Proceedings of the 47th Annual American Association of Zoo Keepers National Conference

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Comparing blue monkey (*Cercopithecus mitis*) enrichment variety at Zoo Knoxville with enrichment at a leading primate sanctuary in Kenya.
Tiffany A. James, Zoo Knoxville, tdemell@zooknoxville.org

As animal caregivers, it is important that we collaborate with other institutions to ensure the highest quality of care for our animals. This study aimed to compare enrichment categories provided for blue monkeys (*Cercopithecus mitis*) being cared for by humans at Zoo Knoxville in Knoxville, Tennessee, USA, and Colobus Conservation in Diani Beach, Kenya. For this study I collected information to compare types of enrichment provided for blue monkeys at Zoo Knoxville and to determine if they are different from the enrichment provided to a similar species at Colobus Conservation. I viewed daily enrichment logs recorded at Zoo Knoxville and sorted them into categories based on enrichment type. I then compared this information to categories shared by Colobus Conservation used with their Sykes’ monkeys (*Cercopithecus mitis*, sometimes classified as *Cercopithecus albogularis*). The purpose of this study was to determine if Zoo Knoxville provides similar enrichment to a well-respected in-situ conservation organization that promotes species-typical behaviors. Results indicated that Zoo Knoxville provides significantly more food enrichment than environmental enrichment, while Colobus Conservation provides primarily environmental enrichment options and virtually no extra food enrichment. By transitioning to using less food-based enrichment items for the blue monkeys at Zoo Knoxville, we may be able to reduce obesity and encourage species-typical behaviors, ultimately improving overall welfare.
Comparing blue monkey (Cercopithecus mitis) enrichment variety at Zoo Knoxville with enrichment at a leading primate sanctuary in Kenya

- Tiffany James · Zoo Knoxville · Knoxville, TN, USA -

Introduction

Blue monkeys (Cercopithecus mitis) are a species of guenon native to sub-Saharan Africa. They live in troops of 10–15 individuals and are often found in mixed-species flocks with other primates. In zoos and sanctuaries, the groups are often much smaller. Blue monkeys are classified as a “Phase-out species” by the Association of Zoos and Aquariums (AZA) and are housed on only four facilities in the USA, at which most zoos use 1 male to 1 female (1:1) groups. However, individualistic species across Africa are seeing an increase in the number of orphaned monkeys in their care as a result of habitat loss, increased hunting, the illegal pet trade, and the spread of pathogens. These individuals are often not prepared for the social dynamics of their own kind and must be slowly integrated to learn or relearn species-typical behavior, and enrichment is often used to help teach these skills. Enrichment is essential to the physical and mental wellbeing of all primates under human care, and facilities accredited by the Association of Zoos and Aquariums (AZA) are required to have programs similar to what we maintain at AZA accredited facilities.

The purpose of this study was to determine if Zoo Knoxville provides similar enrichment to a well-respected in-situ conservation organization that promotes species-typical behaviors. Working in conjunction with Colobus Conservation, a PWA-member primate sanctuary known for their outstanding care and conservation work in Diani Beach Kenya, I compared the types of enrichment provided to their Sykes’ monkeys (Cercopithecus albogularis) with the types being provided to 1:1 Stumptail blue monkey (Cercopithecus mitis albicollis) at my facility in Tennessee, USA. I predicted that Zoo Knoxville’s blue monkeys were given significantly more non-diet food enrichment than their counterparts at Colobus Conservation and less environmental enrichment. By comparing my team’s current practices to those of Colobus Conservation, we were hoping to promote more species-typical behaviors, a higher standard of nutrition, and overall a better quality of life for the monkeys under our care at Zoo Knoxville.

Methods

To compare types of enrichment provided at Zoo Knoxville with enrichment at Colobus Conservation, I observed daily enrichment logs recorded at Zoo Knoxville and sorted them into categories based on enrichment types established by facility. I then categorized the enrichment provided by Colobus Conservation in Table 1. To compare Zoo Knoxville’s enrichment with Colobus Conservation’s, I calculated the index for each category based on the number of times each item was given out of the total amount. I compared the means using a chi-square to determine similarities and differences in the enrichment types and amounts between the two organizations (Figures 2 and 3).

Results

Zoo Knoxville provides substantially more food-related enrichment than any other category. 24.6% of the overall enrichment provided during the study period was additional (non-diet) food items. When removing the required dietary items provided that are included in the overall enrichment, keepers chose to provide “Non-Diet Food” 23.6% of the time, often with items labeled “Objects” which we provided 26.7% of the time. Zoo Knoxville offers “Environmental” enrichment 6.4% of the time based on our overall enrichment data. “Browze” enrichment is provided 23.5% of the time, while “Sensory” enrichment makes up just 3.1% of our total data (“Browze” is only 1.4% of the time, Figure 2).

