did break down towards the end of the pregnancy when the subject began refusing to participate in training. However, at that point, the veterinarians were confident that the baby was developing well.

The following year, Almirena was not

Photo 6. Wipe behavior. *Photo by Shannon Farrell.*

Photo 7. Ultrasound. *Photo by Joe Knobbe.*

recommended to breed and has been contracepted following the current guidelines recommended by the AZA Wildlife Contraception Center at the Saint Louis Zoo. However, keepers observed breeding behavior following a course of Depo-Provera and so Almirena has been re-trained for ultrasound to confirm whether or not the contraception has prevented pregnancy. She retained much of the series of behaviors from 2013 which made re-training her move very quickly. We were able to confirm through ultrasound that she is currently not pregnant. (An additional note on the sifaka contraceptive guidelines, based on this experience and other institutions with similar experiences this year the contraceptive guidelines for sifaka have been revised. Please contact the AZA Wildlife Contraception Center at Saint Louis Zoo for current recommendations on this and other species.)

The same shaping plan will be used for other female sifaka at the Saint Louis Zoo as well. Currently, Sophie, the oldest daughter of Almirena and Caligula is also being trained even though she is not recommended to breed. She has shown much interest in training and may be recommended to breed in the future, so the training will prepare her for that possibility. Irene, a recently acquired female who is recommended to breed this year has also begun training for these behaviors.

There are additional benefits and goals that could be met using this training. Because it is sifaka management practice to separate the female from her group before she gives birth, confirming pregnancy can help with planning for when to separate her and can prevent needless separation from a group when the female is not pregnant. Additionally, the "touch" behavior could be used to get a closer look at the baby without fully pulling the baby from the mother. The trainer was able to determine gender of the last baby at the Saint Louis Zoo using this method. Lastly, if necessary, the "touch" behavior could be used in order to pull a baby from the mother. In order to accomplish this, the subject would be asked to get into the position for palpation, but rather than palpating the female, the baby would be grabbed. However, one must prepare for a breakdown in the behavior following such a scenario.

Acknowledgements

The author would like to thank several people for their help in order to make this training plan a success including Heather Ward for starting Almirena and Sophie's initial training, Larry McNeil for building the training panels, and Dr. Amy Alexander for her help with the ultrasound training. Also, thanks to Ethan Riepl, Joe Knobbe, and Shannon Farrell for providing photographs. Thanks to Heidi Hellmuth and Joe Knobbe for providing help with editing this article. Special thanks go out to JW and HW.

This article was presented at the 2015 Prosimian Taxonomic Advisory Group (PTAG) meeting and workshop in Sarasota, Florida.

Photo 8. Baby sifaka on mother. *Photo by Ethan Riepl.*

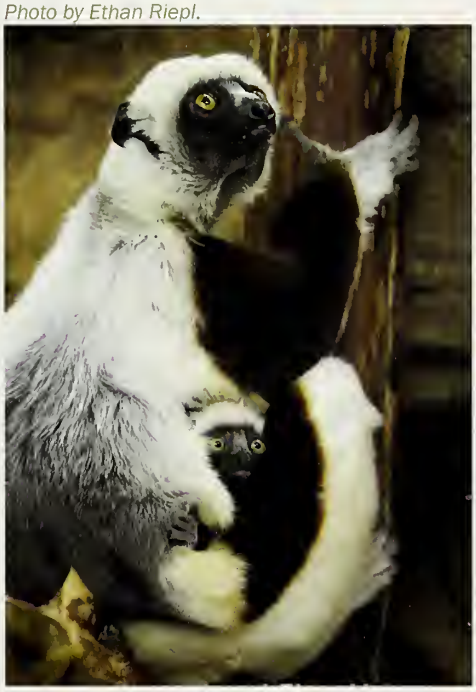
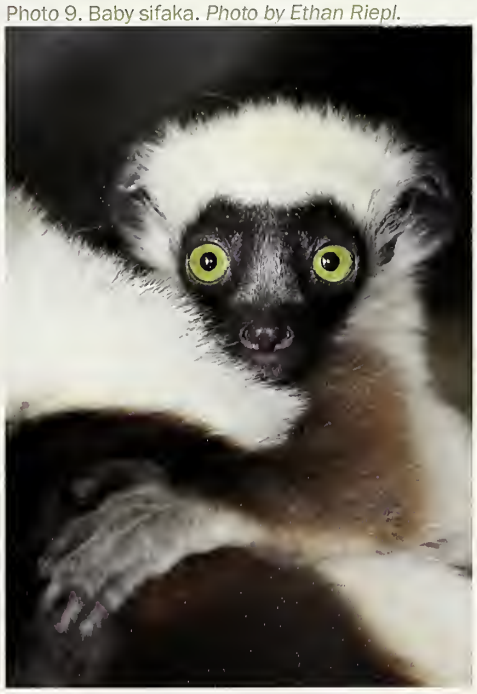


Photo 9. Baby sifaka. *Photo by Ethan Riepl.*



PTAG Behavioral Husbandry Advisory Committee: How can we help?

Liz Kellerman, Abilene Zoo and Meg Dye, Duke Lemur Center

In June, 2013 the Prosimian TAG created the Behavioral Husbandry Advisory Committee. The committee was created to assist the PTAG with addressing facility and keeper questions regarding behavioral management. The vision for the committee was to create a medium for sharing behavioral resources, experiences, and for fielding questions in a timely manner. Dawn Neptune serves as the Advisor for the committee. Dawn is currently the Behavioral Programs Manager at Utah's Hogle Zoo where her main focus is the husbandry, welfare, and behavior of the zoo's collection. Dawn has experience in behavioral program development as well as training and enrichment expertise with ruffed lemurs, ring-tails, crowned and white-fronted lemurs. To assist Dawn, the committee members include Keri Bauer (Busch Gardens, Tampa), Jenn Donovan (Pt. Defiance Zoo & Aquarium), Meg Dye (Duke Lemur Center), Mandy Fischer (PTAG Education Advisor) and Liz Kellerman (Abilene Zoo). Collectively, the committee has experience with every species of prosimian housed in North America!

