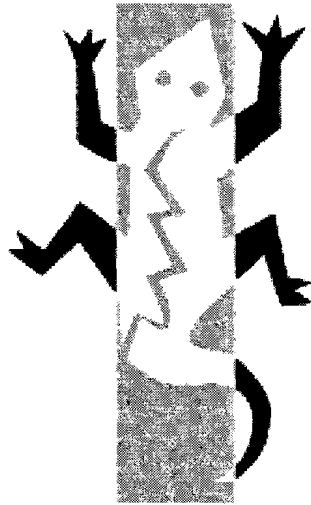


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Crissey Zoological Nutrition Symposium

Raleigh, North Carolina

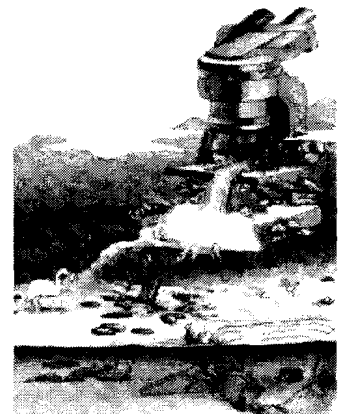
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**Crissey Zoological Nutrition Symposium
Raleigh, North Carolina
December 7 and 8, 2007**

**Susan D. Crissey, Ph.D.
December 12, 1951 – November 23, 2002**

Sue Crissey earned her B.S. and M.S. degrees in human nutrition from Michigan State University and spent four years with the FDA before accepting a scholarship from the University of Maryland to pursue a Ph.D. in animal nutrition. She completed a post-doctoral fellowship at the Smithsonian Institution's Conservation Research Center in Front Royal, Virginia, and began field work studying howler monkeys in Venezuela. From there, she joined the staff of the Brookfield Zoo in Chicago where she developed and led their nutrition programs.

Sue continued as Director of Nutrition for Brookfield Zoo until her death. It was much to North Carolina State University's advantage when Sue moved to Burgaw, North Carolina, to be with her husband, Chris Smith. She accepted an appointment as adjunct assistant professor in the Department of Clinical Sciences and taught many students the basics of zoological nutrition. Sue was an energetic and engaging lecturer who could draw on her work with nutritional diseases in species that included rhinoceros, wild felids, howler monkeys, golden marmosets, bottlenose dolphins, Micronesian kingfishers, and many more, to illustrate her talks and discussions. Sue published over 100 scientific papers including several seminal topical reviews. In 2002, she was awarded the Duane E. Ullrey Achievement Award by the American Association of Zoo Veterinarians for her distinguished work.

Sue loved her North Carolina farm, and maintained a significant menagerie of zoo retirees and castaways there, commuting from her home in Burgaw to Chicago to manage her zoo duties, and traveling to Raleigh at the drop of a hat to teach. Sue was a meticulous scientist whose enthusiastic joys of teaching and insistence on "good science" have become part of those who were lucky enough to be around her for any length of time. Future generations of zoological nutritionists are richer for having been, but poorer for not knowing her.

"I don't know that I was a great teacher, but in almost everything I did, I tried to encourage others to look for opportunities to be helpful to people and to appreciate our natural world."

- Sue Crissey, 2002



Susan D. Crissey

Key Note Speaker

Fourth Crissey Zoological Nutrition Symposium



Sara Rutzky, PhD

Dr. Sara Maurine Rutzky (nee Decherd) was born in Dillingham, Alaska, but grew up amongst the wetlands and among the Douglas Fir trees of the Willamette Valley in northwest Oregon. She majored in geology at Carleton College in Northfield, MN and graduated Cum Laude with a B.S. and having gained hands-on geologic mapping and interpretive experience through fieldwork in southern Minnesota and in the Apennine Mountains of Italy. In addition to her academic pursuits in her undergraduate years she was also a devotee of Ultimate Frisbee and a member of Syzygy a nationally ranked Ultimate Frisbee team. During her undergraduate studies she had the fortune to spend two summers working for the famous Royal Tyrell Museum of Paleontology in Drumheller, Alberta on a dinosaur dig in Dinosaur Provincial Park, Alberta, Canada where she learned paleontology field techniques.

These experiences fueled her interests in paleontology and resulted in her coming to Raleigh, North Carolina for the opportunity to pursue graduate work at N.C. State University under the renowned dinosaur paleontologists Dr. Dale Russell known for his careful assessments of the environment of the cretaceous period and events at the cretaceous-triassic boundary and Dr. Reese Barrick, stable isotope specialist and now director of the College of Eastern Utah Prehistoric Museum. Working with her famous mentors, Dr. Rutzky utilized sophisticated stable isotopic approaches in addition to more traditional approaches to examine how plants responded to the atmospheric composition of the Mesozoic Era in an effort to better understand the food quality available to dinosaurs. Her dissertation, entitled "Primary Productivity and Forage Quality of *Ginkgo biloba* in Response to Elevated Carbon Dioxide and Oxygen – An Experimental Approach to Mid-Mesozoic Paleoecology" was based on direct experimental investigations on extant plants manipulating atmospheric conditions to provide evidence that the plant biomass available to dinosaurs could rationally be predicted to be several fold higher than plant production in our current atmosphere. Her work also provided insight into the nutritional strategies of dinosaurs.

The importance of her research has attracted national and international interest. However, Dr. Rutzky is also a skilled teacher and communicator. During her PhD work she was awarded the coveted University Outstanding Teaching Assistant Award in 2003 for her excellence in teaching. Dr. Rutzky was awarded her PhD in Marine Earth and Atmospheric Sciences from NC State University in December of 2006, promptly married in the spring of 2006, and is currently providing inspiration to geology students lucky enough to be enrolled in her geology courses at Wake Tech Community College in North Carolina.

**Crissey Zoological Nutrition Symposium
Schedule of Events and Table of Contents**

Friday, December 7, 2007

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1:45 – 2:00pm	Maria Serrano	The value of nutritional support and status in chelonian rehabilitaiton	15
2:00 – 2:15pm	Sathya Chinnadurai	Gastrointestinal transit time in the Puerto Rican crested toad (<i>Peltophyrne lemur</i>)	17
2:15 – 2:30pm	Emily Christiansen	Body condition scoring and feeding in sea turtle rehabilitation	19
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11:30 – 11:45am	Meredith Johnson	A bug's perspective: How monensin and oil affect microbial ecology	45
11:45am – Noon	Question & Answer Session		
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12:05 – 1:30pm	Lunch		

Session V: Management Issues			
Session Chair: Dr. Suzanne Kennedy-Stoskopf			
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1:30 – 1:45pm	Karen Wolf	Ventricular diverticula formation in captive parakeet auklets (<i>Aethia psittacula</i>) secondary to foreign body ingestion	49
1:45 – 2:15pm	Liz Koutsos	Feed quality and commercial feed manufacturing	51
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3:35 – 3:45pm	Brigid Troan	“Rickets” in passerine birds: A pathologist’s dilemma	57
3:45 – 4:00pm	Blake Morton	Wild western gorilla diet: Composition, seasonality, and nutrition	59
4:00 – 4:15pm	Michael Power	A survey regarding diabetes among callitrichid species	61
4:15 – 4:30pm	Question & Answer Session		
4:15 – 4:30pm	Conference Closing Remarks		