Colobus Conservation provides primarily naturalistic enrichment that would fall under the “Environmental” category (82%). They provided “Browze” 9% of the time, “Sensory” items 4%, “object” was 3%, and “Food” enrichment was 7% (Figure 3). They do not provide additional food enrichment other than coconuts, but vary diet presentation daily (typically by scattering, burying, or providing bowls of food). They also provide enrichment as treats to motivate their monkeys. This continued practice led to our enrichment goal was to promote foraging (Table 1), and keepers often struggled to find enrichment ideas other than additional food options as treats to motivate our monkeys. This continued practice led to our enrichment goal was to promote foraging (Table 1), and keepers often struggled to find enrichment ideas other than additional food options as treats to motivate our monkeys.

Discussion

Zoo Knoxville’s enrichment program varies greatly from the Colobus Conservation enrichment program. Animal care reason for this discrepancy is the availability of various items. Colobus Conservation keepers can easily access natural items that the monkeys may use in the wild but do not have the same access to store-bought products like we do at Zoo Knoxville. Likewise, we do not have access to the same items that can be readily found near Colobus Conservation. We do, however, have many comparable items to those used by Colobus Conservation, and could work to offer more naturalistic items like sand and rock piles at our site.

For the 1:1 blue monkeys at Zoo Knoxville, we used the information learned from this study to modify our enrichment goals and enhance the quality of care for our monkeys. In the past, our main enrichment goal was to promote foraging (Table 1), and keepers often struggled to find enrichment ideas other than additional food options as treats to motivate our monkeys. This continued practice led to our enrichment goal was to promote foraging (Figure 2), and we are working to reduce stress and encourage species-typical behaviors, ultimately improving welfare. We intend to continue monitoring and analyzing our enrichment practices as done through this study and are working to build relationships with our monkeys to further instill their natural behaviors. Additionally, repeating the study with various species across multiple cross and conservation organizations could help us to learn ways to provide the highest quality of care and enrichment for our animals.

Literature cited


11. Please contact Tiffany James at tdemell@zooknoxville.org for further information.

Acknowledgments

I extend my thanks to my management team at Zoo Knoxville for supporting this project. Lastly, I could not have completed this project without my instructors and peers at Project Dragonfly. Thank you to all for your support throughout this process.

For East Mammals Department 2020-2021 Priority Enrichment Goals

<table>
<thead>
<tr>
<th>Color</th>
<th>Goal</th>
<th>Item</th>
<th>Orientation</th>
<th>Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>Sensory</td>
<td>Leaf Litter</td>
<td>Offer enrichment items daily that require movement to access food and objects</td>
<td>A log will not be added to record items given</td>
</tr>
</tbody>
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For East Mammals Department 2021 Priority Enrichment Goals

<table>
<thead>
<tr>
<th>Goal</th>
<th>Item</th>
<th>Color</th>
<th>Orientation</th>
<th>Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory</td>
<td>Leaf Litter</td>
<td>Blue</td>
<td>Sensory</td>
<td>Use of natural leaf litter to provide enrichment and encourage sensory exploration.</td>
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Table 1: 2018-2020 Departmental blue monkey enrichment goals

<table>
<thead>
<tr>
<th>Zoo Knoxville Categories</th>
<th>Colobus Conservation Categories</th>
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</thead>
<tbody>
<tr>
<td>Food</td>
<td>Browses</td>
</tr>
<tr>
<td>Browses</td>
<td>Food</td>
</tr>
<tr>
<td>Sensory</td>
<td>Leaf litter</td>
</tr>
<tr>
<td>Object</td>
<td>Object</td>
</tr>
<tr>
<td>Environmental</td>
<td>Non-diet food</td>
</tr>
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Table 2: 2018-2020 departmental primate enrichment goals updated to better reflect current enrichment categories

Table 3: 2018-2020 departmental primate enrichment goals updated to better reflect current enrichment categories

Figure 1: Comparing enrichment items given by Colobus Conservation to that of Zoo Knoxville's established categories

Figure 2: Enrichment provided at Zoo Knoxville

Figure 3: Enrichment provided at Colobus Conservation

Acknowledgments

I extend my thanks to the entire team at Colobus Conservation in Kenya for allowing me to volunteer and examine enrichment practices, as well as in-kind support from the Zoo Knoxville Foundation to support this project. I extend my thanks to the entire team at Colobus Conservation in Kenya for allowing me to volunteer and examine enrichment practices, as well as in-kind support from the Zoo Knoxville Foundation to support this project.
United Keepers Uniting Otters: A case study
Sabrina Ridel & Cylia Civelek, Montreal Biodome, sabrina.ridel@montreal.ca