The first goal the committee was tasked with was to assist with the Behavioral Management section of the Animal Care Manuals (ACM). With much assistance from the approved Eulemur ACM, the committee modified and combined the Eulemur ACM, primate guidelines, safety guidelines and enrichment guidelines to create a Behavioral Husbandry Template. The Behavioral Husbandry template is available to any ACM Coordinator to modify and use to assist with the completion of their manual.

Additional objectives of the committee include:

- Assist PTAG in implementing program goals
- Provide direct assistance to facilities on behavioral husbandry challenges
- Create a resource database of prosimian training and enrichment
- Create behavioral management workshops
- Develop behavioral management educational materials

The Behavioral Husbandry Committee hosted their first workshop at the 2015 PTAG Husbandry Workshop at the Lemur Conservation Foundation (LCF) in Myakka,

Mongoose lemur infant, Oscar, uses his mom's head to get a better look at the world.


Photo 2. Kennel training


Photo 3. Voluntary netting


Photo 4. Scale training

Florida. The workshop, "Solving the Impossible: Developing a Prosimian Behavioral Management Plan", focused on problem solving and developing action plans. After a discussion on the framework for problem solving, the participants headed outside to observe behavioral challenges selected by the LCF staff. Divided into three groups, each group learned the history of their specific animals, watched a training session and brainstormed ideas on possible solutions to the behavioral challenge.

The workshop also included the opportunity for facilities to share videos and pictures of innovative enrichment and training ideas. With the increase in husbandry behaviors that are becoming incorporated into prosimian training sessions, the workshop was the perfect forum to learn more from each other. Advancements in husbandry training included refinement of some more familiar behaviors as well as the emergence of behaviors that, currently, have only been conditioned with a few animals.

Facilities represented at the PTAG workshop continue to be creative with conditioning voluntary kenneling to fit specific situations. Facilities have conditioned multiple animals to enter multiple kennels for one trainer, kennel in large habitat enclosures and created kennels for protected contact animals. (See Photo 2)

Conditioning lemurs to voluntarily enter a net is a new husbandry behavior. This behavior can have several benefits including moving an animal within a building or a husbandry need for light restraint. (See Photo 3).

Scale training is a behavior that has been of use to keepers for quite some time. With more formalized training programs, animals that are historically shy or hide are being trained to come to the scale for regular weights. (See Photo 4)

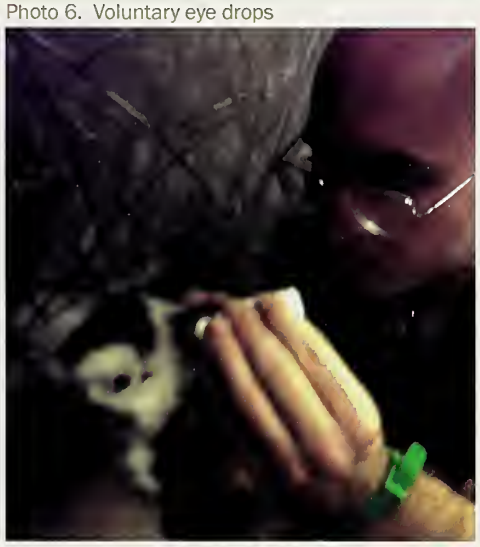
Researchers collecting behavioral data need the ability to quickly identify individual animals from a distance. For this reason, the Duke Lemur Center utilizes small tail shaves to assist with identification. For some animals, voluntary tail shaves can be incorporated into a training session (Photo 5).


Photo 5. Voluntary tail shave

Management of diabetes with voluntary daily insulin injections is currently being done at the Oakland Zoo and Duke Lemur Center. The application of training to this critical medical procedure has increased consistency of receiving daily dosages while decreasing the stress for both the individual animal and the keeper staff. (See Photo 7)

The Oakland zoo has conditioned several lemurs for a stethoscope exam to allow vets to voluntarily listen to a lemur's (calm) heart or to scan for transponder chips.

Photo 6. Voluntary eye drops



Trainers at the Omaha Zoo have conditioned a ring-tailed lemur to accept eye drops on a regular basis (Photo 6). The eye drops are vital to keeping the animal comfortable post-surgery.

Voluntary acceptance of an ultrasound probe


Photo 7. Voluntary injection training

provides opportunities to confirm a pregnancy and monitor the growth and position of a fetus. Several facilities have completed this behavior, all with a slightly different setup that works best for their specific animals. (See Photos 8 & 9)

Behaviors to assist with Sifaka prenatal and infant care have also been incorporated into training programs. Prior to delivery, voluntary palpation and milk checks of the dam are very informative for the vet staff. After delivery, a voluntary post-partum exam avoids the dam needing to be in hand. Voluntary infant removal for determining weights reduces the stress associated with a crucial husbandry procedure for monitoring an infant's health. (See Photo 11)

Training has also been incorporated into preparing animals for future research projects. For research involving locomotion, shape

recognition or color discrimination, training gives the lemurs the opportunity to learn the desired behavior prior to the researcher's arrival. This benefits both parties as the lemurs are more relaxed and confident with the behavior, and the researcher collects accurate data in a shorter amount of time. (See Photos 10, 12, and 13)

The committee would like to thank the participants of the 2015 PTAG Behavioral Management workshop for sharing their training accomplishments and challenges with each other. The committee looks forward to serving as a resource for behavioral husbandry questions, challenges, and exchange of training and enrichment ideas. If you have questions or ideas regarding prosimian behavioral husbandry, please contact Dawn Neptune at dneptune@hoglezoo.org.