DIAGNOSIS, MANAGEMENT AND POSSIBLE ETIOLOGY OF A TRANSCOLONIC MEMBRANE IN SAVANNAH MONITOR (*VARANUS EXANTHEMATICUS*)

Sathya K. Chinnadurai and Ryan S. De Voe

Common causes of constipation in reptiles are dietary, metabolic, behavioral and neurological in nature. This case report describes impaction with rodent hair and subsequent transcolonic membrane formation in a Savannah monitor (*Varanus exanthematicus*). Medical management with repeated warm soapy water enemas and oral laxatives were unsuccessful. Contrast radiographs and colonic endoscopy showed a full membranous obstruction of the distal colon. Full removal of the membrane was not possible endoscopically and an exploratory celiotomy was performed. The membrane was removed via a colotomy incision. Post-operatively, the animal was managed with ceftazadime, penicillin, and neomycin for antibiotic therapy. The monitor received one supplemental dose of morphine and meloxicam for pain management and lactulose as a laxative. The diet was changed to skinned adult mice once weekly, with pinky mice containing oral medications force-fed daily. Twenty-four days after the celiotomy and surgical deobstipation, the patient was reevaluated and was not passing feces. A second surgery revealed recurrence of the membrane and a dilated atonic proximal colon. The colonic mucosa reacted to the chronic irritation by forming a membrane around the hair bolus, which eventually led to a complete obstruction of the colonic lumen. This case highlights the problems intrinsic in feeding a haired rodent diet to varanid lizards and the role of contrast radiography and endoscopy in diagnosis.

EVALUATING NUTRITIONAL SUPPORT IN CHELONIAN REHABILITATION

Maria E. Serrano, Gregory A. Lewbart, M.S., V.M.D, Dipl. ACZM ,
Michael K. Stoskopf, DVM, PhD, Dipl. ACZM

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Nutritional support plays an essential role in the recovery of sick and injured animals and presumably chelonians. It is common that chelonian patients are or become anorexic during their rehabilitation, and even with the administration of appetite stimulants (examples). The resulting poor plane of nutrition can delay recovery and may complicate proper wound healing. Assisted feeding, either through indwelling esophageal-tube placement or assist-feeding is considered a useful adjunct therapy in these cases.

This retrospective study looks at cases from a North Carolina State University student run reptile rehabilitation program, "Turtle Team" and cases seen at the NCSU Veterinary Teaching Hospital where assisted feeding was used as part of the therapeutic effort. An assessment is made related to the impact of the supplementation on outcome and on how to assess ongoing supplementation.

**GASTROINTESTINAL TRANSIT TIME IN THE PUERTO RICAN CRESTED TOAD
(*PELTOPHRYNE LEMUR*)**

Erika E. Evans, MBA, **Sathya K. Chinnadurai, DVM, MS** and Ryan DeVoe DVM, MSpVM, DACZM, DABVP

Normal gastrointestinal transit time in ectotherms is variable based on species and husbandry conditions. Our goal is to determine normal gastrointestinal transit time and characterize the normal GI radiographic anatomy of the Puerto Rican Crested Toad (*Peltophryne lemur*) using contrast radiography. This information will be useful not only for identifying GI stasis, but also in determining appropriate surgical fasting periods to avoid emesis and aspiration. We further propose to document the effect of opioid analgesics on gastrointestinal transit times. Providing analgesia to a captive amphibian is not without potential side effects. Butorphanol and morphine are commonly used analgesics in herpetological medicine. In domestic mammals, GI stasis is noted as a potential side effect of using these forms of analgesia. After determining normal the gastrointestinal transit time for this species, intramuscular administration of these analgesics will be performed and their effects evaluated with a second set of contrast radiographs. We hypothesize that the use of these analgesics will delay gastric emptying times. The results of this baseline study may serve as a basis for future projects assessing the effect of ambient temperature and diet on GI transit time in Puerto Rican Crested toads and other ectotherms.

BODY CONDITION SCORING AND FEEDING IN SEA TURTLE REHABILITATION

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Feeding practices within sea turtle rehabilitation facilities tend to be based upon very subjective criteria, often relying upon visual perception of the animal's general condition and/or using an arbitrary percentage of the animal's body weight to determine the quantity of foodstuffs offered. Retrospective analysis of these subjective feeding practices at two facilities with long experience rehabilitating stranded sea turtles was used to assess the validity of allometric scaling equations for use in calculating caloric requirements of debilitated sea turtles. Evidence suggests that sea turtles may possess higher metabolic rates and different nutritional needs than other chelonian species as a result of their marine environment and unique natural histories. Several equations have been used to generalize across species and calculate minimal energy requirements; each uses body mass as well as a variable taxonomic constant which may range from 10 to 30 for the reptile order. Assuming that most wild animals will perform some self-regulation of their diet to meet metabolic needs, feeding records for a cohort of over one hundred sea turtles of three species indicate a constant on the higher end of the published range for reptiles, if not even higher, to be most appropriate for these particular species.

In order to effectively utilize the information gained from these equations, it is helpful to have an objective means for assessing the condition of individual animals upon presentation to rehabilitation. One described method for calculating body condition scores in chelonian species is the ratio of body weight to straight carapace length (SCL) cubed. This number is often then multiplied by a factor of 100,000 for ease of interpretation. There remains little published data on normal body condition values for sea turtle species, presumably due to the challenges inherent in obtaining accurate body weights for healthy wild animals in the field. Nor is the tool commonly utilized in the rehabilitation setting; either as a prognostic indicator of survival, or for the purpose of calculating appropriate dietary regimens during rehabilitation. Studies of wild juvenile loggerhead sea turtles off the coast of North Carolina indicate a median body condition score of 14.8 ± 1.5 (Keller et al, 2004).

On admission to one rehabilitation facility on the Gulf coast of Florida, the mean body condition ratio was 13.99 (n=106). In loggerhead sea turtles (*Caretta caretta*) specifically, the mean score is 14.06 (n=72). For Green sea turtles (*Chelonia mydas*), the mean is a slightly lower 12.48 (n=16), and the Kemp's Ridley turtles (*Lepidochelys kempii*) possess the highest mean score at 15.08 (n=18). In the case of loggerhead sea turtles, these body condition scores are lower than published values for wild-caught juvenile animals off the coast of North Carolina, as might be expected from the debilitation contributing to most sea turtle strandings. Within this small sample, these calculations do appear to have some value as a prognostic indicator: among those animals successfully rehabilitated and released, the mean body condition is 14.33 (n=58), and the mean score is nearly one point less, 13.34, for those that died in rehabilitation (n=39).

