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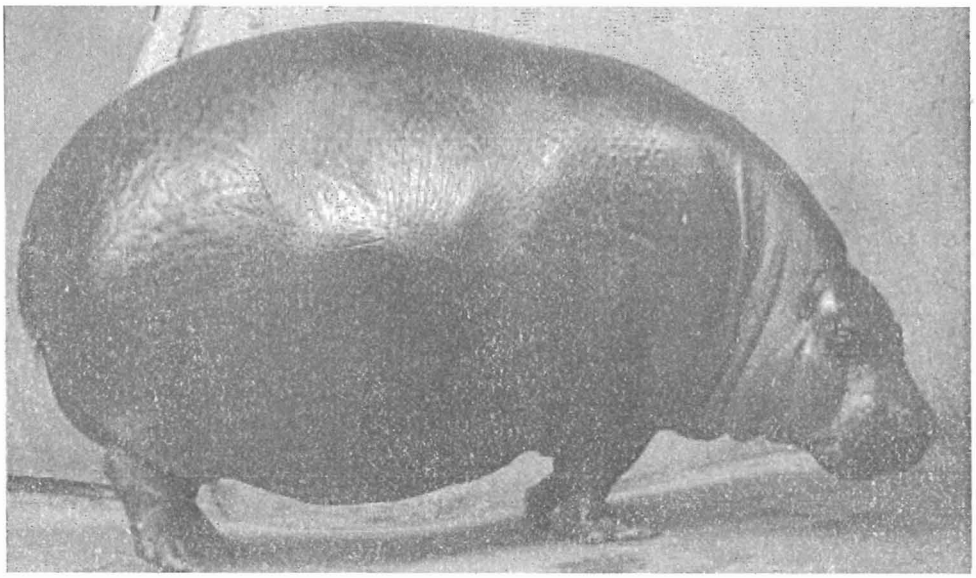

Crissey Zoological Nutrition Symposium

Raleigh, North Carolina

December 12 and 13, 2008

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Crissey Zoological Nutrition Symposium
Raleigh, North Carolina
December 12 and 13, 2008

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

Friday, December 12, 2008			
12:30 - 1:00pm	Registration		
1:00 - 1:30pm	Conference Introduction & Welcome	Michael Stoskopf, Kimberly Ange-van Heuten, Michael Power	
	Session I: Etiology of Obesity Chair: Michael Power, Smithsonian National Zoological Park		
1:30 - 1:45pm	My Hormones Are Making Me Fat and My Fat is Making Hormones	Scott Whisnant	9
1:45 - 2:00pm	Indirect Respiration Calorimetry to Measure Substrate Oxidation and Energy Expenditure in Domestic Cats	Alice Green	11
2:00 - 2:15pm	Does Captivity Make Me Look Fat? Obesity in Captive Common Marmosets (*Callithrix jacchus*)	Michael Power	13
2:15 - 2:30pm	Question & Answer Session		
2:30 - 2:35pm	Conundrum I presentation - Michael Power		17
2:35 - 3:00pm	Break and First Poster Session Blue Commons		
	Session II: Assessment of Condition (Scoring and Biomarkers) Chair: Karen Lisi, National Zoological Park		
3:00 - 3:15pm	Conundrum I discussion – Michael Power		
3:15 - 3:30 pm	Body Condition Scoring in Asian Elephants: Subjective and Objective Methods	Kibby Treiber	19
3:30 - 3:45pm	Evaluation of Oyster Body Composition and Metabolism	Andrey Tikunov	23
3:45 - 4:00pm	Kidney and Femur Marrow Fat as Indicators of Physiological Condition for White-Tailed Deer	M. Colter Chitwood	27
4:00 - 4:15pm	Health and Nutritional Evaluation of Gorillas on Diets without Commercial Biscuits	Ray L. Ball	29
4:15 - 4:30pm	Behavioral Changes in Captive Gorillas Following the Introduction of a Biscuit-Free Diet	Richard A. Bergl	31
4:30 - 4:45pm	Question & Answer Session		
4:45 - 4:50pm	Conundrum II presentation - Esther Finnegan		33
5:00 - 6:30pm	Evening Reception – Blue Commons		
6:30 - 7:00pm	Tribute to Ed Stevens Michael Power, Esther Finnegan, Michael Stoskopf		