Photo 9. Ultrasound training.

Photo 12. Sifaka behavioral research.

Photo 10. Aye-aye behavioral research.

Photo 13. Black and white lemur research.

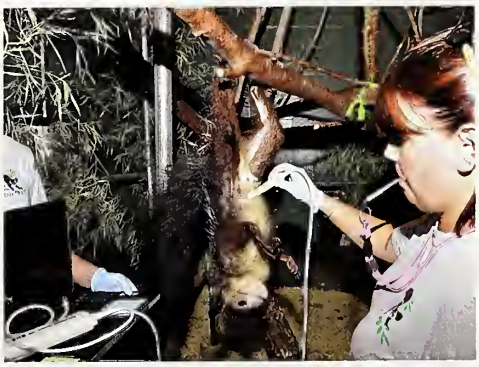


Photo 8. Ultrasound training.

Photo 11. Training for palpation.

Photo 14. Scale training.

Blue-eyed black lemurs

Opportunities for Expanding the Enrichment Process

Meg H. Dye
Behavioral Management Coordinator/
Student Project Coordinator
Duke Lemur Center

The advancement of behavioral management programs has included a greater understanding that enrichment is an ongoing process which is not limited to the delivery of a single item once a day. Experiences which elicit species-specific behavior, increase activity and provide mental simulation should occur throughout an animal's day. A holistic look at stimulating experiences during the day should reveal enriching opportunities that are in addition to a structured enrichment program. From guest experiences to research, unique opportunities can be found at each of our facilities. These additional enriching opportunities may not be marked on an enrichment calendar or labeled as enrichment but still contribute to enhancing a prosimian's overall well-being.


A pygmy slow loris enjoying some frozen applesauce

At the Duke Lemur Center (DLC), Primate Technicians are responsible for providing and documenting daily enrichment for the prosimians in their care. Similar to other facilities, technicians rotate through different categories of enrichment and look to encourage species-specific behavior. In addition to these efforts, facility design, guest experiences and student involvement provide additional opportunities to provide stimulating experiences for the animals. While some of the following experiences will be unique to the DLC, several will be experiences that can be found in many facilities housing prosimians.

Guest Experiences

As facilities offer an increasing number of immersive activities for the public, additional enriching opportunities arise. The DLC offers a variety of educational programs for the public, including several guest experience tours that take place behind-the-scenes. One such tour discusses the importance of enrichment and provides the opportunity for guests to create and observe enrichment in action. Summer camp instructors often provide enrichment items to the animals to highlight behavior of a species they are discussing. For both of these programs, the enrichment is supplemental to the documented enrichment for that day.

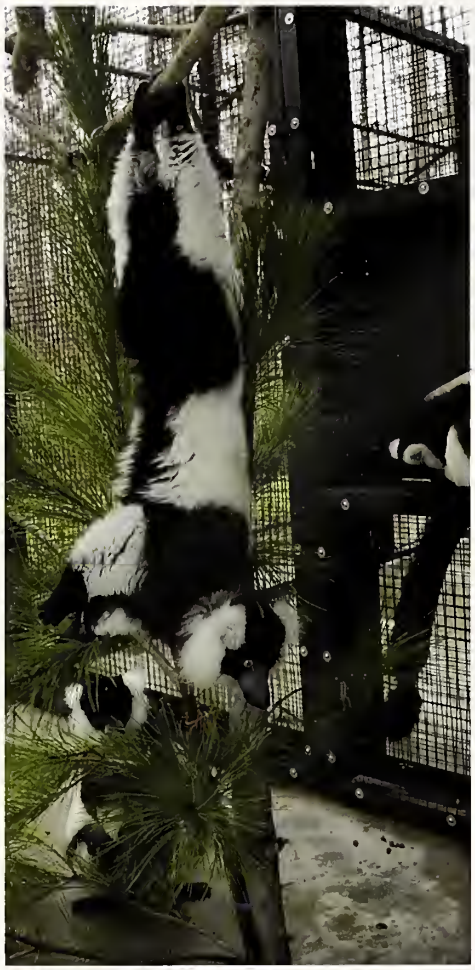
Interns

Interns can be an invaluable resource of dedicated time to any facility. Depending on the needs of a program, interns can specialize in assisting with the overall enrichment program or focus their efforts on a specific enrichment project. Each summer, college students participate in DLC's ten-week internship program and complete a research project of choice. With dedicated time to focus on a project, some students concentrate on animals that can be a challenge to enrich. Projects have included the effectiveness of different types of enrichment with pygmy slow lorises, enrichment modification for a blind geriatric lemur, fishing for grapes by a pygmy slow loris and the creation of novel bamboo feeders for aye-ayes. With each project, the animals involved benefited from the additional enrichment while the enrichment program gained valuable information applicable to other animals in the colony.

Enclosures

Creating species-specific usable space is essential to the housing of prosimians. From mouse lemurs to *Varecia* to sifaka, each species utilizes their space differently. While each facility has different housing spaces, strategic placement of structural enrichment can promote an ongoing array of natural behaviors. Enclosures at the DLC are emptied and washed every six to eight weeks and re-branched as needed. Branching structures are tailored to the species' locomotion type, as well as the individual's age and mobility. New nesting, perching and play structures (crates, firehose, swings, etc.) are incorporated in the enclosure on a weekly basis. Nocturnal animal rooms are stocked with fresh browse,

Science Camp students learning about aye-ayes



Strategic structural enrichment can elicit a variety of natural behaviors

Guests photographing free-ranging sifaka

An aye-aye is shown two color choices in a color discrimination trial

Ring-tailed lemurs exploring scented wooden dowels

pine shavings, species-appropriate nesting materials and specialized items such as logs to promote natural foraging behavior with aye-ayes. By changing and adding structural enrichment on a regular basis, the environment promotes natural behaviors such as scent marking, chewing, play, foraging and other exploratory behaviors.