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Grateful acknowledgment is due to the staff and volunteers of the Mote Marine Laboratory Sea Turtle Rehabilitation Hospital and the Karen Beasley Sea Turtle Rescue and Rehabilitation Center for selflessly sharing their time and dedication to the sea turtles and this project.

Fourth Crissey Zoological Nutrition Symposium

Conundrum I

Nutritional research in aquariums has grown exponentially in the last decade. However, there are many challenges applying methods developed for mammals to aquatic species.

Are digestibility studies feasible for aquatic species such a fish?

If so, how could they be conducted?

AGED TO PERFECTION – FEEDING THE SENIOR HORSE

Shannon E. Pratt, PhD.

Department of Animal Science, North Carolina State University

The number of horses living into their twenties and beyond is rapidly increasing. In fact, the National Animal Health Monitoring Systems study in 1998 found that approximately 7.5 percent of the equine population is older than 20. With age, profound changes occur; both on the outside (graying hairs, loss of topline, decreased muscle mass) and inside (dental issues, arthritis, tumors, endocrine and nutritional changes). From a nutritional standpoint, one of the greatest concerns in our older horses is maintenance of body condition. The use of the Henneke body condition scale can greatly assist horse owners in monitoring their horse's condition. The ideal body condition for an older horse will depend on its overall health, but 4.5 – 6 is likely a good range. In effort to maintain weight and condition, there should be adequate intake of digestible energy. However, the energy requirements for older horses are currently unknown. Research in other species suggests that basic metabolism decreases with age, though digestibility of feedstuffs may also decrease. It is recommended to begin with basic energy requirements (from the NRC, Nutrient Requirements of Horses, 2007), monitor body condition score and adjust the dietary energy intake accordingly. Another concern is the source of dietary energy. It has been shown that diets high in starch and sugar can reduce insulin sensitivity (Pratt et al., 2006), potentially predisposing animals for laminitis. Therefore, diets with more of the calories coming from fat and fiber might be a better option. Research has found decreased digestibility of both protein and phosphorus in older horses compared to younger horses (Ralston et al, 1989). Thus, senior diets should have higher amounts of these nutrients. Research has also suggested that vitamin C status is affected by age (Ralston et al., 1988) so supplemental vitamin C into senior diets is likely warranted. Most commercially available senior diets are formulated accordingly for the changing digestive system and nutritional needs of older horses. Conditions such as kidney or liver disease will require specialized diets. In general, providing good quality forage with concentrate formulated for senior horses should meet the needs of our aging equine population. Soaking feeds (both hay and concentrate) can assist those with dental problems and supplementing with vegetable oil can contribute to increased calorie needs to maintain body weight.

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ASSESSING BODY CONDITION IN RHINOS

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Introduction: Anecdotal evidence suggests that rhinos in captivity are overweight compared to their wild counterparts. Excess weight in captive zoo animals can result in adverse health effects (i.e. inflammatory-mediated diseases) and interfere with captive breeding efforts (Leigh, 1994; Videan, 2007). Regular use of quantitative tools, such as body weight and visual body condition scores, can also provide insight on long-term changes on individual and herd health (Stephenson, et al, 2002). As part of a larger study, rhino health status will be measured using the following parameters: weight, morphometric measurements, A-mode ultrasound of muscle and fat thickness, quantitative body condition, and serum markers.

Methods: Historical zoo records will be charted for each rhino and the herd as a whole. In addition we will ask each zoo to monitor their animals on a monthly basis for the next two years. At the beginning and end of the study morphometric measurements: height, length, girth behind front leg and after last rib will be measured. Body condition will be scored monthly, using a 1-5 ordinal system, based on the method of Reuter et al. and the Ezemvelo KwaZulu-Natal Wildlife ranger training system (Reuter, 1998). In addition, A-mode ultrasound of several sites on the rhino (i.e. flank, shoulder, and tail head) will be measured with the PregAlert Pro handheld ultrasound (Renco Corporation, Minneapolis, MN). Serum will be collected to measure glucose, triglycerides, and other endocrine markers of body condition (i.e. leptin, insulin growth factor I).

Existing data on wild white rhino weight and lengths will be compared to the captive population (Rivera, Citino and Bush, unpublished). Similar data will be gathered during black rhino captures in 2008 in South Africa. Body condition scores and ultrasound will also be assessed on wild animals for comparison.

Discussion: We will discuss several examples of how long-term monitoring is useful. Examples of chute designs with walk-through scales will be shown. In pasture situations, weight monitoring will highlight if any rhinos are not getting their share of supplemental food. Decline in pasture and seasonal changes also affect weight. Other factors affecting weight in a group situation would be a change in social status, or introduction of new animals.

Ultrasonographic assessment of muscle depth and fat stores in captive and wild rhinos will give us better understanding of what is optimal health for these animals. Wild rhinos live in environments that can change drastically between seasons and years. How weight cycling impacts positively or negatively on their health and reproductive potential is unknown.

This study will provide insight on what the best weight and body condition ranges are in wild and captive rhinos to optimize reproductive success. Data from wild rhinos will be compared to captive rhinos in order to validate the idea that rhinos are overweight in captivity. If this is the case, future studies will address how to improve diet composition and husbandry practices to manage our captive populations for optimal body condition.

Acknowledgements: *Our sincere thanks to the zoos and individuals participating in this study: particularly Busch Gardens, Hamilton Zoo, Western Plains Zoo and White Oak Conservation Center. Thanks to Ezemvelo KwaZulu-Natal Wildlife, in particular Sue van Rensburg, Lulama Falayo and Craig Reid for facilitating our studies there. The authors would like to gratefully acknowledge the International Rhino Foundation for support of this project. In addition, Ms. Berkeley is supported by a PhD Scholarship from Victoria University of Wellington.

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“PICA” IN AMPHIBIANS AND REPTILES

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Introduction:

Wild and captive amphibians and reptiles are known to ingest non-food items, and in some cases, this activity can cause morbidity and even mortality. While this phenomenon may be referred to as “pica,” it is probably more accurately described as the inadvertent or unintentional consumption of non-food items. Several definitions of pica, with references, are included below:

Definitions:

1. Pica is an appetite for non-nutritive substances (e.g., coal, soil, chalk, paper etc.) or an abnormal appetite for some things that may be considered foods, such as food ingredients (e.g., flour, raw potato, starch).[1]¹
2. A depraved or perverted appetite; a hunger for substances not fit for food.²
3. Craving for unnatural articles of food; a depraved appetite. Expressed in animals by licking or eating foreign materials. Often caused by a nutritional deficiency of bulk, fiber, or a specific nutrient, e.g. phosphorus, salt or copper. May lead to botulism, foreign body lodgement in mouth, pharynx, esophagus, in the reticulum to cause reticuloperitonitis, at the pylorus and, in the horse, in the small colon. Called also allotriophagia.³

Clinical Cases:

The literature contains a number of reptile pica (unnatural food item ingestion) cases.⁴⁻⁸ Most of these describe unintentional ingestion of foreign bodies by snakes. Despite the claim that reptiles, such as tortoises, will display lithophagy (ingestion of rocks or stones) to satisfy a nutritional need or deficiency, the clinician should be most concerned about possible clinical complications from this practice.⁹ Inadvertent ingestion of stones and other materials along with food items can prove fatal in both amphibians and reptiles.