The Montreal Biodôme, an indoor zoological museum, closed to the public for a large-scale renovation “Migration project”, from 2018-2022 (delays due to COVID). During this time, the Biodôme’s North American river otters (NAROs) were permanently moved to another institution. To renew our collection, we prepared for a young, reproductive, wild-caught female NARO to arrive from the USA in August 2020. A young, nonreproductive, captive-born male NARO from Calgary Zoo was scheduled to arrive in May 2021 in hopes of forming a reproductive couple. In the midst of these challenges, movements of staff and retirements made it so that new animal care technicians with different levels of experience were integrated into the team. Knowledge gained through this process motivates us to share in a poster with fellow AAZK members, our successes and areas of improvement, through collaboration, innovation, experience and a lot of passion. We have united a Canadian and an American otter into our francophone province. Wouldn’t you say that’s a great pair, eh? Online forums, collaborative documents, and interpersonal communications were consulted to implement our NARO introduction protocol. Collaboration between several departments allowed for the necessary structural modifications and the installation of monitoring equipment. The female’s quarantine and introduction into her new habitat was our first challenge. She was then gradually introduced to our new male using olfactory, auditory, visual and tactile communication, before their first physical contact. Ultimately, the otters’ introduction was a success, through a combination of careful planning and decision making, with many more to come.
Introduction

The work of our peers, such as Reed-Smith et al., is extensive and we are grateful for the NARO community. The introduction of our 1.1 otters is well documented, and through our experience, hope that our work will be used as a resource and tool that other institutions can use and implement with their otters. Although some of the challenges we faced were unique to the specific health status of our time, our methods can be employed broadly. Ultimately, we are United keepers uniting otters throughout institutions – united in other words...collaborators

METHODS

ADD ENRICHMENTS

RESULTS

SUCCESSFUL introduction and maintenance of NAROs: reproduction remains an objective

- Male North American River Otter (Lontra canadensis) Age: 1Y 2M (juvenile)
- Male Captive-Born Calgary Zoo, Alberta, Canada Known history

Preparation:

- Quarantine (incl. COVID), husbandry, introduction protocols and intervention tools
- Previous medical and hospital experience
- Adjustments to quarantine area, holding quarters & habitat (Fig. 2)
- Name unchanged

Arrival:

- Arrival: mid-April 2021 AM
- Priorities during quarantine: 
  - Refer to female’s
  - Training (same cues as with female): bridge, target, shift, crate (for transfer)

Results:

- Step 1a - Defecation (post-quarantine)
  - Exchange of diets (stool, bedding, enrichment items)

- Step 1b - Auditory
  - Female in habitat
  - Male transferred to holding quarters
  - Fed before intro., then simultaneously, with empty stall between them

- Step 2 - Visual
  - Step 1 repeated but in adjoining stalls

- Step 3 - Full visual and limited contact
  - Certain visual + tactile barriers removed
  - Select enrichments offered simultaneously

- Step 4 - Shared space with rotation between habitat & holding quarters
  - Step 1-4 completed with positive interactions before proceeding. Note, female not in estrus

- Step 5 - Physical
  - In holding quarters:
    - Experienced personnel and veterinarian on-site
    - Tools available if alteration (food, nets, brooms, crate, water hose, sound alarm, intervention chart)
    - Contact-time based on behavioural observations.
  - Goalt to separate individuals on a positive note.
  - Gradually extended daily, non-food enrichment items offered
  - In habitat + holding quarters:
    - Access to habitat
      - one after the other (distance)
    - Team members positioned on, both sides with tools

Conclusion

Challenges

- Movement of animals (Migration)
- Staff with different levels of experience
- Grand reopening of the Biodôme (collaboration with management and education)
- New individuals with no animal-keeper relationship
- Wild-captive female with limited human contact

COVID-19 pandemic
- Health and safety of animals and staff
- Quarantine husbandry, order of contact with other mammals (biomedical education, consultation, etc.)
- Captive-born male with limited visitor contact
- Training: modified (NGS mask)
- Transportation (e.g. permits)
- Skeleton staff; limited technical/trades

Contact Information

Cylia Civelek, cylia.civelek@montreal.ca • Sabrina Ridel, sabrina.ridel@montreal.ca

Acknowledgements
We give special thanks to Dr. Eniko Varghese, Yves Picard, Caroline Blais, Lorraine Lacombe, Dr. Joelle Garand, Dr. Karine Beland, Dr. Lydie-Amy Leduc, Gheysen-Daghous, Brice Teher, Léanne Trempe, Stéphanie Laplante, Jodie Dufort, Stéphanie Chi Sang, Gay Bouchard, Carl-Eric Faubert, Hélène Céronnier, the vet clinic, management, life support and education team.

We also thank the other care team at Calgary Zoo.