7:00 - 8:00pm	Key Note Panel on Obesity: **Michael Power**, Smithsonian National Zoological Park **Barbara Toddes**, Nutrition Program Director, Philadelphia Zoo **Andrea Fidgett**, Zoo Nutritionist, Chester Zoo, UK		35-37
Saturday, December 13, 2008			
8:00 - 9:00am	Continental Breakfast		
	Session III: General Nutrition Chair: Esther Finnegan		
9:00 - 9:15am	Conundrum II discussion - Esther Finnegan		
9:15 - 9:30am	A Method for Evaluating Urine for the Presence of Urolithogenic Compounds and the Influence of Dietary Mineral Concentration on their Formation	Sharon Freeman	39
9:30 - 9:45am	Calcium and Phosphorous Metabolism in Rehabilitating Green Sea Turtles (*Chelonia mydas*)	Elizabeth Stringer	41
9:45 - 10:00am	New Insights into Trace Mineral Interactions in Ruminants	Stephanie Hansen	43
10:00 - 10:15am	Gorilla Chow-Free Diet: A Keeper's Perspective	Aaron M. Jesue	45
10:15 - 10:30am	Question & Answer Session		
10:30 - 10:35am	Conundrum III presentation - Kimberly Ange- van Heugten		47
10:35 - 10:55am	Break and Second Poster Session Blue Commons		
	Session IV: Obesity Co-morbidity (Associated Disease States) Chair: Barbara Toddes, Philadelphia Zoo		
10:55 - 11:10am	Conundrum III discussion - Kimberly Ange- van Heugten		
11:10 - 11:25am	Lipid Keratopathy in Captive Moray Eels	Allison Clode	49
11:25 - 11:40am	The Effects of Obesity on Tricaine Methanesulfonate Anesthesia Recovery of Fish	Eric Anderson	51
11:40 - 11:55am	The Effects of Body Fat on Blood Parameters of Glucose and Lipid Metabolism in Common Marmosets	Michael Power	53
11:55am - 12:10pm	Question & Answer Session		
12:10 - 12:15pm	Conundrum IV presentation - Eric van Heugten		55
12:15 - 1:15 pm	Lunch		

	Session V: General Nutrition Chair: Mike Maslanka		
1:15 - 1:30pm	Conundrum IV discussion - Eric van Heugten		
1:30 - 1:45pm	Potential Impact of Season and Diet Choice in Fecal Glucocorticoid Stress Monitoring in African Herbivores	Sathya Chinnadurai	57
1:45 - 2:00pm	Proximate Composition of Wild Mountain Gorilla Milk	C. Whittier	59
2:00 - 2:15pm	Evaluating Diet Preferences in Pigs with Potential Application in Zoo Species	Brynn Seabolt	61
2:15 - 2:30pm	Investigation of Retinol Status and Metabolism in Two Toad Species	Alejandra McComb	63
2:30 – 2:45pm	Question & Answer Session		
2:45 – 2:55pm	Conundrum V presentation - Michael Stoskopf		65
2:55 - 3:05pm	Break		
	Session VI: Obesity Management Strategies Chair: Andrea Fidget, Chester Zoo		
3:05 - 3:15pm	Conundrum V discussion - Michael Stoskopf		
3:15 - 3:30pm	Getting the Weight Off: The Story of Weight Loss in 1.1 Ocelots (*Leopardus pardalis*) at the North Carolina Zoological Park	Brigitte Thompson	67
3:30 – 3:45pm	A Dietary Comparison of Ornamental *Cyprinus Carpio* Commercial Diets	Maria Serrano	69
3:45 - 4:00pm	Nutritional Management of an Obese Spectacled Bear (*Tremarctos Ornatus*)	Karen Lisi	71
4:00 - 4:15pm	Question & Answer Session		
4:15 - 4:30pm	Parting Words		

Posters

MY HORMONES ARE MAKING ME FAT AND MY FAT IS MAKING HORMONES

C. Scott Whisnant, PhD* and Julia R. Raddatz, MS
Department of Animal Science, North Carolina State University
scott_whisnant@ncsu.edu

That the hormonal milieu can affect the rate of adipose tissue accretion has been long known. More recently it has been appreciated that adipose tissue produces its own hormones (adipokines) that regulate physiological processes such as feed intake, metabolic rate and insulin sensitivity. Concentrations of some adipokines increase (leptin, tumor necrosis factor α) as adiposity increases. However at least one, adiponectin, is decreased with increased adipose mass. We will discuss briefly the roles of some of these adipokines and present data from some experiments measuring their concentrations in livestock.

Leptin has been shown to inhibit feed intake and increase metabolic rate and should through these mechanisms as well as direct effects on adipocytes limit obesity. Leptin deficient mice and humans are morbidly obese but most obese individuals in the speeies studied have high plasma leptin concentrations. It appears that leptin resistance develops in these individuals. Tumor necrosis factor α (TNFα) concentrations are also elevated in obesity. Adiponectin appears to increase the insulin response and the lower adiponectin concentrations combined with higher TNFα concentrations may be responsible for the insulin resistance seen in obesity.

Adiponectin concentrations were compared in lactating and non-lactating dairy cows. Lactation is a time when dairy cows have low levels of insulin and are relatively insulin resistant as measured by insulin tolerance tests. Lactating cows had lower ($P<.01$) plasma adiponectin concentrations than non-lactating and this may explain some of the insulin resistance in during lactation. Intravenous infusion of glucose (0.25g per kg BW) increased plasma insulin concentrations ($P<.01$) in both dry and lactating cows but did not affect plasma adiponectin.