Natural Habitat Enclosures

The DLC has nine Natural Habitat Enclosures (NHE), which range in size from one to fourteen acres. Between April and November, select pairs or family groups free-range in the NHEs. Free-ranging lemurs have a choice of sleeping, eating and living in the forest, or coming and going at will indoors to an accessible building. Free-ranging lemurs are naturally enriched in a variety of ways including changes in climate, habitat, foraging opportunities and social interactions. The arrival of guests for special tours, such as a Photo Tour, provide additional novelty to the day.

Research

With different levels of involvement, several facilities participate in a wide variety of prosimian behavior, physiology, developmental and cognitive research. Participation in non-invasive research can provide novel stimulation for prosimians. This is particularly true for research projects that require active participation from the animals or ask subjects to perform tasks that mimic natural behavior. For example, a suite of studies at the DLC focused on olfactory communication in ring-tailed lemurs, specifically asking if lemurs can discriminate the information encoded in scent marks. To accomplish this, researchers first swabbed the scent glands of DLC ring-tailed lemurs with cotton swabs. Next, these swabs were rubbed on wooden dowels and the dowels were presented to different ring-tailed lemurs. Responses towards the dowels included sniffing, licking, biting, scent marking, and even stink fighting. With trials concluded, the DLC staff continues to use odor dowels as a form of olfactory enrichment.

Training

In recent years, prosimian training has increased both in the number of facilities training prosimians as well as the types of behaviors which are being conditioned. Similar to other facilities, the DLC training program provides mental stimulation for our prosimians as they learn to participate in their health care. Technicians also use the training sessions to condition behaviors for use in non-invasive research projects. Increased technician interaction has been an added benefit for the nocturnal species who participate in the training including pygmy slow lorises, mouse lemurs, fat-tailed dwarf lemurs and aye-ayes. Training sessions for both nocturnal and diurnal animals are in addition to daily technician enrichment.

As we continue to advance our behavioral management programs and improve the overall wellbeing of our animals, we look for new opportunities to provide animals with stimulating experiences throughout their day. New enriching opportunities for prosimians can arise from the unique design and programs found at each of our facilities. While utilizing a structured enrichment program as a base, we can look for additional stimulating experiences to create a dynamic and changing enrichment process that benefits the prosimians in our care.

Acknowledgements

Special thanks to Lydia Green and Erin Shaw for their contributions to the article and David Haring for use of his photographs.

Duke Lemur Center Prosimian Life History Data: Breeding Variables

Species			Gestation		Peak Breeding		Peak Birth		Min AAC (y)		Max AAC (y)		Litter Size		
Diurnal	Code	N	Calculator	Range	Month	Season	Month	Season	Dam	Sire	Dam	Sire	Mean	Common	Max
E. albifrons	EALB	40	120	120-128	12	1.12..	4	4.5	2.57	2.75	11.31	16.31	1.65	1,2	4
E. collaris	ECOL	71	120	120-128	12	1.11.12..	4	3.4.5	1.64	2.52	23.20	21.22	1.23	1	2
E. coronatus	ECOR	79	120	120-126	1	1.12..	5	4.5	1.71	2.48	17.47	19.92	1.24	1	2
E. flavifrons	EFLA	77	120	120-129	11	11..	3	3	1.59	2.66	16.89	21.13	1.04	1	2
E. fulvus	EFUL	66	120	120-128	12	11.12..	4	3.4	1.39	1.74	19.18	19.18	1.13	1	2
E. macaco	EMAC	119	120	120-129	11	11.12..	3	3.4	1.48	0.73	15.69	14.73	1.38	1	2
E. mongoz	EMON	130	120	120-128	12	1.12..	4	4.5	1.78	2.92	23.60	19.69	1.03	1	2
E. rubriventer	ERUB	30	120	120-127	12	1.11.12..	4	3.4.5	1.78	3.70	13.15	14.30	1.05	1	2
E. rufus	ERUF	170	120	120-128	11	11.12..	3	3.4	1.55	1.50	22.37	24.29	1.08	1	2
E. sanfordi	ESAN	22	120	120-128	1	1.3.12..	5	4.5.6.7	1.61	2.03	19.28	8.43	1.06	1	2
E. hybrid	EUL	274	120	120-128	12	1.11.12..	4	3.4.5	1.01	1.60	17.70	9.65	1.17	1	3
H. g. grieseus	HGG	62	145	145-150	12	11.12..	5	4.5.6	1.53	3.70	16.98	15.98	1.10	1	2
L. catta	LCAT	333	130	130-136	11	11..	3	3.4	1.34	1.66	21.70	29.53	1.30	1	3
P. coquereli	PCOQ	185	160	155-168	8	7.8.9..	2	1.2.3.12	2.64	2.60	20.40	29.76	1.00	1	1
Varecia hybrid	VAR	50	98	98-102	1	1.2.12..	4	4.5	1.64		6.73		2.04	2	3
V. rubra	VRUB	177	98	98-102	1	1.2..	4	4.5	1.67	1.79	24.26	30.36	2.21	3	4
V. V. variegata	VVV	192	98	98-102	1	1.2.12..	4	4.5	1.61	2.68	23.41	31.84	1.90	2	4
Nocturnal															
C. medius	CMED	255	60	60-64	5	4.5.6..	7	6.7.8	0.80	1.80	14.85	16.11	2.20	2	5
D. madagascariensis	DMAD	44	165	157-172	0	0..	0	0	4.22	3.66	26.03	28.47	1.00	1	1
G. moholi	GMOH	324	124	110-126	0	0..	0	0	0.40	1.02	8.48	6.63	1.44	1	2
L. tardigradus	LTAR	61	167	150-169	0	0..	0	0	0.99	1.04	13.38	11.64	1.02	1	2
M. murinus	MMUR	284	60	57-63	4	4.5.6..	6	6.7.8	0.60	0.60	13.32	9.47	2.30	3	4
M. zaza	MZAZ	110	90	89-90	0	0..	0	0	0.82	1.41	12.84	13.70	1.58	2	2
N. coucang	NCOU	85	193	185-197	0	0..	0	0	1.33	1.28	8.16	14.86	1.00	1	1
N. pygmaeus	NPYG	49	185	183-198	0	0..	0	0	1.87	3.74	11.35	11.56	1.72	2	3
O. g. garnettii	OGG	339	129	126-134	0	0..	0	0	0.59	0.76	14.65	10.84	1.10	1	2
P. potto	PPOT	33	170	170-172	0	0..	0	0	2.16	3.15	17.63	13.63	1.00	1	1