References

- United Keepers: Unitiging Otters: A Case Study
- DeLong et al., 2019)
Artificial intelligence in monitoring animal identification, health, & behaviour
Dr. Jenna V. Congdon, Toronto Zoo, jcongdon@torontozoo.ca

Modern zoos, like the Toronto Zoo, are at the forefront of efforts to save species from extinction, and to ensure that animals in their care enjoy enriched, healthy lives in species-typical environments. Research on animal behaviour is a vital part of these efforts, however, this is typically achieved by scientists collecting real-time data in a fairly lengthy and tedious process. Together with our partner organization, the technology company EAIGLE Inc., we have created artificial intelligence (AI) capable of mass data collection, which will provide 24/7 animal monitoring to greatly improve animal welfare outcomes, monitoring where the animals are, what they are doing, and with whom in their social group they are interacting. This will allow for change of management and environment to improve welfare outcomes. We will report on the function and application of this technology with regards to animal health and welfare, successes in training with Toronto Zoo orangutan footage, as well as the challenges faced in developing innovative technology. In addition, we will share what we have learned about connecting with industry partners, and how to navigate assembling a team to tackle a project effectively.
Artificial intelligence in monitoring animal identification, health, & behaviour

Congdon, J. V.1,2, Hosseini, M.1,3, Franke, M.4, & MacDonald, S. E.1
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Introduction

• Technology for monitoring non-human lives has advanced to be smaller, more affordable, and highly accurate.
• Types of technology include:
  • Accelerometers
  • Drones
  • Radiotracking & GPS collars
  • Camera traps
  • Artificial Intelligence (AI)
• Primary purposes for technological advances:
  • Monitoring health
  • Differentiating between individuals
  • Tracking behaviours

Current Limitations & Proposed Novel Technology

![Image of AI technology in monitoring]

Current Limitations:
- Current technology is not compatible with many species.1
- Evidence suggests wearable devices affect individuals’ behaviour.1,3
- No current camera technology is capable of collecting all types of data remotely.

Objective: Training AI to collect information on zoo animals’ location, identity, and behaviour in order to monitor and improve individual welfare, provide advanced enrichment, and for 24/7 mass data collection to aid in scientific research.

Results

Monitored Behaviours:
- Foraging
- Breach
- Locomotion
- Feeding
- Scanning
- Patrolling
- Hiding
- Inactivity
- Urination
- Defecation
- Object Play
- Object Manipulation
- Affiliative Movement
- Affiliative Behaviour
- Agonistic Behaviour
- Keeper-directed
- Self-directed
- Baby-directed
- Tech-directed

Figure 1. An example of an annotated image of training the artificial intelligence (AI) model to identify Sumatran orangutans. The displayed tool allows for a choice between annotating individual animals vs. objects vs. four quadrants, and identification between the six orangutans.

Figure 2. An example of an annotated image of training the artificial intelligence (AI) model to identify Sumatran orangutans. The displayed tool allows for a choice between annotating individual animals vs. objects vs. four quadrants, and identification between the six orangutans.

Figure 3. Screen capture of the AI detecting an orangutan.

Figure 4. A blueprint of the indoor orangutan exhibit study area. The orangutan exhibit location is indicated in red. Note: The orangutan exhibit is blue dotted.

Figure 5. A panoramic photo taken from the edge of the moat at Toronto Zoo’s indoor orangutan exhibit. Blue boxes indicate the location of each of the five (5) cameras around the perimeter of the enclosure.

Figure 6. A panoramic photo taken from the edge of the moat at Toronto Zoo’s indoor orangutan exhibit. Blue boxes indicate the location of each of the five (5) cameras around the perimeter of the enclosure.

Figure 7. An image of EAIGLE’s original artificial intelligence, identifying the number of people in a room (top left), monitor individual body temperature (top center), and flag suspected cases (top right) of COVID-19.

Figure 8. An image of EAIGLE’s original artificial intelligence, identifying the number of people in a room (top left), monitor individual body temperature (top center), and flag suspected cases (top right) of COVID-19.

Conclusions & Future Directions

Our proposed novel AI addresses a current gap in technology for unobtrusive monitoring, collecting a wide-range of information that can ultimately inform:
- Where animals spend their time
- How to rearrange enclosures to be more suitable, comfortable, and cognitively stimulating
- How to further improve enrichment
- How to decrease any detrimental impacts incurred

Once the AI is fully validated, we propose extending this project to record and analyze the behaviours of other critically endangered non-human animals, such as polar bears and Sumatran tigers.

References

Acknowledgements

Special thanks to Ezekiel Gading, Mahdi Masousi, & Toronto Zoo keepers for their contributions.

The potential value of infrared thermography (IRT) has begun to be recognized in the zoological world with the advance of the technology and a decrease in cost associated with equipment. African Lion Safari has been integrating IRT into our research, conservation, husbandry and veterinary care programs since 2018. While the technology is similar to a point and shoot camera, thermography does require the user to recognize some key considerations when using the technology. Understanding the factors that can impact the accuracy of a thermal image is imperative to obtaining inferable results. Considerations include distance to object, ambient conditions and animal behavior, which can be accounted for when analyzing thermal images. We will present results from a variety of our projects, ranging from tracking estrus cycles, monitoring pregnancy and adaptation to a temperate climate, with the intent of highlighting the pros and cons associated with use of the imagery in a modern zoo.
**Introduction**

**What is Infrared Thermography (IRT)?**
- Digital imagery of emitted thermal radiation converted to a surface temperature.