Several amphibian and reptile cases of non-food item ingestion, including medical and surgical intervention when appropriate, will be reviewed and discussed. Interested students and clinicians can find details of clinical treatment and prevention of pica in amphibians and reptiles by reviewing some of the references listed subsequently.

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Mark your calendar!

December 12 & 13, 2008

**Fifth Crissey Zoological
Nutrition Symposium**

NC State College of Veterinary Medicine

Raleigh, NC

Fourth Crissey Zoological Nutrition Symposium

Conundrum II

How can we plan to balance economics and health in terms of nutrition and feeding in the zoo environment?

Recent research has shown that increasing the natural browse and forage levels in exotic animal diets (the giraffe and the rhino for example) may increase their captive welfare. However, the costs to supply these browses and high quality forages can be extreme for the zoological institutions housing the animals.

The costs can be so extreme that decisions may have to be made to

- 1). Knowingly feed the captive animal a diet that is not optimal,
- 2). House fewer of these species in to afford their proper diet, or
- 3). House alternative species that consume less expensive browses.

The question: How can we plan to balance zoo economics with the rising costs of browse and forages (especially in the current drought market in the Southern USA)?

HOW THE COMPOSITION OF MILK OF ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*) DOES AND DOES NOT VARY DURING THE FIRST YEAR OF LACTATION

Nicole Abbondanza¹ MS, Michael L. Power^{2,3,*} PhD, Melissa Carden⁴ PhD, Janine Brown¹ PhD, and Olav T. Oftedal² PhD

¹Department of Reproductive Sciences, Smithsonian Conservation and Research Center, Front Royal, VA; ²Nutrition Laboratory, Smithsonian National Zoological Park, Washington DC; ³ Research Department, American College of Obstetricians and Gynecologists, Washington DC and ⁴Dickerson Park Zoo, Springfield, MO.

Lactation strategies of mammals have evolved as an efficient means to transport nutrients and immune substances from mother to young. All mammals lactate, however, the diversity of the mammalian radiation is reflected in the diversity of evolved lactation strategies. Although the principal constituents of milk (lipids, proteins, carbohydrates, minerals, vitamins, and water) are similar across species the actual amounts vary considerably; the variation is associated with phylogeny and lactation strategy. We present data on the composition of Asian elephant milk over the first year of lactation

Materials and Methods

Samples were collected from three Asian elephants over four lactation periods between 1996 and 2001. Sample collections started with two Asian elephants during the later stages of lactation. Collections for the remaining two lactations were initiated immediately around the time of birth, and continued throughout the first year.

Dry matter, fat, crude protein, sugar, calcium and phosphorus were assayed at the Nutrition Laboratory of the National Zoological Park using standard.

Results

Strong positive correlations were shown between the age of calf / day of lactation and the following variables: fat, crude protein, calcium, phosphorus, and gross energy. Sugar was negatively correlated with calf age / day of lactation. Gross energy of the milk increased with calf age during the first year of lactation. Phosphorus and calcium concentration also significantly increased with calf age, basically in parallel (Figure 1).

Consistent with the increase in milk GE over lactation, the percentage of GE from the lipid fraction of milk increased over the first year and the percentage of GE from the sugar fraction decreased. Interestingly, the percentage of GE from the protein fraction of milk was remarkably constant. If expressed as grams per kcal of milk, over the first year milk fat increased on average from .065 g/kcal to .075 g/kcal, milk sugar decreased from .055 g/kcal to .033 g/kcal, but milk protein was constant at .032 g/kcal (Figure 2).

Discussion

Nutrient composition in elephant milk changes significantly throughout the first year of lactation. Gross energy of milk increases with calf age due to an increase in milk fat. Milk protein increases as well, but milk sugar decreases with calf age. When the constituents are expressed per Kcal of milk the patterns remain the same for fat and sugar, however, interestingly the grams of protein in 1 Kcal of milk appear to remain constant.

Figure 1. The concentrations of milk calcium and phosphorus increase in parallel over the first year of lactation.

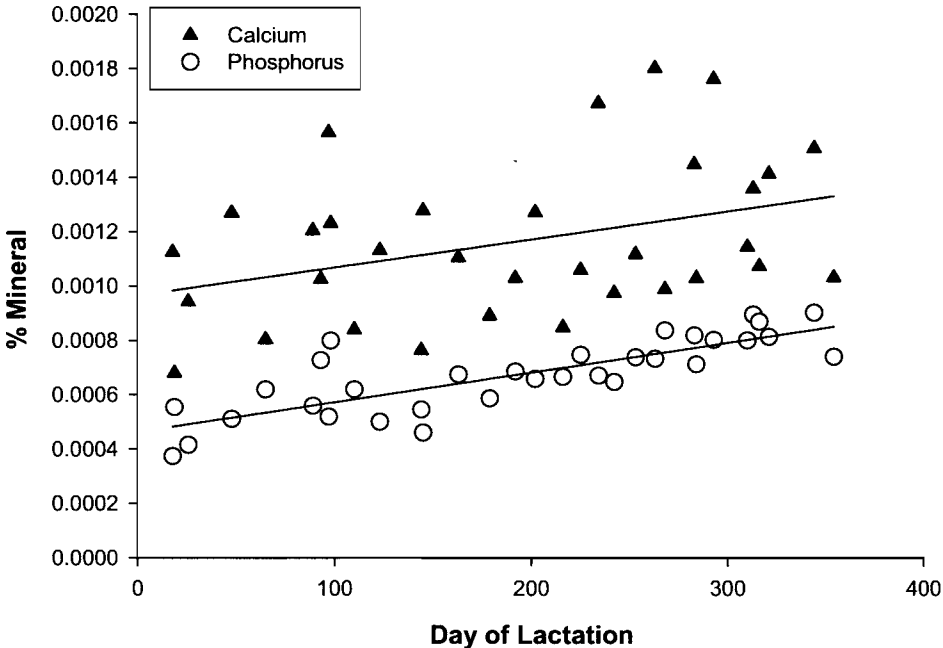


Figure 2. The grams of fat per kcal of milk increases and the grams of sugar per kcal decreases over the first year of lactation. The grams of protein per kcal of milk remains remarkably constant.

THE EFFECT OF ELEVATED NUTRITION ON BIRTH SEX RATIOS IN CAPTIVE RHINOS

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Introduction: Male-biased birth sex ratios have been observed for many years in the captive rhino population (Atkinson, 1997). Recent advances in other species, notably mice, domestic cattle and feral horses, led to the theory that sex selection around the time of conception is mediated by glucose (Cameron, 2004, Cameron and Linklater, 2007). As glucose increases due to stress have been hypothesized to affect birth sex ratios in translocated rhinos, it seems reasonable that elevated glucose due to diet could also increase male births (Linklater, 2007). There is additional evidence that there are seasonal effects on birth sex ratios in black rhinos (Hrabar and duToit, 2005, Berkeley and Linklater, unpublished). The purpose of the current study is to test whether glucose, through diet, influences birth sex in captive rhinos.