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Duke Lemur Center Prosimian Life History Data: Weight and Longevity Variables

Species		Mean Adult Weight			Birth weight (all)			Mean Birth Weight		Maximum Age			Median Age			% Infant Mortality		
Diurnal	N	All	Male	Female	Mean	Min	Max	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
EALB	40	2232	2155	2461						34.6	27.7	34.6	18.6	18.6	19.7	21%	8%	23%
ECOL	71	2336	2318	2367	58.8	28	99	67.0	50.6	32.6	32.1	32.6	20.8	21.1	19.5	25%	22%	24%
ECOR	79	1646	1698	1588	54.7	45	69	58.8	46.6	27.4	26.2	27.4	20.0	17.2	20.2	35%	35%	27%
EFLA	77	2447	2388	2535	80.3	56	103	73.3	86.5	25.4	25.4	24.4	18.3	18.0	18.4	25%	17%	34%
EFUL	66	2481	2367	2627	73.0	36	92	60.5	85.5	36.0	34.4	36.0	20.7	16.2	23.1	27%	16%	29%
EMAC	119	2467	2387	2542	65.7	44	83	68.5	60.0	31.3	31.3	31.1	14.9	15.5	14.3	31%	21%	32%
EMON	130	1553	1524	1583	60.2	40	78	59.7	60.8	36.3	36.3	29.2	25.7	26.7	21.9	24%	19%	28%
ERUB	30	2193	2052	2351	78.4	70	89	74.9	89.0	32.8	32.8	30.8	16.1	13.7	23.6	36%	38%	33%
ERUF	170	2285	2263	2309	73.1	26	94	75.7	71.5	32.2	32.2	32.2	20.3	20.6	20.1	24%	26%	18%
ESAN	22	2111	2040	2175	93.6	94	94	93.6		32.8	24.2	32.8	20.1	18.5	20.4	6%	11%	
EUL	274	2418	2388	2444	81.0	42	112	86.4	76.9	29.4	29.1	29.4	17.1	16.2	16.9	21%	18%	21%
HGG	62	1023	1044	1005	47.3	36	57	44.3	51.8	23.4	23.0	23.4	10.1	9.7	9.7	33%	35%	31%
LCAT	333	2449	2534	2347	63.6	35	101	64.8	62.8	32.2	32.2	27.2	17.2	17.7	15.4	23%	17%	16%
PCOQ	185	4016	3910	4147	106.4	83	132	107.1	105.9	30.6	30.6	22.3	10.5	10.7	9.7	24%	28%	13%
VAR	50	3335	3364	3322	108.5	74	139		108.5	34.9	16.7	34.9	8.3	9.0	8.3	18%	11%	20%
VRUB	177	3603	3584	3618	109.9	68	156	108.9	110.8	37.5	31.7	37.5	20.5	21.2	19.6	15%	17%	7%
VVV	192	3493	3453	3543	106.6	68	137	105.6	110.5	39.4	39.4	35.8	15.6	16.2	15.5	30%	24%	33%
Nocturnal																		
CMED	255	240	235	247	12.8	8	21	12.7	12.8	29.6	29.6	25.2	14.6	13.1	16.6	30%	16%	24%
DMAD	44	2663	2604	2709	107.9	69	136	110.1	106.3	32.4	32.4	31.6	24.9	24.9		11%	8%	13%
GMOH	324	169	179	160	12.1	8	19	12.4	12.1	16.6	16.6	14.5	6.2	6.2	6.2	37%	31%	22%
LTAR	61	185	186	184	11.5	8	15	12.3	11.2	21.5	21.5	18.6	14.9	15.8	12.4	34%	15%	27%
MMUR	284	83	80	85	8.1	5	13	7.6	9.4	18.0	18.0	15.9	8.3	8.5	8.4	16%	13%	7%
MZAZ	110	302	298	306	15.9	14	20	15.1	16.3	20.0	18.1	20.0	13.0	12.8	13.0	35%	19%	28%
NCOU	85	1161	1144	1179	51.2	40	65	50.6	51.6	24.0	22.2	24.0	12.9	12.9	12.8	14%	11%	13%
NPYG	49	494	507	483	25.0	17	32	24.3	27.8	19.3	15.5	19.3	11.6	10.6	10.3	39%	29%	36%
OGG	339	1059	1137	976	48.6	40	57	48.9	48.0	20.0	20.0	18.9	12.8	12.9	12.0	33%	28%	16%
PPOT	33	918	944	876	32.5	21	44	32.5		32.4	26.3	32.4	14.5	14.5	8.9	69%	50%	50%

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Husbandry Challenges Associated with Managing an Individual with Diabetes in a Ring-tailed Lemur (*Lemur catta*) Troop