INDIRECT RESPIRATION CALORIMETRY TO MEASURE SUBSTRATE OXIDATION AND ENERGY EXPENDITURE IN DOMESTIC CATS

Alice S. Green PhD*[1], Cecilia Villaverde DVM, PhD, Jon J. Ramsey PhD and Andrea J. Fascetti VMD, PhD, DACVN, DACVIM

Department of Molecular Biosciences, School of Veterinary Medicine, University of California, Davis, Davis, CA 95819

[1]Current address: Department of Animal Science, Agricultural Research Complex, University of Arizona, 4101 N Campbell Avenue, Tucson, AZ 85719 asgreen@email.arizona.edu

Indirect respiration calorimetry is a useful tool for studying animal energetics and macronutrient utilization. In this abstract, we discuss two studies as examples of the application of this methodology. The first study assessed the domestic cat's ability to adapt substrate oxidation to different concentrations of dietary protein and other macronutrients(Green et al. 2008). The second examined adaptations of energy expenditure to caloric restriction in obese domestic cats (Villaverde et al. 2008).

Indirect respiration calorimetry methodology was used in both studies. Indirect respiration calorimetry estimates energy expenditure (EE), or heat production, based on the chemical processes that result in gas exchange. The production of CO_2 and disappearance of O_2 can be measured in a respiration calorimetry chamber in which airflow is controlled and sampled. Total EE and the contribution of each of three energy substrates (protein, fat and carbohydrate) can be estimated when combined with urine collection. Protein oxidation is calculated based on urinary N excretion, whereas carbohydrate and fat oxidation are calculated from gas exchange measurements and the characteristic respiratory quotient (RQ) of each substrate.

The objective of our first study was to assess cats' ability to adapt substrate oxidation to diets containing different concentrations of protein, including one below their protein requirement. It is well-known that cats and other carnivores have higher protein requirements compared to non-carnivores, apparently because of an inability to regulate hepatic urea cycle enzymes. We thus hypothesized that cats are unable to fully adapt protein oxidation to protein intake, particularly at low protein concentrations.

The study included nine cats (5 males and 4 females; 2.7 ± 0.5 yr; 4.49 ± 0.19 kg). Cats were fed each of 4 semi-purified diets containing 7.5% (low protein), 14.2% (adequate protein), 27.1% (moderate protein) and 49.6% (high protein) of metabolizable energy from protein in a modified crossover design. After adaptation to each diet, cats completed a 5-d nitrogen balance trial and at least 2, 12-hour indirect calorimetry measurements. There was a significant effect of diet on protein oxidation ($P<0.001$), and protein oxidation increased linearly with protein intake ($R^2 = 0.946$). However, the ratio of protein oxidation/protein intake was significantly higher with the LP diet (1.39 ± 0.07) than the other 3 diets (AP, 1.00 ± 0.07; MP, 0.93 ± 0.06; HP, 1.07 ± 0.03; $P<0.0001$), indicating a net loss of protein on the LP diet. Thus, we showed that cats are unable to sufficiently decrease protein oxidation to maintain nitrogen balance when consuming a diet with 8% protein of metabolizable energy. When consuming diets with 14-50% protein, cats are able to match protein oxidation to intake and thus maintain nitrogen balance. This study helps to explain why cats, and likely other carnivores, have a high protein requirement.

In our second study, we used indirect respiration calorimetry to study changes in EE associated with body mass loss and regain in domestic cats. Obesity is the most common nutritional problem affecting domestic cats in the U.S., and it is increasingly impacting exotic cats kept in captivity. Dietary energy restriction (ER) is a common treatment for obesity in both domestic and exotic cats. However, ER is often unsuccessful, and even when the desired weight loss is achieved, it is difficult to maintain. We hypothesized that ER results in a sustained decrease in mass-adjusted energy expenditure in cats, which would help to explain this lack of success. This phenomenon has previously been observed in humans, monkeys, rodents and dogs.

Energy expenditure and body composition (estimated using deuterium oxide dilution) were measured in 10 adult neutered cats at baseline (obese cats), during weight loss (40% ER), and following weight regain, when cats were allowed to eat ad libitum. Throughout the study, cats were fed a dry expanded maintenance diet. At baseline, the cats had a body weight (BW) of 6.1 ± 0.30 kg, body condition score (BCS) of 7.6 ± 0.14 (on a 9-point scale), and body fat mass (FM) of 38 ± 1.0% of BW. ER resulted in decreased BW (5.0 ± 0.19 kg), BCS (5.5 ± 0.07) and FM (31 ± 1.6% ($P<0.01$). After weight regain, BW (6.2 ± 0.30 kg) and BCS (7.7 ± 0.16) were not different from baseline, but FM (42 ± 1.8%) was increased relative to baseline ($P<0.01$). Total EE decreased from 1258 ± 33.7 kJ/d at baseline to 1025 ± 39.6 kJ/d during weight loss ($P<0.001$). After weight regain, EE (1103 ± 41.5 kJ/d) was lower than at baseline ($P<0.001$). This study showed that ER results in decreased EE, which persists when cats are allowed to eat ad libitum and regain BW. Diet plans for obese felines should include frequent monitoring and adjustments in order to achieve and maintain desired weight loss. Because weight loss is so challenging for cats, prevention of obesity is likely the most important strategy for management of this disease.