The Trivers-Willard hypothesis states that a female will adjust the sex of their offspring in response to environmental conditions in order to produce the sex that has the greatest potential to reproduce (Trivers and Willard, 1973). This phenomenon has been observed reliably and frequently across taxa for at least 50 years. What has been lacking is an understanding of the mechanism regulating birth sex ratio. Two main theories exist, one pre-conception, one post-conception. The pre-conception theory centers around the idea that steroid hormones (i.e. testosterone) in the developing follicle predispose the maturing egg towards one sex or the other (James, 2004). The post-conception theory proposes that glucose concentrations in the uterus during the time of early embryonic development (pre-blastocyst stage) differentially effect male and female embryo metabolism with high glucose levels resulting in more male offspring (Gutierrez-Adan, et al. 2006). We can address these conflicting theories by careful experiment design and selection of appropriate serum markers.

Methods: We will reduce diets in several rhinos in order to approximate a 1% weight loss over a one month period during and after breeding. Fasting glucose tests will be performed at the beginning and the end of the diet trials. We will measure the following parameters: weight, morphometric measurements, A-mode ultrasound of muscle and body fat, quantitative body condition, and serum markers.

Discussion: While it may be an oversimplification to state that glucose governs birth sex ratios, there is enough evidence both in rhinos and other species to believe that diet plays a significant role. By optimizing captive diets and husbandry practices, we may shift birth sex ratios towards parity or even a female bias.

Acknowledgements: Our sincere thanks to the zoos and individuals participating in this study: particularly Busch Gardens, Hamilton Zoo, Western Plains Zoo and White Oak Conservation Center. Thanks to Ezemvelo KwaZulu-Natal Wildlife, in particular Sue van Rensburg, Lulama Falayo and Craig Reid for facilitating our studies there. The authors would like to gratefully acknowledge the International Rhino Foundation for support of this project. In addition, Ms. Berkeley is supported by a PhD Scholarship from Victoria University of Wellington.

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FECAL CORTISOL IN TWO NEW WORLD PRIMATE SPECIES SUPPLEMENTED WITH INULIN-TYPE FRUCTANS

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Dietary inulin-type fructans (ITF) are fermented in the gastro-intestinal tract (GIT) and thus may alter GIT microbial activity and increase immune function. ITF have been added to diets for humans, domesticated livestock, companion animals, and recently also to exotic animals (Verdonk et al., 2005). Effects of ITF reported in the published literature are not been consistent but ITF supplementation could be pertinent to the survival of captive woolly monkeys (*Lagothrix spp.*) specifically by their potential to alleviate diabetes, hypertension, and observed stress while increasing reproductive and immune functions. Woolly monkey health problems associated with hypertension and diabetic type disorders probably reduce their survival in captivity while their close relative, the spider monkey, has fewer problems (Ange-van Heugten et al., 2008; Ange-van Heugten, in review). The current research studied the effect of ITF added to the daily diets consumed by spider (*Ateles fusciceps robustus*; $n = 9$) and woolly monkeys ($n = 7$). It is hypothesized that high cortisol levels are unfavorable to health. If ITF can prevent or reverse high fecal cortisol concentrations, then these concentrations could be used as a non-invasive assessment tool to track positive health changes. In addition, comparing the impact of ITF on fecal cortisol concentrations between woolly and spider monkey species could elucidate important species specific differences to help determine why woolly monkeys are less successful in captivity.

A three day spider and woolly monkey diet disappearance study was conducted and indicated that, in general, the diets met nutrient recommendations. However, vitamin A concentrations, which included β -carotene, were 10 to 30 times above recommendations (NRC, 2003). Monkeys were given ITF supplements (containing 90 to 94% inulin), individually, at 5 g per day for four weeks. ITF was well tolerated by the spider and woolly monkey species. Fecal samples were collected prior to ITF supplementation and after two and four weeks of supplementation. Fecal cortisol concentrations were not significantly affected by the addition of ITF, however, fecal cortisol was numerically decreased after the 4 week ITF supplementation, primarily in spider monkeys (110 versus 65 ng/g dry feces) (Table 1). These results suggest that ITF supplementation may have the potential for decreasing fecal cortisol concentrations. Thus, additional research with larger populations of monkeys using higher doses of ITF is recommended to determine if this dietary additive can illicit positive effects on captive primate well-being.

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Table I. Fecal cortisol in spider and woolly monkeys supplemented with inulin-type fructans

Fecal cortisol, ng/g [‡]	Period (wk)			Overall
	0	2	4	
Spider monkeys	110 ± 24.0 (n=15)	103 ± 26.3 (n=12)	65 ± 28.5 (n=9)	93 ± 16.3(n=36)
Woolly monkeys	65 ± 19.0 (n=21)	88 ± 28.0 (n=10)	80 ± 19.0 (n=20)	78 ± 13.3 (n=51)
Overall	88 ± 15.8 (n=36)	95 ± 19.8 (n=22)	73 ± 17.3 (n=29)	

[†]n = number of fecal samples analyzed in each category.

[‡]Cortisol represented as concentration present in dry feces.

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Conundrum III

We often use a species' natural diet to aid in formulating captive diets. For mammals, the first natural diet is mother's milk. For many species milk composition is relatively constant while for others it varies both over lactation and among births. Some milk constituents can be fairly constant and others can be quite variable. Maternal diet and body condition can affect milk composition; possibly even the sex of the infant has affects in some species.

How can zoo nutritionists use data on milk composition to improve captive feeding management?

THROUGH THE FISTULA: A MICROBIOLOGIST'S PERSPECTIVE ON ANIMAL NUTRITION

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The microorganisms that inhabit the gastro intestinal tracts of macroscopic organisms have been shown to be vital for the overall health of the host. These microbial communities are responsible for breaking down ingested food that the host is incapable of digesting on its own, providing supplemental nutrients that the host can not supply itself, and helping to prevent pathogens from colonizing the GI tract.

There are a number of techniques and technologies available to examine these complex communities. These methods rely either on cultivation-based methods, molecular techniques, or a combination of the two. Cultivation-based methods provide information on the microbial community, not only phylogenetic information, but also metabolic information. Due to the limitations of cultivation based methods only a small percentage of the total microbial community is identified using this approach.