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Zoo New England, Franklin Park Zoo, Boston, Massachusetts

Introduction

In 2013, the Tropical Forest Pavilion at Zoo New England's (ZNE's) Franklin Park Zoo housed a collection of ring-tailed lemurs (*Lemur catta*), consisting of two groups. Group 1, the family group, 1.0 Maki and 0.1 Nebbie, as well as 4.2 of their offspring. Group 2 was comprised of our geriatric lemurs, 0.2 Emily and Lulu, who are separated from the family group due to their age and aggression that stemmed from changes within the troop's hierarchy. Historically, the ring-tailed lemur training program has encountered a variety of obstacles including aggression, hand-rearing, high animal-to-trainer ratio, and age-related mobility constraints. In October of 2013, a new challenge emerged when our three-year-old female, Sofina, began exhibiting signs of lethargy and decreased activity while on and off exhibit. Shortly after, in November of that year, Sofina was diagnosed with diabetes. Tropical Forest keeper staff needed to make several alterations to the current training program and develop a management plan that would efficiently manage Sofina's diabetes.

Lemur Exhibit in the Tropical Forest Pavilion. *Photo by Matt Stierhof.*

This submission to *AKF* is intended to share adjustments made to our husbandry routine, lemur diets and training program to manage our newest challenge within our lemur troop. A management plan was developed which allowed us to effectively manage the troop while providing Sofina with the immediate care and medication she required. Specific medical details of Sofina's treatment will not be covered in this article; however, we are happy to share this information by contacting mstierhof@zoonewengland.com.

Diagnosing Sofina

In October 2013, the keeper staff first observed Sofina to be lethargic, isolating herself from the group and lying down on her back for the majority of the day. At the time, it was difficult to determine the nature of Sofina's condition because of daily changes in her energy level, group interactions, and appetite. With combined efforts from keeper staff observations and veterinary care following a physical examination, Sofina was found to be experiencing episodes of hyperglycemia (high blood glucose). Hyperglycemia occurs when the body does not have enough insulin or when the body does not utilize insulin appropriately (American Diabetes Association). These findings indicate diabetes mellitus. Sofina was started on a combination of oral medications to increase her sensitivity to insulin, decrease the amount of sugar she would absorb from her diet and decrease the levels of glucose produced by her liver. Furthermore, the ring-tailed lemur diet was undergoing a substantial modification to reduce her access to simple sugars.

Following several months of receiving oral medications, Sofina still showed occasional signs of lethargy. Her blood work continued to indicate high blood glucose; only showing minor decreases over time. Tropical Forest keepers collected urine samples as often as possible, typically every other day. The urinalysis consistently returned with sugar in her urine. Veterinary staff collected additional blood samples, and after a series of glucose readings and fructosamine tests, a decision was made to administer daily insulin injections.

Off-Exhibit Layout

The layout of our ring-tailed lemur off-exhibit space inside the Tropical Forest Pavilion is U-shaped, with three dens of various sizes on both sides and one large den area connecting them (Figure 1). The size of each holding den varies to provide a diverse housing arrangement for the troop. In anticipation of possible daily insulin injections and the challenges of managing Sofina in such a large group, a decision was made to install a squeeze chute. We purchased a Tomahawk Live Trap™ 307SQ - Squeeze Cage -24L x 12W x 16H, complete with squeeze panel (See Photo 2). The squeeze chute was installed in Den 7 because of the den's small size and the location of the shift door. The chute was

permanently attached to the wall with the opening facing and adjacent to the Den 6 shift door. This setup allows us to shift a lemur from Den 6 directly into the training chute and close the shift door behind them once they are inside. This modification also meant that Den 7 could no longer be used for regular housing.

Developing a Plan

The lemur trainers quickly developed a plan for the most effective, safest, and least stressful approach to administer medication to Sofina, while still addressing the husbandry needs for the rest of the troop. With the loss of Den 7 as regular housing, managing two groups became further complicated.

Our more efficient management plan was as follows:

Step 1: Tropical Forest keepers became educated about diabetes

Step 2: We discussed our ability to manage a diabetic lemur and what quality of life parameters we would measure/evaluate

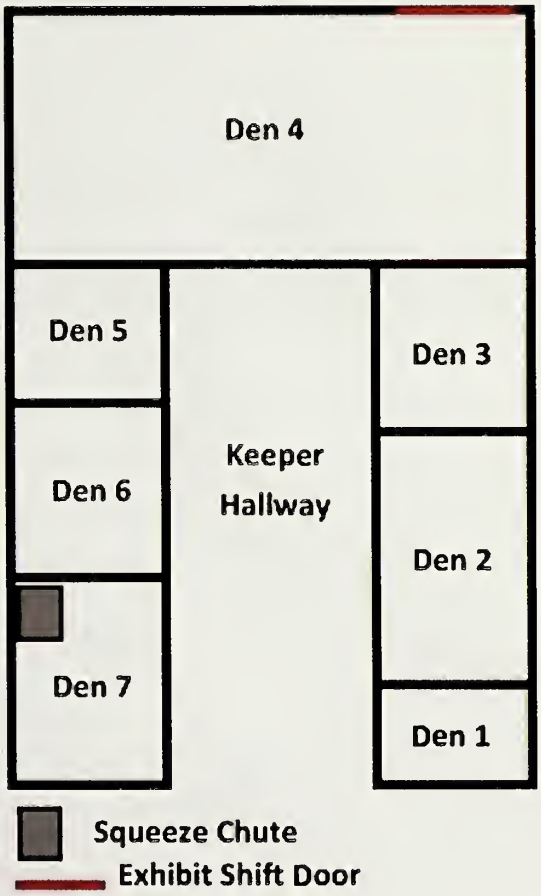
Step 3: Lemur keepers were trained to administer subcutaneous injections by our veterinary staff to prepare for possible insulin administration