These studies have provided valuable insights into the ability of the domestic cat to adapt substrate oxidation to macronutrient intake and to adapt energy expenditure to energy restriction. It would be useful to study similar questions in zoo animals using the same methodology. Indirect respiration calorimetry is a non-invasive technique that can be applied in zoo settings to study the effects of dietary treatments and energy restriction on energy expenditure.

Green A.S., J.J. Ramsey, C. Villaverde, D.K. Asami, A. Wei, and A.J. Fascetti. 2008. Cats are able to adapt protein oxidation to protein intake provided their requirement for dietary protein is met. J Nutr 138: 1053-60.

Villaverde C., J.J. Ramsey, A.S. Green, D.K. Asami, S. Yoo, and A.J. Fascetti. 2008. Energy restriction results in a mass-adjusted decrease in energy expenditure in cats, which is maintained after weight regain. J Nutr 138: 856-860.

DOES CAPTIVITY MAKE ME LOOK FAT?

Obesity in captive common marmosets (*Callithrix jacchus*).

Michael L. Power[1,2*] and Suzette D. Tardif[3,4].

[1]Smithsonian National Zoological Park, Washington DC; [2] American College of Obstetricians and Gynecologists, Washington DC; PowerM@si.edu
[3] University of Texas Health Science Center at San Antonio, San Antonio TX; [4] Southwest National Primate Research Center, San Antonio TX.

Unfortunately, captive conditions can be conducive to the development of obesity. Animals have easy access to food and relatively little need for physical activity. Not all species are vulnerable to developing obesity, nor all individuals within a species. Understanding the circumstances which predispose animals to gain excessive amounts of fat is important for their successful captive management.

This presentation considers the case of a small New World primate, the common marmoset (*Callithrix jacchus*). In the wild, common marmosets average 320 to 336 grams (Araujo, et al., 2000). The average weight of captive animals, however, varies from 283 to 530 grams, depending upon the colony. We have noticed a consistent trend in our marmoset colony, which was established in 1994 and has been continuously breeding since that time, for an increase in body mass at all age stages. Mean adult mass has increased over time, as well as mean birth weight. This change has occurred despite minimal changes in husbandry. It appears that over generations captive marmosets become more vulnerable to developing obesity.

Methods

This study takes a retrospective look at body weights for common marmosets from the same colony over a 13 year period. The following data are available for > 80% of individuals born into this colony who were reared to weaning: dam, sire, sex, birthdate, litter size, birth weight, average early adult weight (taken as the average of all weights between 17 and 24 months of age) and maximal obtained weight. Tardif and Bales (2004) provide details on routine methods for weighing and assessing birth condition in this population. The total population in this analysis was 210 individuals with documented birth weights and average early adult weights.

In addition, estimates of fat mass for animals have been obtained using several methods during this time period. At the beginning of the colony's formation body composition was estimated using labeled water dilution. Recently we have estimated fat mass using quantitative magnetic resonance (QMR). These data are used to examine how the proportion of fat and lean mass has changed in the colony in concert with the observed change in mean body weight.

Results

Previous research indicated that the marmosets in the first years of the colony were relatively lean (mean adult weight of 342 g and mean estimated fat mass of 8.3%; Power et al., 2001). There was no difference between males and females in body weight or estimated fat mass.

Several generations later mean early adult body weight for animals born in 2004 exceeds 400 g. Based on the QMR data most of this change in body mass appears to represent an increase in fat mass. Mean birth weights have also increased over this time period, from an average of 26 g to almost 30 g.

Although mean birth weight did not differ between males and females for any time period, early adult weight is now greater for females; for animals born after the year 2000, females were significantly larger than males (females = 394.2+/- 9.0 g; males = 365.8 +/- 6.0 g; p= 0.007). Females also achieved a higher mean maximal weight (436.9+/-10.6 g versus 400.9+/-7.8 g; p=.006). Using an operational definition of >90th percentile in body weight as obese, 18 females versus 2 males were defined as obese in early adulthood (p<0.0001). Early adult weight was significantly related to birth weight, but only for females (Fig 1).