Molecular based approaches do not rely on the researcher's ability to culture the microorganisms. To identify these microorganisms, 16S rDNA sequence analysis is used. 16S rDNA encodes a 16S rRNA which is used as both a structural backbone and has catalytic sites for the small subunit of the bacterial ribosome. The 16S rDNA gene makes an excellent target for molecular identification since 16S rRNA is found in all prokaryotic life and its function is to some extent dictated by its sequence, catalytic sites can not change drastically because a drastic sequence change could cause a loss of function. The conserved sites allow for primers to be used to amplify a wide selection of microorganisms from the community. Traditionally these PCR products are ligated into plasmids and transformed into competent bacteria which are plated out. Individual colonies are then isolated for, the plasmid isolation, and the 16S sequence amplified and identified. While this method has provided an abundance of phylogenetic information on complex microbial communities, it does have limitations. Since sequencing is time and cost intensive, normally only a small percentage of the total number of potential 16S rDNA genes are sequenced and identified. Other methods exist that utilize 16S rDNA but do not use the downstream sequencing steps.

One of these methods, Terminal Restriction Fragment Length Polymorphism (TRFLP), is a 16S rDNA-based, sequencing independent method that can provide a rapid community profile. This method utilizes tagged PCR products that are then subsequently digested with restriction enzymes. The digested products are run out on a gel to identify the tagged fragments. These fragments are then matched to patterns in a software database and microorganisms are identified. This method allows for a cost effective and rapid profiling of complex communities.

Using this high throughput molecular method, these complex communities of microorganisms can be elucidated and this might shed light on how the community shifts in response to diet change, stress or disease. Understanding of these populations and how they shift in response to different conditions might lead to more effective treatment strategies for treating unhealthy animals.

THE EFFECTS OF AN *IN VITRO* MODEL OF COLD STRESS SYNDROME ON THE FLORIDA MANATEE, *TRICHECHUS MANATUS LATOROSTRIS*, GASTROINTESTINAL MICROBIAL FERMENTATION

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Cold stress syndrome is a cascade of events that predisposes manatees to opportunistic pathogens involving multiple organ systems. The authors' hypothesizes that the lack of feed and thus gut microbe alterations, are the primary factors involved in the pathogenesis of cold stress syndrome. Without normal gut flora, the necessary nutrients and heat production are not provided and thus the animal may succumb to disease and death. An experimental model was developed to study the possible effects of cold stress syndrome on the gut microflora and long term survivability of the Florida manatee. Incubation of manatee microbial cultures based on *in vitro* fermentation techniques used for rumen contents proved successful. Overall sea grass incubated with manatee cultures produced significantly higher concentration of total SCFA, lower concentrations of methane and resulted in a lower pH than rumen fluid fed the same substrate. Furthermore, manatee cultures resulted in a higher concentration of acetate when compared to rumen microbes fed the same substrate. Higher acetate and lower methane fermentation pattern suggests that manatee microflora were more efficient in reducing the potential loss of carbon energy in the form of methane. Delaying feeding resulted in significant reductions in overall fermentation. Microbial cessation was not seen. The effect of starvation on microbial growth may be more pronounced at intervals greater than 24 or 48 h. Further manatee microbial fermentation work is needed to provide better conservation and health protocols for captive and rehabilitating manatees.

A BUG'S PERSPECTIVE: HOW MONENSIN AND OIL AFFECT MICROBIAL ECOLOGY

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Cows in peak lactation are fed supplemental fat and ionophores to help meet their tremendous metabolic requirements. Individually, these additives increase feed efficiency by improving the fermentation profile, as they decrease the acetate:propionate ratio and reduce methane production (Jenkins, 1993, Russell and Strobel, 1989). Because of their ability to alter the fermentation profile of the rumen, oil and ionophores, such as monensin, likely have effects on the microbial population (Jenkins, et al., 2003, Sauer, et al., 1998, Van Nevel and Demeyer, 1995). However, their mode of action is not similar. Monensin, an ionophore, exerts its influence by disrupting the ionic balance across the cell membranes. Oil has a coating effect and restricts microbial attachment or access to fiber. Oil can also have a direct toxic effect on microbes and the magnitude varies with degree of saturation. The objectives of this study were 1) to determine the effects of antibiotics and oil on rumen fermentation and 2) to monitor the effect of the additives on rumen microbial populations. It was hypothesized that although the changes in fermentation by monensin and oil are similar, they have different effects on the microbial population of the rumen due to their different modes of action.

Mixed cultures of rumen microbes were incubated in three artificial fermentors for 10d. One fermentor served as a control (C) and received alfalfa hay, while one received monensin (M) and the other received oil (O). Each run was replicated three times (n=3). Fermentation variables measured were volatile fatty acids (VFA), total cell number, methane production, culture pH, ammonia (NH₃), and digestibility. Additional samples were taken to analyze the microbial population using terminal restriction fragment length polymorphisms (T-RFLP). There were no significant changes in the fermentation parameters in C over time. As expected, both M and O reduced acetate (p<0.01), increased propionate (p<0.05), and decreased methane production (p<0.05). Based on T-RFLP analysis, microbial adaptations in the C fermentor to *in vitro* conditions occurred within 4 days. Although both M and O had similar effects on fermentation, the T-RFLP data showed there were differences in microbial diversity and in divisions at the class level between the two additives. This suggests that the effect of additives is due to their impact on different microbes. It seems clear that feed additives improve animal performance by altering fermentation efficiency, but understanding the mechanism of their action requires molecular techniques to identify specific microorganisms. Our approach indicates that different microbes were affected by the two additives to achieve similar results on fermentation. Our data also suggests the existence of several microorganisms in the rumen that have not been previously identified. Because these organisms make up such a large percentage of the data, it is possible that they play a much more important role in the rumen than previously thought.

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Conundrum IV

A question of silage.

Browse silage is of interest to many zoo nutritionists. However, is it feasible as a food stuff for use in zoological settings?

What issues are there with the source of silage and the control of quality?

Is silage palatable to zoological species?

How well will silage deliver the necessary nutrition to zoological species?

VENTRICULAR DIVERTICULA FORMATION IN CAPTIVE PARAKEET AUKLETS (*AETHIA PSITTACULA*) SECONDARY TO FOREIGN BODY INGESTION

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In January 2006, a 7.5 yr old female parakeet auklet was evaluated for weight loss, lethargy and slight dyspnea. An enlarged, stone-filled ventriculus was observed on survey radiographs. A ventriculotomy was performed and stones (n=76 stones, 2-8 mm diameter) were removed. The bird died following surgery and necropsy revealed a ventricular diverticulum extending dorso-laterally from the greater curvature of the ventriculus. The left caudal liver and sections of the surrounding small intestines were adhered to the diverticulum. The diverticular wall was composed of mature granulation tissue with minimal inflammation and the lumen was lined with necrotic cells and debris. It was hypothesized that the diverticulum gradually developed from weakening of the ventricular wall due to contractions of the stone-filled ventriculus.