**Background**
- IRT is widely used in husbandry in the agricultural industry.
- It is gaining interest in zoological facilities due to its non-invasive nature.
- Validation is needed for individual species, and uses.
- African Lion Safari is integrating IRT into every-day animal care.

**IRT can help:**
- Detect inflammation and injury
- Monitor treatment efficacy
- Monitor cryptic species
- Track estrus and ovulation
- Confirm and monitor pregnancy

**Hypothesis:** Based on the success in the agricultural industry, IRT is predicted to be a beneficial tool in husbandry and veterinary care in zoological facilities.

**Methods**

**Hypothesis:** Based on the success in the agricultural industry, IRT is predicted to be a beneficial tool in husbandry and veterinary care in zoological facilities.
- We use two Teledyne FLIR models in thermography research:
  - FLIR T540: Research grade, High resolution, Still image and video modes
  - FLIR ONE PRO: Phone attachment, Lower resolution, Cost effective, Still image only

**Research Program**
- Focal species include elephants, rhino, lions and birds.
- Study design and analysis conducted by trained expert
- Collaborative implementation by staff, veterinarians and researcher
- Staff training and support provided as required.
- Images analyzed by trained expert using specialized software
- Results disseminated in layperson reports and used for manuscripts in peer-reviewed journals.
- We are working to create a network of IRT researchers within the zoological community

**Results**

**Detecting and monitoring inflammation**
1. Keepers noted the Seriema displayed weakness in the right leg. IRT identified increased surface temperature in the leg, indicative of inflammation.
2. IRT was used to monitor the bird while receiving treatment. Images suggested improvement.
3. Images indicated a decrease in the surface temperature following treatment. Keepers noted improvement consistent with results suggested by IRT.

**Monitoring cryptic species**
- Bongo prefer dense shrub and shade where they are hard to locate and monitor (left).
- IRT images easily detect animals (right), which allows keepers to conduct daily census and remote health checks for animals maintained in the reserves.

**Reproductive status**
1. Tests underway to monitor ovulation and pregnancy in multiple species.
2. Results suggest reproductive females present unique thermal profiles.
3. Surface temperatures of mammary glands is increased while nursing

**Discussion**

**Benefits**
- IRT is a tool that has the potential to increase animal care in zoological facilities.
- The non-invasive nature makes it ideal for gaining valuable information while allowing the animal to continue its normal routine.
- Can provide key insights that aren’t visible to the naked eye.

**Drawbacks**
- Research grade technology is costly.
- Validation is required for the zoological setting.
- Many factors can affect the image (e.g. distance, solar radiance, animal behaviour), which must be documented and accounted for to minimize error.
- Software is required to analyze thermal images for conclusive results.

**Conclusions**

- Integration of IRT into animal care has improved our ability to monitor and care for the animals in our care, including veterinary care.
- Studies must be carefully designed and integrate validation.
- The value of IRT is enhanced through communication and cooperation with animal care staff and veterinarians.
- While the technology is accessible to the layperson, research staff need to conduct analysis and ensure results are correctly interpreted.

**Acknowledgements**
I would like to thank the continual efforts of the animal care staff, Managers, veterinarian staff and research team at African Lion Safari for their assistance in research and validation efforts, and for always welcoming new ideas.
Olive is a 12-year-old female North Sulawesi babirusa who came to the Toronto Zoo in 2011 on a breeding recommendation. Unfortunately, during transport Olive suffered an injury to her hip and right hind leg that has affected her use of this leg ever since. Although initial surgery allowed Olive to be well enough to breed, her condition began to further deteriorate in 2017. After a second surgery in 2018 to help increase the range of motion of her leg, zoo vets suggested physiotherapy as a way to build up and maintain Olive’s use of her leg. Keepers began physiotherapy in early 2019. It was important to make this process rewarding enough for Olive to voluntarily participate despite some of the exercises being potentially uncomfortable for her. Keepers chose to use tactile reinforcement in a protected contact scenario where Olive had the space and freedom to leave the session at any time. Since beginning this training, keepers have been able to introduce more exercises while also progressing on the initial exercises. Olive’s mobility has improved in this time. It is difficult to know if this is from physiotherapy or due to other factors, such as her surgery or adjustments in medications that also occurred over this time. Despite this lack of certainty, keepers feel the physiotherapy training has improved Olive’s welfare in additional ways. For example, increasing Olive’s confidence, strengthening her trust in her care team, and allowing keepers to better observe and treat other conditions as they arise.
Using Physiotherapy to Manage Pain and Mobility in a Babirusa with a Pre-Existing Injury
By Laura Huculak & Elise Schembri Swann, Indo-Malaya Keepers, Toronto Zoo

Background
- Olive is a 13-year-old female North Sulawesi babirusa (Babyrousa celebensis) who was injured on route to Toronto in 2011. She presented as lame on her right hind leg.
- Surgical removal of her dislocated right femoral head allowed Olive to live a relatively normal life for a time. She had a barely perceptible limp and successfully raised a piglet.
- In 2017, her lameness appeared to be getting worse and she was no longer able to fully extend her hip. She had almost no use of her leg, either from pain or a physical inability.
- To improve her range of motion, Olive underwent a surgical debridement of the remnants of her right hip joint in September 2018.