Discussion

We have documented a general increase in body size over generations in our marmoset colony, despite consistent husbandry conditions. The base diet of the colony has not changed, and consists of a low-fat, purified diet. Caging and housing conditions have not changed. However, the animals have. On average they are larger at birth and as young adults. The increase in adult weight appears to represent an increase in mean fat mass. We are also beginning to see a sexual dimorphism in body mass and fat mass.

Marmosets are generally described as sexually monomorphic, and a previous study by our group (Power, et al., 2001) found no sex differences in total body weight or the proportions of fat and lean mass during the early years of the colony, when the animals were relatively lean. Males and females still do not differ in birth weight, however females now achieve higher mean early adult weight and maximal obtained weight. Lean mass did not differ between males and females in either Power et al. (2001) or in the present study, suggesting that female marmosets, in common with humans (Power & Schulkin, 2008), have a higher propensity to gain fat mass under certain conditions. The endocrine mechanisms underlying this difference are not known. It is reasonable to speculate that an enhanced ability to store fat under conditions of high food availability may be more adaptive for females, given the higher costs of female reproductive effort. Even in captivity, small marmoset females produce lower fat milk, their infants grow at a slower rate, and the females experience a longer interbirth interval (Tardif et al., 2001). Although obese female marmosets do not have higher reproductive success, the ability to increase fat stores may have adaptive significance under environmental conditions that constrain fat gain.

References

Araujo A, Arruda M, Alencar A, Albuquerque F, Nascimento M, Yamamoto M. Body weight of wild and captive common marmosets. Intl J Primatol. 2000; 21:317-324.

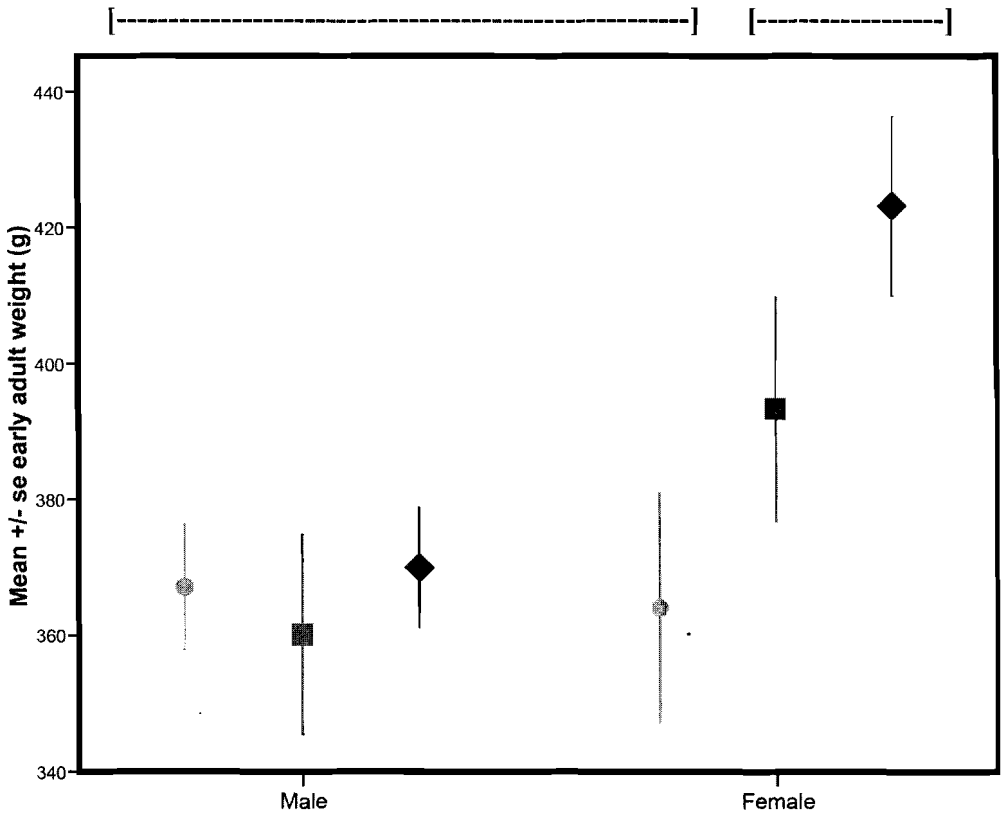
Power M, Schulkin J. Sex differences in fat storage, fat metabolism, and the health risks from obesity: possible evolutionary origins. Br J Nutr. 2008;

Power R, Power M, Layne D, Jaquish C, Oftedal O, Tardif S. Relations among measures of body composition, age and sex in the common marmoset monkey (Callithrix jacchus). Comp Med. 2001; 51:218-223.

Tardif S, Power M, Oftedal O, Power R, Layne D. Lactation, maternal behavior and infant growth in common marmoset monkeys (Callithrix jacchus): effects of maternal size and litter size. Behav Ecol Sociobiol. 2001; 51:17-25.