Following the death of the first bird, a flock investigation was undertaken to determine if additional birds had evidence of ventricular stones. Because the parakeet auklet had been loaned to the NC Zoo from another facility 3 yrs. previously, along with 7 other auklets, all of the remaining birds on loan were evaluated. Six of the 7 birds had radiographic evidence of ventricular stones (numbers ranging from 2 to ~25). In order to determine if other birds had ventricular changes secondary to stone ingestion, contrast fluoroscopy was performed on these auklets along with 2 apparently normal NC Zoo birds. None of the birds were definitively diagnosed with a ventricular diverticulum, although 3 birds with > 12 stones had enlarged ventriculi. Over time, 2 birds with >12 stones developed clinical signs similar to the first bird. These birds also underwent ventriculotomies with resolution of clinical signs following surgery. One of these birds also had a ventricular diverticulum diagnosed intraoperatively.

Routine ingestion of stones has not been reported in wild parakeet auklets. The natural diet consists of copepods, amphipods, krill, jellyfish, and fish. The captive birds' diet consists of krill, squid, a variety of fishes and daily vitamin supplementation (thiamine and vitamin E). Only incidental stones are available within the alcid habitat at the NC Zoo. However, the birds on loan were previously housed on loose pea-gravel substrate. Animals will consume non-food items for a variety of reasons including nutritional deficiencies, to assist in mechanical breakdown of food, and secondary to other factors including undetermined or speculative causes, i.e., as ballast in diving birds. Eating inappropriate items may also be a result of stress, anxiety, or boredom. The cause for the ingestion of the stone foreign bodies in these parakeet auklets remains undetermined.

FEED MANUFACTURING AND QUALITY CONTROL

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Formulating and manufacturing diets for animals requires an understanding of their nutritional requirements, as well as the types of ingredients that are available and suitable for incorporating into diets. In addition, and just as critical, is the management of feed manufacturing such that a quality feed is produced. A good quality assurance program involves collaboration between the manufacturer and state and federal government agencies. Federal and state governments are responsible for administration of feed laws, in order to protect the consumer and the manufacturer. A variety of agencies are involved in these processes, including the Food and Drug Administration (FDA), State Departments of Agriculture, and the Association of American Feed Control Officials (AAFCO)¹. The FDA regulates animal feed under the Food, Drug and Cosmetic Act, State Departments of Agriculture regulate the manufacture and distribution of commercial feed within their state, and AAFCO's purpose is to create clarity and uniformity among state and federal feed control rules and regulations. Together, these agencies work to regulate animal feed products, via policies such as the establishment of uniform feed ingredient definitions and proper labeling to assure the safe use of feeds. FDA and the state regulatory authorities have inspection authority in manufacturing facilities and may conduct routine inspections for surveillance as well as "for cause" inspections. Inspectors may sample products for nutritional guarantee compliance as well as feed contaminants.

Feed manufacturers will have compliance with state and federal guidelines, and often have additional measures to ensure quality control. For example, the International Organization for Standardization provides guidelines for certification of ISO 9001:2000² quality management systems, which supports the development, maintenance, and testing of all manufacturing practices according to a standard set of parameters. Certification (by an outside accrediting agency) as ISO 9001:2000 ensures that these parameters are implemented, and that quality is a driving force in all aspects of manufacturing. When applied to the feed manufacturing industry, this certification ensures that feed manufacturing, from development of the product to routine manufacturing, is closely monitored, and that the efficacy and safety of the production methods and final product are also evaluated.

The use of medication in animal feeds is also a critical issue for quality control, and is regulated by the federal government. The Minor Use and Minor Species Animal Health Act of 2004³ legislation governs the ability to provide medication for minor uses and minor species (defined as all animals except humans, cattle, horses, swine, chickens, turkeys, dogs and cats). At this time, there are a very limited number of approved drugs for exotic animals⁴. The Animal Medicinal Drug Use Clarification Act of 1994⁴ provides for use of a drug in a manner that is not in accordance with the approved labeling, in order to treat an animal when the "health of the animal is threatened or suffering or death may result from failure to treat." Thus, a veterinarian (required component for this use) is permitted to use approved human and animal drugs in an extra-label manner. However, the extra-label use of animal drugs in feeds is explicitly prohibited. FDA has issued a Compliance Policy Guide (615.115)⁵ for Extra-Label Use of Medicated Feeds For Minor Species, although there are conditions that must be satisfied in order to use: 1) Veterinarian involvement; 2) Treatment only use; 3) No production use; and, 4) No feed reformulation or re-labeling. Feed must be manufactured and labeled as approved for use in a major species. Again, this results in an inability to produce medicated diets for exotic animals. Further, the risk of cross-contamination of other feeds with drugs that may be toxic or harmful to species for which the drug is not intended provides further impetus for cautious use of medications in the feed manufacturing facility.

In summary, manufacturing quality feed is a complicated process governed by federal and state regulations, and driven by internal and external quality assurance processes. A quality product can only be achieved if recognized and assessable standards for quality manufacturing are implemented, routinely evaluated, and regularly improved.

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Conundrum V

Evaluating the nutritional status of animals is challenging at best and even more difficult when it is not possible to sample invasively (blood samples etc). This conundrum is to discuss ways to assess nutritional status without invasive sampling.

Consider how you would assess nutritional condition of an animal that can be captured but not bled or otherwise invasively sampled.

Then consider how you would do it if the animal could not be captured.

REPORT OF A POTENTIALLY VITAMIN RESPONSIVE NEUROPATHY IN A JUVENILE GRIZZLY BEAR

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A nineteen month old male grizzly bear was presented by telemedicine for abnormal gait and rear limb weakness. The bear was recently acquired by the current owner from a roadside display situation and the condition was evident to the owners when they acquired the bear approximately 10 days earlier. Prior husbandry practices were not known, however, the bear was a sibling of another bear owned by the current owner. The sibling was not displaying the same condition. The diet provided to both bears by the current owner was based in large part on mixed fruits supplemented with Mazuri Omnivore A 5635. Videos of the affected bear's gait suggested posterior limb weakness, ataxia with the possibility of a mild proprioceptive deficit. This impression was supported by observations of the local attending veterinarians who examined the bear in person. The bear was bright, alert, and reported to be eating well, though underweight. There was no known history of trauma or exposure to toxic substances, though the early history of the bear was not available. A suspicion of *Taenia* infection was arrived at from owner descriptions of the stool containing small rice like objects.

A conservative approach to management was initiated based and diet changes were recommended. This consisted of increasing the proportion of Mazuri Omnivore A 5635 in the diet and reducing the fruit to approximately 1/4 of the daily diet. Diagnosis of the possible tapeworm infection by stool examination was recommended. The bear accepted the diet change readily and began its condition score began to improve rapidly, however, in coincidence with a sudden change to wet cooler weather one week after the diet change, the bear seemed unable to rise in the rear early one morning. This situation resolved itself within an hour, but the decision was made to investigate the condition through a neurologic examination and imaging of the spine and rear limbs.