Step 4: Adjustments were made to morning and evening shifting of lemurs to accommodate the administration of Sofina's oral medication

Step 5: A second trainer was added to the program

Off-Exhibit Layout

Figure 1: Ring-Tailed Lemur Holding



Step 6: Trainers developed a new training schedule to work with both groups and Sofina

Step 7: Trainers worked closely with the Animal Training Advisor to develop a behavioural plan for closing Sofina inside the squeeze chute, if needed, to receive an insulin injection

Step 8: Trainers began incorporating low-sugar foods such as carrots, wax worms, peanuts, and sugar-free jelly (a high value training reward)

Diet

Starting in October 2013, our troop underwent a substantial diet modification that would not only benefit Sofina, but the group as a whole. Reducing sugar availability in the diet was the main priority. Prior to diagnosis, the lemur diet consisted of apple, banana, sweet potato, carrot, a mixture of greens (romaine and kale), and Mazuri® Primate Maintenance Biscuits. A list of novel, low-carbohydrate and low-sugar food items was generated to determine what alternatives the lemurs might eat, including squash, cabbage, celery, cucumber, sweet peppers, and broccoli. We gradually introduced these items from our list; observing and recording what foods they were quickly consuming and which ones they were not.

Our first change was to eliminate apple and banana from the diet, and replace them with green beans and additional romaine. To increase the protein and fiber levels in the diet while reducing the added sugars and fat, we removed the Mazuri® Primate Maintenance Biscuits and offered Mazuri® Primate Biscuit Banana as a possible replacement. We slowly introduced the new biscuit and observed that the group showed no interest over a two-month period. After researching other commercial dry diets, Mazuri® Leaf-Eater Primate Mini was selected for its zero-added sugar, high protein and high fiber. This biscuit was slowly transitioned into the diet and is still a core item today.

The diet our ring-tailed lemurs have today is the end result of several reductions and modifications to each ingredient. As Sofina's condition began to stabilize with daily insulin injections (discussed in detail below), a small amount of sugar was re-incorporated back into her diet. This sugar ensured, most importantly, that Sofina did not have episodes of low blood sugar (hypoglycemia). This sugar item was a highly desired food, like sweet potato or apple, which we could put her medication in and use for rewards during training sessions. As a whole, these diet alterations were a drastic, but necessary, change that was crucial in managing Sofina's diabetes.

Daily Administration of Insulin

After numerous blood and urine tests over the course of several months, Sofina's oral medications alone were not enough to regulate her blood

Photo 2: Tomahawk Live Trap® 307SQ - Squeeze Cage installed in Den 7

glucose. An immediate adjustment to our plan was needed to include a daily injection of long-acting insulin each morning. Long-acting insulin allowed us to avoid the need for multiple injections. While squeeze chute training was still in its beginning stages, this was not yet a viable option for a daily injection. As an immediate solution, each morning Sofina was shifted into Den 3, hand-restrained (with the use of a net), and then given her subcutaneous insulin injection by a member of the Tropical Forest staff. To help eliminate any negative association with squeeze chute training or other dens used for training, restraint was always done in Den 3. As time went on, her daily restraint was becoming progressively more difficult, with increasing chances for either keepers or Sofina to get injured. A decision was made to go from manual restraint to using the squeeze chute. We knew that this would potentially sacrifice our squeeze chute training, but for the health and safety of everyone involved, it was necessary.

Lemur Training

Approach 1

Prior to Sofina's diagnosis, the trainer to lemur ratio at its maximum was 1:10 due to limited staff available for training. At the start of the training program the main goal was to obtain regular weights on each of the lemurs. Upon Sofina's diagnosis, the lemur-training program was prioritized and a second trainer was added shortly after the installation of the squeeze chute.

Tropical Forest keepers worked on creating a positive environment around the squeeze chute by giving Sofina access to it throughout the day, scattering it with some of her preferred low-sugar items. We also started to train the other group members to go into the chute while Sofina was observing them. Once she was comfortable with the chute, our goal was to condition her using approximations to enter the squeeze chute and allow the door to be closed when cued.

Squeeze chute training sessions took place later in the day, after Sofina had received her medication and was more alert, responsive, and ready to participate in training sessions. Her bridge was a clicker, and rewards were limited to low- or no-sugar items, such as wax worms, carrots and peanuts. We began by bridging Sofina when she was near or touching the door, and then eventually for entering the squeeze chute on a verbal cue. She was conditioned to station in the middle of the chute, so the door could be closed calmly without startling her. Closing the door was broken down into several approximations: Sofina entering the chute; trainer reaching toward and holding the shift door handle; the noise of the door moving; and then closing the door.

During this time, our training efforts with Sofina proved to be quite challenging because her diabetes was not yet fully controlled. We observed her to be very lethargic, both on and off exhibit. Her food consumption, as well as her energy level when participating in training sessions, was inconsistent. Unfortunately, we were unable to successfully train Sofina to voluntarily enter the chute and allow the door to be closed in the allotted time. Due to the urgency of treating her with insulin, we elected to take an alternate approach to shifting her into the squeeze chute.

Approach 2

To achieve our goal of reducing stress and risk of injury to both staff and Sofina, we utilized the presence of a keeper entering her den to displace or herd her into the squeeze chute. Once Sofina was closed inside the squeeze chute, she was immediately rewarded with sweet potato or a peanut. A keeper would then use the squeeze panel to secure her into position for another keeper to administer the injection of insulin subcutaneously either in her thigh or belly. Injection sites were rotated to avoid oversensitivity. After the injection was complete, Sofina was bridged, the squeeze was released, and she was immediately rewarded. The door was then opened, giving Sofina access to Den 6, where we could observe her before reuniting her with the group. Using this approach took less than two minutes, with far less risk of injury to Sofina or keeper staff, and was much less stressful than being manually restrained.