Tardif S, Bales K. Relations among birth condition, maternal condition and postnatal growth in captive common marmosets (Callithrix jacchus). Am J Primatol. 2004; 62:83-94.

Figure 1. Relation between birth weight and early adult weight in males and females; birth weights are segmented into low, (o), medium (▫), and high (◊). Groups that do not share a line ([-----]) differ from one another at p <0.05.



FIFTH CRISSEY ZOOLOGICAL NUTRITION SYMPOSIUM

CONUNDRUM I

Michael Power

When a captive female mammal is lactating it often is standard management to increase the amount of food offered. However, in humans a serious risk factor for gestational diabetes is failure to lose weight post partum; i.e. women that do not lose the weight they gained in a pregnancy are at much higher risk for gestational diabetes in any subsequent pregnancy. This risk is in addition to the risk associated with being overweight or obese. There are other subtleties, such as obesity in women is associated with poor lactation performance, possibly due to the high levels of estrogen coming from adipose tissue. Thus offering overweight and obese lactating females more food might actually compromise lactation instead of supporting it.

How should we balance providing sufficient energy to lactating animals to support appropriate milk production against the risks of compromising lactation due to obesity and the possible risks to future pregnancies due to a failure to go through what is a natural weight cycling?

BODY CONDITION SCORING IN ASIAN ELEPHANTS: SUBJECTIVE AND OBJECTIVE METHODS

Kibby Treiber[1], Roy McClements[2], Ann Ward[1]
[1]Fort Worth Zoo, Texas, USA, [2]Faculty of Veterinary Science, Univ of Sydney, NSW Australia

Body condition (BC) is a major indicator of energy and health status in animals. Extreme BCs (emaciation and obesity) are associated with health risks including metabolic disease (e.g. diabetes), cardiovascular disease, and reproductive complications across species (1-5). Body condition scoring systems standardize the evaluation of BC for controlled comparisons (1, 5). Ultimately BC scoring systems offer a guide to help managers avoid increased risks and disease states associated with BC.

Body condition scoring systems are primarily subjective, involving a range of scores (usually 1 to 5 or 1 to 9) with specific descriptions (verbal or pictographic) for each score. Subjective scores are limited by the specificity of each description and by the bias of individual scorers. Qualifying words such as 'very', 'profound', 'sharp', 'mounded', 'thick', etc. may be interpreted differently by scorers and relate to the scope of each scorer's experience. Therefore trained experienced scorers are important when scoring BC subjectively. However subjective BC scoring systems do provide the most comprehensive evaluation by taking into consideration the entire subject and all potential fat deposits.

Objective BC scores can be derived from morphometric measurements (e.g. the human body mass index (weight/height^2)), and have been correlated to health risks in humans and other species (5, 6). Objective BC scores rely on a measurement of fatness (e.g. weight or girth circumference) often corrected for a measure of lean mass (e.g. height), since lean mass influences most morphometric measures of fatness (e.g. weight depends on fat mass and height). Objective BC scores rely on the assumption that a simple measure provides an accurate prediction of total body fat or health risks. Although correlations between objective measures and subjective BC scores in elephants has been attempted (7) morphometric measures have previously only been successful in predicting elephant weight (8, 9).

Subjective and objective methods of BC scoring in Asian elephants were evaluated using four Asian elephant cows (10-38 yo) at the Fort Worth Zoo. Elephants were weighed, photographed and measured using a soft tape measure monthly from November 2007 to September 2008. Using established BC scoring systems for domestic and exotic animals (1, 7, 10, 11), a subjective 5-point BC scoring system was developed to describe the range of BCs possible for Asian elephants based on photographs of wild and captive animals (Table 1). Three trained scorers evaluated 44 standardized photosets each representing one elephant in one month. Morphometric measurements included weight, girth (heart girth around the torso behind the shoulder and elbow perpendicular to the ground), length (from point of shoulder (humeral tuberosity) to point of hip (measured to anus)), and height (wither height, just behind shoulder). Combinations of these measurements were evaluated as objective indices of BC (Table 2). Comparisons were made using regression adjusted for intragroup correlation (i.e. repeated monthly measures) and STATA software (Intercooled Stata, version 9.2). Linear regression was used to predict subjective BC scores from objective morphometric indices. The precision of these predictions was tested using the concordance coefficient (12) and Bland-Altman standard deviations (13).

Median monthly BC scores ranged from 2 to 5, with one elephant scoring 2-3, one 3.5-5, and two 4.5-5. Weight was highly correlated to girth ($r = 0.94$, $P = 0.008$), but neither weight nor

girth were strongly correlated to subjective BC score (Table 2). Estimates of subjective BC score were improved by correcting for lean mass using height. Adjusting weight for both height and length (quadrupedal lean mass), provided a better BC estimation than adjusting for height alone. The best objective predictors of subjective BC score were girth:height and weight:(height x length) and had Bland-Altman standard deviations of ~0.6, indicating that ~90% of BC scores predicted from these objective indices will fall within 1 BC score of the subjective method.