The Problem
- Three months after Olive’s debridement surgery, she was only using her right hind leg about 1 step out of every 3.
- When walking her toes did not fully extend, and we are able to feel them extend further during the stretch.

Training Objectives
- To increase the use of her leg, veterinarians and keepers discussed introducing Olive to a light physiotherapy program with the goals of:
  1. Improving mobility of the hip with a hip extension stretch.
  2. Decrease contraction of the toes with a toe extension stretch.
  3. Increase blood flow to the hip and right hind leg and help manage and reduce pain with massage.

Training Methods
- Training began in January of 2019. At this point, Olive was already lining up at a fence and allowing keepers to rub her hip/leg.
- Keepers progressed from massaging the leg/hip to gradually applying pressure to her leg/foot for stretches.

A Typical Physiotherapy Session
- Ideally starts after Olive has been up and moving around and muscles are already warm. A hot compress is sometimes applied to help.

  Massage
  - Next, we apply gentle stroking massage which can decrease pain and muscle tension, reduce inflammation, and increase lymphatic drainage in her hip.
  - Massage of her unaffected limb is also performed to help compensation limb tension and correct muscle balance.

  Feeling for knots along her spine with a massage ball to help.

  Massaging inner & outer thigh of affected limb

  Hip extension stretch

  Hind leg forward stretch

  Toe extension stretch

  Cold Therapy
  - Cold therapy can be good when dealing with swelling and inflammation, particularly after exercise/therapeutic exercises or after a flare up when she is particularly sore.
  - Cold therapy can absorb heat from the irritated area which reduces the metabolic rate, keeping inflammation down.
  - We use a flexible covered cold pack and hold it to her hip for 5-10 minutes.

Results
- Increased use of leg: She uses her leg almost all of the time when she is walking and sometimes uses it when running.
- Hip extension: At first, we were only able to hold this stretch for a few seconds before Olive walked away. Olive will now allow us to hold it for up to a minute. Initially, we were also only able to extend her leg back by a couple of degrees. Now we are able to extend it back almost fully.
- Toe extension: She is walking better on her toes and we are able to feel them extend further during the stretch.
- Muscle gain: While there is still marked muscle atrophy on her right hind leg, her annual veterinary exams report that this is less severe than it was prior to the start of her physiotherapy program.

Conclusions
- It is difficult to know if her improvements are from physiotherapy or due to other factors, such as her surgery or adjustments in medications that also occurred over this time. Despite this lack of certainty, keepers feel the physiotherapy training has improved Olive’s welfare in additional ways, such as:
  1. Increased confidence and stronger bond with her keepers.
  2. Keepers are better able to observe and treat other conditions as they arise. For example, being able to treat and prevent cracks on her feet in winter with topical treatment.
  3. OLIVE APPEARS TO ENJOY PHYSIOTHERAPY!! We conclude this based on her willingness to participate and her relaxed state during sessions (e.g. yawning, closing eyes, and stretching on her own).

Future Goals
- Use of video to watch progression and monitor progress and use of leg
- Take measurements around each of her hind legs to track muscle growth and loss
- Veterinarians and keepers have discussed the possible use of laser therapy as an additional treatment.

Acknowledgements
- We owe many special thanks to Dr. Pauline Delnatte, DVM, Staff Veterinarian at the Toronto Zoo, for the care and support she has provided to both Olive and her care team on this journey.
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Elise Schembri Swann pschembri@torontozoo.ca
By the end of winter 2020, keepers noticed that Abby, a Southern White Rhino, had a sharp tooth on the top left side of her mouth. She was eating normally but her left eye was watery. A decision was made by keepers and vet staff to anesthetize to take care of it. There is a rhino barn all rhinos are used to going to, but this area was deemed not easily accessible for all involved; keepers, vet staff, and ASAR (animal search and rescue).

The annex is a separate barn, with three paddocks, currently housing retired 0.1 rhino, Olivia. The space has what is called the “Sandrock paddock” that has horizontal cables and plenty of space to maneuver large equipment. There are two main issues:
1. Abby has never been to the annex before
2. Bonnie, another 0.1 Southern White Rhino, has an attachment to Abby and separating the two may be difficult, as white rhinos operate in herd bonds.