On arrival at the CVM, the bear was bright and alert, inquisitive, and actively mobile though showing the stiff legged swaying gait seen in the original videos. The bear's condition index was already improving on the diet being provided and he was actively curious about his environment and well coordinated in investigating his surroundings. A neurologic examination of the awake bear was conducted which confirmed apparently normal cranial nerves, paraparesis and ataxia when walking with delayed proprioception in both hindlimbs but with strong patellar reflexes. He did not withdraw his hindlimbs properly and exhibited no panniculus reflex but care was being taken to not over stimulate him during the examination which could have accounted for the lack of response. His clinical signs were localized to T3-L3 spinal cord by the neurological examination.

He was anesthetized with an induction of medetomidine and telazol delivered by pole syringe and then intubated and maintained on isoflurane for conduct of an MRI scan of his thoracic and lumbar spine. His actual weight at the time was 133 kg. The MRI showed no evidence of spinal cord compression or inflammation suggesting, along with the long duration of signs that meningitis was extremely unlikely. Efforts to obtain a sample of CSF from a lumbar tap were unsuccessful.

The bear was recovered with administration of atapamizole and returned home with recommendations for preventative health care including vaccinations and treatment of the *Taenia* infection with praziquantel. The signs the bear displayed were reminiscent of signs described in swine maintained on pyridoxine deficient diets¹ during the early research investigating the role of pyridoxine. Pyridoxine deficiency has been implicated in peripheral neuropathies, as paradoxically, has pyridoxine oversupplementation.² The bear was placed on 400 mg supplemental pyridoxine in food once a day and evaluated for improvement at two week intervals through telemedicine videos. Marked though incomplete improvement was noted at two weeks. At 4 weeks improvement continued but was less easily discernable. This was compatible with responses seen in an earlier case of pyridoxine responsive neuropathy in a human where response was primarily seen after a week of supplementation. At 6 weeks a removal trial was conducted for 5 days which was felt to be long enough to see a recrudescence of signs if the pyridoxine was responsible for the improvement. The results of that trial, video of the bear's condition, and plans for further management of the case will be presented.

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“RICKETS” IN PASSERINE BIRDS: A PATHOLOGIST’S DILEMMA

Dr. Brigid V. Troan

Rickets is a bone disease of young animals in which there is failure of the normal, orderly mineralization of cartilage and osteoid during the growth due to nutritional imbalances / deficiencies in vitamin D, calcium and phosphorus. In birds, this disease typically presents as swelling of the hocks, angular limb deformities, fractures, thickening of the metaphyseal growth plates or a more general “failure to thrive.” Theoretically, the histologic pattern of lesions within the rachitic growth plate (and parathyroids) can be used to differentiate between diets too high in calcium / too low in phosphorous from diets deficient in vitamin D or calcium. However, these distinctions are based on controlled experimental modification of diets within commercial flocks and in practice these lesions can be difficult to distinguish in situations where the ratios, timing and duration of the available diets are constantly changing. Furthermore, when evaluating passerine chicks for rickets, there is no published data on “normal” bone development and tissues for comparison with known non-affected chicks within the same species may not be available. Clearly affected animals are easily diagnosed, but borderline cases are often confusing and other differentials such as inappropriate flooring, other nutritional problems such as vitamin A toxicity, genetics or concurrent diseases including mycotoxicosis, and enteritis have to be considered. Ideally, a full evaluation for rickets would include full necropsy of the bird, serum and feed analysis. Using several cases of rickets in the red-billed leiothrix (*Leiothrix lutea*) as examples, I will go through the diagnosis and touch on the management of this complicated disease in a passerine species.

WILD WESTERN GORILLA DIET: COMPOSITION, SEASONALITY, AND NUTRITION

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Western gorillas (*Gorilla gorilla*) represent the majority of the extant *Gorilla* genus, yet knowledge of their socioecology in the wild has remained elusive. Although traditionally assumed to be purely herbaceous foragers, it is now clear they have a much more heterogeneous diet that includes many arboreal fruits and insects. Western gorilla diet is highly selective and is regulated by seasonal patterns within their environment. However, due to the difficulty of habituating these primates, previous studies inferred gorilla diet through trail signs and fecal analyses which have notable biases. This presentation discusses research collected via direct observation from a recently habituated gorilla group in southwestern Central African Republic. Specific aims are to combine this information with previously published data to highlight key features of western gorilla foraging and nutrition.

A SURVEY REGARDING DIABETES AMONG CALLITRICHID SPECIES

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Anecdotal evidence indicates that the prevalence of poor glucose regulation among certain callitrichid species (e.g. lion tamarins and Geoffroy's marmoset) held in zoological collections has increased. The common marmoset is currently being evaluated as a biomedical model for dietary induced obesity and diabetes. In humans, poor glucose control is associated with age and obesity, and this appears to be true for common marmosets as well. Obesity is a common problem among captive animals; callitrichids are no exception. Zoos also have growing geriatric populations of many callitrichid species. Poor glucose control eventually leads to significant morbidity, reducing quality of life and increasing the risk of premature death.

Surveys were sent by email to individuals at zoos and other institutions housing callitrichids as identified by studbook keepers for five callitrichid species (Golden lion tamarins, Cotton-top tamarins, Geoffroy's marmoset, Pygmy marmoset, and Goeldi's monkey). A total of 61 institutions housing a total of over 1,000 individual callitrichids returned completed surveys. In general, the respondents considered the problem of diabetes among captive callitrichids to be of moderately serious, and had only a moderate concern about the prevalence of diabetes within their own collection (Table 1).

In general, respondents answered that methods to diagnose and treat diabetes in callitrichids were moderately effective, though significant numbers of respondents had no opinion. Methods to diagnose diabetes were rated slightly higher than methods to treat diabetes (Table 1). Just under half of the respondents (44.3%) said their institution had a protocol for screening for diabetes; 80.3% indicated their institution had a protocol to monitor body weight. The most common frequency for obtaining weights was monthly (24.6%).

This survey is a first step toward investigating the extent of concern regarding diabetes in captive callitrichids among zoos and research institutions that house them. The purpose of the survey is to begin to document: level of concern with diabetes as a health issue in these taxa; variation in susceptibility to diabetes among callitrichid taxa; general dietary management of callitrichids among institutions; and preventive and treatment protocols among institutions. The data from this survey project will be used to evaluate: the extent of diabetes/poor glucose control among captive callitrichids; which taxa appear most vulnerable; and whether there are any animal husbandry and dietary management issues that might need to be addressed.

Table 1. Concern about diabetes prevalence in captive callitrichids.

	Not very serious	Moderately serious	Serious	Very serious	No opinion
How serious a problem is diabetes in captive callitrichids?	23.0%	44.3%	9.8%	0%	22.9%
	Not concerned	Moderately concerned	Concerned	Very concerned	No opinion
How concerned are you about diabetes among callitrichids in your collection?	39.3%	39.3%	11.5%	3.3%	6.6%
	Not effective	Moderately effective	Effective	Very effective	No opinion
How would you rate current methods for diagnosing diabetes?	3.3%	42.6%	27.9%	1.6%	24.6%
	Not effective	Moderately effective	Effective	Very effective	No opinion
How would you rate current methods for treating diabetes?	9.8%	42.6%	13.1%	0%	34.4%



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