Subjective and objective methods can provide comparable estimates of BC scores in Asian elephants and offer managers, veterinarians, and nutritionists tools to evaluate animals. As in other species, further research is needed to determine how subjective or objective BC scores relate to health risks in elephants.

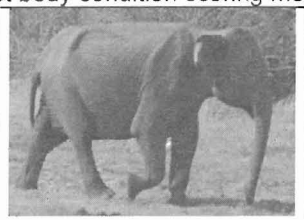
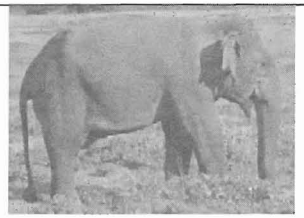
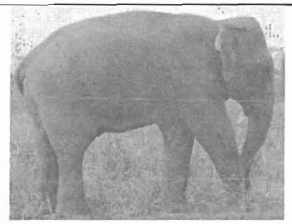
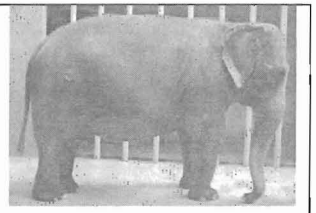
Table 2. Comparison of objective BC scoring indices and subjective BC scores.

Morphometric Index	Pearson's R	P-value	Concordance r_c	Bland-Altman Standard Deviation
weight	0.533	0.16	0.442	0.859
weight: height^2	0.648	0.16	0.591	0.773
weight: (height x length)	0.776	0.056	0.752	0.639
girth	0.627	0.20	0.564	0.808
girth: height	0.796	0.047	0.776	0.614

Literature Cited

1. Wildman EE, Jones GM et al. A dairy cow body condition scoring system and its relationship to selected production characteristics. J Diary Sci. 1982. 65:495-501.
2. German AJ. The Growing Problem of Obesity in Dogs and Cats. J Nutr. 2006. 136:1940S-6.
3. Testa JW, Adams GP. Body condition and adjustments to reproductive in female moose (Alces alces). J Mammology. 1998;79:1345-54.
4. Andreasen KR, Andersen ML et al. Obesity and pregnancy. Acta Obstet Gynecol Scand. 2004. 83:1022-9.
5. WHO. Obesity, preventing and managing the global epidemic. Report of a WHO consultation on obesity; Geneva; 1997.
6. Carter RA, Geor RJ et al. Apparent adiposity assessed by standardised scoring systems and morphometric measurements in horses and ponies. Vet J. 2008 Apr 25.
7. Wemmer C, Krishnamurthy V et al. Assessment of body condition in Asian elephants (Elephas maximus). Zoo Biology. 2006. 25:187-200.
8. Sreekumar KP, Nirmalan G. Estimation of body weight in Indian elephants (Elephas maximus-indicus. Veterinary research communications. 1989. 13:3-9.
9. Hile ME, Hintz HF et al. Predicting body weight from body measurements in Asian elephants (Elephas maximus). Journal of Zoo and Wildlife Medicine. 1997. 28:424-7.
10. Henneke DR, Potter GD et al. Relationship between condition score, physical measurements and body fat percentage in mares. Equine Vet J. 1983. 15:371-2.
11. LaFlamme D. Development and validation of a body condition score system for dogs. Canine Practice. 1997. 22:10-5.
12. Lin LI. A concordance correlation coefficient to evaluate reproducibility. Biometrics. 1989. 45:255-68.
13. Bland JM, Altman DG. Measuring agreement in method comparison studies. Statistical methods in medical research. 1999. 8:135-60.

Table 1. 5 pt body condition scoring method for elephants

					
	I	II	III	IV	V
Head	Sharply prominent crater with bony ridge	Prominent crater but contours slightly smoothed	Temporal depression clearly visible but contours smooth	Visible depression but mostly filled	Filled, flat temporal area
Neck	Sunken, sharp angle with shoulder	Slightly sunken, clear angle with shoulder	Depressed but blends into shoulder	Smooth, flat with shoulder	Filled, rounded, continuous with shoulder
Shoulder	Sharply prominent shoulder-blade	Prominent shoulder-blade, depression visible in front and behind shoulder	Planes around shoulder-blade flat/smooth	Barely noticeable	Rounded, shoulder not visible
Torso	Individual ribs visible	Impression of ribcage visible	Ribs not visible	Smooth, rounded	Smooth, rounded and continuous through neck, shoulder and hip
Back	Sharply prominent finlike backbone	Prominent backbone, smooth concavity between backbone and torso/hip	Backbone visible as a low ridge	Back slopes smoothly downward into torso/hip	Back rounded or flat
Hip	Sunken in front, sharply prominent hip bone	Slightly sunken in front of hip, prominent hip bone but contours smoothed	Smooth depression in front of hip	Depression in front of hip barely noticeable	Filled, rounded, hip not visible
Croup	Sunken plane behind hip, sharply prominent tailhead	Depressed plane behind hip, prominent tailhead	Flat plane between hip and tailhead	Slightly rounded between hip and tailhead	Filled, rounded

ASSESSMENT OF CONDITION AND METABOLISM OF THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*)

Andrey Tikunov, M.S.*, Michael Stoskopf, D.V.M., Ph.D., D.ACZM, Haakil Lee, Ph.D., Jeffrey M. Macdonald, Ph.D.