Keepers had to not only train Abby rhino to leave the comfort of her 40 acre habitat and her small herd, but they had to train Bonnie to remain calm with Abby’s absence. With operant conditioning, keepers not only trained Abby to enter the annex by herself, but to enter a chute to put on a sling and received the injection, then walk out into the Sandrock paddock for the procedure.
Abby is a 16-year-old southern white rhino at the North Carolina Zoo. In December 2020, keepers noticed that her left eye was watering and her breath smelled unusual. After investigating, a sharp tooth was found on the top left side of her mouth. To properly take care of it, it was decided that she should be anesthetized. Abby weighs 5,660 pounds, so staff required help from Animal Search and Rescue. ASAR has a mobile tripod hoist capable of lifting Abby from a sling in the case she went down in an undesirable location. (Abby is already trained to wear this sling.) The challenge became where this procedure would take place. The rhino barn is too cramped and there is not space for all of the people and equipment needed for the procedure. The annex retirement barn, however, has a sandrock paddock that is spacious and mostly flat.

**The next problem is twofold:**
1. Abby has never been to the annex
2. She is part of a group including 0.3 other southern white rhinos, (Natalie, Nandi, and Bonnie,) that have a close bond. Bonnie has an attachment to Abby, so keepers had to ensure she was calm once Abby is out of sight during the procedure and recovery.

**Results:**
Abby was brought to the annex the day before her procedure for fasting overnight. Morning of, we lined her up in the chute and she allowed keepers to put on her sling without a problem. ASAR had requested we add extra straps they had brought to help with the weight load, Abby was mostly ok with the additional straps but due to her size, the carabiners clinked against the bars of the chute and made her nervous. In the end, she did not stand for the injection. She was darted in a stall and let out into the sandrock paddock, where she went down and keepers and staff helping with the ASAR equipment were able to get in and get her lifted and adjusted into position with relative ease. Bonnie was calm and hanging out with her other companions on habitat.

*Abby was too tense to open her jaw and due to complications, vets made the call to wake her, she was released from the equipment and all materials were taken out of the paddock within minutes. Abby is healthy and happy. Despite the result not being preferred, her training made the entire process much easier for everyone involved.*

**Acknowledgments:**
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Deepwater cisco are a food source for predatory species of fish in the great lakes. The population of deepwater cisco in the 1900s was abundant, as these fish did not have any natural predators. They experienced commercial fishing exploitation and went extinct in the 1940s. This extinction negatively impacted the food chain and ecosystem, so actions are now being taken to cultivate and reintroduce them to the great lakes, as they are an important food source for other freshwater fish. Bloaters are important trophic integrators because they feed on different plankton as they vertically traverse the water column throughout their life cycle. The OMNRF has been breeding deep water cisco for several years at the White Lake Fish Culture Station, their focus is on trying to improve reproductive performance of broodstock held in captivity by altering feed formulations. The captive Bloater egg production and quality have been abnormally low, limiting successful restocking, despite the extensive research and practices that exist. Researchers believe that the use of fish feeds that are formulated for piscivorous species being fed to broodstock is directly correlated with nutritional deficiencies that cause poor sperm and egg quality. Controlled experiments have compared and contrasted wild versus captive Bloater diets and evaluated the impacts of diet and nutrition on the growth and survival of the fry. The supplementation of Mysids is helpful for introducing them to wild feedstuffs, the fatty acids, protein, and carotenoids are linked to higher survival rates and superior gamete viability and quality.
THE POSITIVE IMPACT OF MYSIDS ON LAKE ONTARIO'S REPOPULATION OF DEEPWATER CISCO
Samantha Brijbassi, Tim Drew, Justin R. Chan, Zoe Zrini, Flavia M. Damasceno, David Huyben and Dominique P. Bureau
Dept. of Animal Bioscience, University of Guelph & Ontario Ministry of Natural Resources and Forestry

INTRODUCTION

Deep water ciscoes (Coregonus spp.) are species that inhabit the Great Lakes and are an important food source for predatory fish species, such as Lake Trout. Bloaters (Coregonus hoyi) were driven to extinction by over-exploitation and environmental degradation of the Great Lakes. Efforts in Canada and the USA are underway to re-introduce deep water cisco (Coregonus hoyi) in Lake Ontario by breeding brood fish in captivity. The reproductive performance of captive fish is poor and may be related to nutritional deficiencies because they are fed salmonid diets. Since these fish feed mainly on zooplankton in the natural environment, it has been hypothesized that supplementation of the diet with krill or mysis could improve the fecundity of these animals.

EXPERIMENTAL APPROACH

- At the White Lake Fish Culture Station, bloater broodstock were fed various diets with different ingredients and nutritional values
- Commercial diets were fed with automatic feeders and items such as frozen krill were hand-fed
- Egg and brood tissue samples were taken during the spawning period for further analysis and eggs were incubated in egg jars
- The measurements such as egg size and quality, viability and size of larvae, and survival were analyzed

RESULTS

- The supplementation of krill in a first study had a positive effect on reproductive success (eye-up egg, Figure 1) but in a subsequent trial, krill and mysid shrimp supplementation did not appear to have beneficial effects (Ex: Table 1).
- Compositional analysis of diet, gonads, eggs and fish samples for fatty acids and carotenoids are being conducted to determine if some measures of reproductive success can be linked to certain nutrients

CONCLUSIONS

Further research is needed to understand the nutritional requirements of Bloater in order to improve the success of restoration program for these species

ACKNOWLEDGEMENTS: THIS RESEARCH EFFORT WAS SUPPORTED BY FUNDING FROM THE ONTARIO MINISTRY OF NATURAL RESOURCES AND THE GREAT LAKES FISHES COMMISSION. THE EXPERT ASSISTANCE AND DEDICATION OF THE PERSONNEL OF THE WHITE LAKE FISH CULTURE STATION IS ACKNOWLEDGED.