Current Update

Our family group size was reduced when our two sets of male twins (4.0) were transferred to another facility in July 2014. This reduction of animals was extremely helpful in working with Sofina, reducing our space constraints and animal to trainer ratio. At the time, when a second trainer was added to the program, we also amended our protected contact training protocol for this species to allow for free-contact training sessions, with the exception of our aggressive breeding male, Maki.

Free-contact training with our ring-tailed lemurs has facilitated our current training goals of reducing stress and eliminating the need for using the squeeze chute. Giving credit to the Animal Care Staff at Henry Doorly Zoo and Aquarium in Omaha, Nebraska, we are training each of our lemurs to step onto a stanchion/platform with a supporting upright bar for them to hold onto. Sofina now will position on a stanchion, placing her hands on the crossbar. We are pleased with Sofina's progress as she is desensitized to the tenting of her skin and a poke with a capped syringe. Once Sofina allows hand-injections, we will begin the process of desensitizing her to other animal management staff (not just her trainers) to successfully inject her. While this will be a timely process, it will allow us to utilize more staff within the Tropical Forest.

Photo 3: Squeeze chute training session

With Sofina responding well to stanchion training, she is gradually becoming more trusting of us. By rebuilding this positive relationship with her, trainers have been able to resume daily chute training sessions with positive results. We know it will take time to have her enter the chute on cue and allow the door to be closed, but we will continue to work towards this goal.

Conclusion

The work we have done with Sofina has been exceptionally challenging, but also extremely rewarding. She has been able to remain integrated with her family group; she participates in regular training, and allows our staff to administer her insulin daily. Sofina has come a long way and can live a relatively normal life here at Zoo New England because of the approaches and changes our team made to the husbandry routine. The training that we have done, and continue to do with her, has allowed me to develop my

relationship with Sofina as well as my skills as a trainer. It is rewarding to watch the positive results of our efforts and to see Sofina thrive with the rest of her family group. Our veterinary staff has been extremely helpful and resourceful throughout this entire process, and Sofina's success is very much a reflection of their expertise and professionalism.

Lemur trainers are taking what we have learned throughout this entire process and are preparing for possible reoccurrences in the future with other troop members. We are working closely with all of our remaining lemurs to enter into the squeeze chute, in addition to desensitizing them to the stanchions. As our training program develops, staff as well as the animals will be better prepared for a variety of medical endeavours that we may face in the future.

Acknowledgements

I would like to thank the Tropical Forest Keeper Staff for all of their hard work treating Sofina and working together in order to successfully implement a new management plan. Additionally, I want to thank our Training Advisor, Kim Kezer, for her valuable input and guidance towards achieving our many training goals for our lemur troop, and for the extensive contribution in reviewing this article. I would like to thank Jeannine Jackle (Assistant Curator, Tropical Forest) for her leadership and expertise in managing a diabetic collection animal. Furthermore, I would like to thank our staff veterinarians Dr. Susie Bartlett and Dr. Eric Baitchman for their exceptional support and quality level of care they provided Sofina throughout this process.

Sofina

BHC Comments by Jay Pratte:

There are so many great things to comment on in this Tale. First, the author and team demonstrated tremendous flexibility while creating their plan and goals, and then modifying them as the situation changed. Second, there is clearly excellent communication here between the trainers, managers, and the veterinary team. This is absolutely vital to any medical behaviors you are training, because you want to know that you are shaping positions and behaviors that will support the end goals. Training an animal for intramuscular injections is very different from the extra step(s) needed (i.e.- tenting the skin) for a subcutaneous shot, and the trainer needs to be aware of these parameters.

Third, the trainers clearly collaborated with other facilities in order to network with peers and look for other solutions when they ran into unexpected obstacles. As trainers, we ALL need to recognize that we do not, and will not, ever know everything, and it's a wonderful thing to have a network of professional colleagues that have found other ways of overcoming challenges that are new to us in our own facilities.

Last, I wanted to remark on the use of negative reinforcement. When they herded Sofina into the chute, the cessation of being herded is technically the rewarding stimulus in that scenario. However, the trainers do the correct thing in immediately also providing a strong positive reinforcer afterwards, which should help in alleviating any potential stress associated with experiencing an aversive stimulus. We all have instances where we find we need to use negative reinforcement; the trick is to recognize them and also rebuild trust with a positive reward association as well.

Congratulations on another great Training Tale!

We want to hear your Training Tales – the good, the bad and the fabulous!

Please submit your "Training Tales" and experiences in operant conditioning to share with *Animal Keepers' Forum* readers. This opportunity provides a convenient outlet for you to exhibit your training challenges, methods and milestones with the AAZK member network. Please submit entries based on the following guidelines:

Submit a brief description of a training project at your facility. These can be 500 words or less, in text or bullet points – it can be longer (up to 1000 words); however, short and simple descriptions with a few images are just as perfect. Details should include the following:

- Define the training goal (what did you try to do and for what purpose?)
- List important steps (How did you do it – include plans that changed along the way/what worked & what didn't work)
- Timeline used (how long did it take)
- Tips you learned along the way
- Include 3-5 digital photos that clearly depict the animal in the learning process or performing the desired goal (provide photo caption and photographer of each image). Photos need to be 300 dpi and at least 1200 x 1800 pixels.

Please send submissions or questions to:
Kim Kezer at kkezer@zoonewengland.com or
Shane Good at shane.good@aazk.org
(use Training Tales Submission as the subject)

Have a Magical Christmas!

May this Christmas end the present year on a cheerful note and make way for a fresh and bright New Year. Here's wishing you a Merry Christmas and a Happy New Year!

— Your Friends at Desert Plastics

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