SUMMARY OF EXPERIMENTAL WORK CONDUCTED

- 2017-2018: Comparison of wild broodstock vs. captive broodstock at the White Lake FCS in two year-classes (2012 & 2013 stocks)
- 2019-2020: Comparison of commercial feed and commercial feed plus frozen krill in broodfish from two year-classes (2015 & 2016 stocks)
- 2020-2021: Comparison of a commercial feed, frozen krill, or frozen freshwater mysis
- 2021-2022: Comparison of commercial and custom complete feeds with and without krill
- 2022-2023: Comparison of commercial feeds - upcoming


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Figure 1. Eye-up rate of eggs from wild and captive deep water cisco female over time and in response to different treatments

Table 1. Summary data from the bloater diet pilot study. Overall mean values ± SEM.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Eye-up Rate (mean ± SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild</td>
<td>73.2 ± 2.1</td>
</tr>
<tr>
<td>2012</td>
<td>76.8 ± 2.5</td>
</tr>
<tr>
<td>2013</td>
<td>70.2 ± 1.8</td>
</tr>
<tr>
<td>Commercial Feed + Krill</td>
<td>83.5 ± 1.9</td>
</tr>
<tr>
<td>Commercial Feed</td>
<td>69.3 ± 2.7</td>
</tr>
</tbody>
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Figure 1. Eye-up Rates From Different Garnet Sources at White Lake FCS

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Photobiomodulation therapy (formerly known as low-level laser therapy) has seen increased use and success in treating arthritis-related mobility issues in exotic animals in recent years. Utah’s Hogle Zoo currently employs photobiomodulation therapy techniques to treat a 0.1 Southern white rhinoceros and a 0.1 Hartsmann’s mountain zebra with varying levels of success.

The Rocky Shores team at Utah’s Hogle Zoo cares for a variety of North American species, including 1.2 wild-born rescued grizzly bears. One 0.1 grizzly bear has a rear left leg chronic limp. Medical records from a previous institution that housed the bear as a juvenile noted that the rear left leg bone is shorter than the rear right leg bone but were unspecified as to whether this was a result of a growth deformity or an injury. A medical work-up in May 2021 showed significant arthritis in the knee and surrounding area of that rear left leg. Current oral treatment includes a Cosequin supplement, resulting in no visual improvement.

Rocky Shores keepers are interested in attempting photobiomodulation therapy with the previously mentioned 0.1 grizzly bear. As this treatment has not been performed on a large carnivore at Utah’s Hogle Zoo before, this will be a learning experience for both animal care and veterinary staff. This presentation will cover the process for planning how to do this therapy safely with a large carnivore and show all of the factors that the Rocky Shores staff will be taking into consideration (i.e. animal holding modifications, equipment modifications and desensitization training).
Bear with us:
Developing a plan to safely perform photobiomodulation therapy on a large carnivore
Kimmy McIntyre, Rocky Shores Team, UHZ Hospital Staff
Utah's Hogle Zoo
Salt Lake City, Utah

The Patient:
0.1 grizzly bear "Dolly" has a rear left leg chronic limp as a result of either an injury sustained as a juvenile or a growth deformity.

The Goal:
To relieve some of the symptoms of severe arthritis that are being observed in Dolly's rear left leg using photobiomodulation therapy.

The Challenge:
UHZ has not done this type of therapy with a large carnivore before. What do we have to do to perform this therapy safely and successfully?

Training "Dolly":
1. Line up against the mesh of an indoor holding stall for proper positioning using pre-established "target" behavior
2. De-sense to photobiomodulation equipment (beeping noises, red light), bridging for calm behavior/indifference toward equipment
3. Touch de-sense to allow keepers to remove debris from fur (due to heat from laser, fur should be free of any debris that may catch fire)
4. Hold positioning for duration of therapy process (4-5 minutes)

Animal Holding Modifications:
Build a plexi-glass access panel (with an open space/window in the middle) to slide into a mesh panel slot to allow for safe, close contact of therapy equipment.

Therapy Equipment Modifications:
Modify a PVC pipe to use as an extender/sleeve for the photobiomodulation probe to help increase the distance between the staff member's hand holding the probe and the plexi-glass access panel opening.

How does photobiomodulation therapy work?
An infrared light is applied over the area to reduce inflammation, stimulate healing in soft tissue or to provide relief for acute or chronic pain issues.

What is the latest update on how Dolly's therapy is going?
Scan to find out!