Environmental Medicine Consortium and Center for Marine Sciences and Technology (CMAST), North Carolina State University, 303 College Circle, Morehead City, NC 28557, and Joint Department of Biomedical Engineering NC State University and UNC Chapel Hill, Chapel Hill, NC 27599-7575 (all authors) and the Department of Clinical Sciences, College of Veterinary Medicine, North Carolina State University (Stoskopf)

Oysters are filter feeders contributing to the overall filtration capacity of the near shore marine and estuarine ecosystems in addition to being an economically important food species harvested wild and produced in mariculture. The investigation of physiology of marine bivalves, classically relies on destructive methods, because an hermetic shell protects the animal. Similarly, assessment of body condition of oysters has routinely been a destructive assessment. The assessment of body condition in oyster is important in grading oyster quality in the market place, but is also extremely important in the conduct of research on these animals. The Eastern Oyster, *Crassostrea virginica.* is well adapted to tidal activity and can tolerate being exposed to the air for prolonged times. This has led to misconceptions about the sensitivity of oysters to handling and manipulation. Much of the research on oysters, including basic studies of physiology, have been performed on oysters that are not being maintained or managed in a manner that would permit growth and homeostasis. For this reason, much of the extant data on oyster nutrition, nutrient metabolism, nutrient distribution and nutrient storage are suspect.

Oxygen consumption of oysters is high when the valves are open, but may be reduced to near zero for prolonged periods, even several days, when the valves are closed (Galtsoff, 1964). This may be possible because of rapid switching between aerobic and anaerobic glycolysis, with conversion of glucose into glycogen occurring during the aerobic phase. It has been shown that glycogen accumulates in specialized storage cells found at different locations in oysters, including the area around the labial palps and the gonadal region (Eckelbarger *et al.* 1996). But the control of storage and mobilization of glycogen in oyster is not adequately studied. Also there are no data available about transition of metabolism from aerobic to anaerobic state.

From the preliminary studies we have identified a gelatinous structure near the labial palps, which we believe is a major glycogen storage depot. This structure is large and obvious in oysters taken directly from wild oyster beds where they are feeding naturally. Holding an oyster

in aerated seawater without providing food results in dramatic rapid reduction of the size of this structure, and its complete disappearance to the unaided eye within 2 to 3 days of fasting. Providing bacterial growth in the water for an oyster with the putative glycogen storage structure depleted to feed on results in slow restoration of the structure (figure 1). This suggests that the gelatinous structure will be a useful means of evaluating oyster nutritional condition.

Non-invasive imaging methods have been investigated to measure anatomic traits and predict body composition in a variety of freshwater and marine species, including some bivalves, since the early 1990's. However, magnetic resonance imaging (MRI) techniques have been under-utilized to observe live marine animals, and specifically MR spectroscopic imaging (MRSI), which permits metabolic profiles to be generated in a conventional MR image format using different colors representing the various metabolites. Oysters constitute an interesting model because 1) the oyster has few well separated organs with certain functions resulting in distinct metabolic profiles, 2) its lipid-rich organs are easily distinguishable using T_1-weighted MRI 3) oysters are easy to immobilize during data accumulation allowing long acquisition times for high resolution images without any blurring effects.

We are using ^{13}C NMR spectroscopy and also ^{1}H MRI and MRSI techniques to evaluate the consumption, distribution and storage of the glucose, glycine and their metabolites in the eastern oyster using ^{13}C-labeled substrates. Preliminary studies are focused on using NMR techniques on dissected tissues to localized metabolic pathways. Planned studies will monitor glycogen consumption, metabolism and distribution in the live, intact oysters under different oxygen and nutrition conditions. These studies utilize MR imaging techniques to localize reverse spectroscopy allowing observation of time-dependent metabolic profiles for different organs simultaneously with morphological observations.

Literature Cited

Eckelbarger, K.J., and Davis, C.V. 1996. Ultrastructure of the gonad and gametogenesis in the eastern oyster, Crassostrea virginica, I: ovary and oogenesis. Mar Biol 127:79–87

Galtsoff, P. S. 1964. The American oyster, *Crassostrea virginica.* Fishery Bull. 64. U. S. Govt. Printing Office, Washington, D.C.

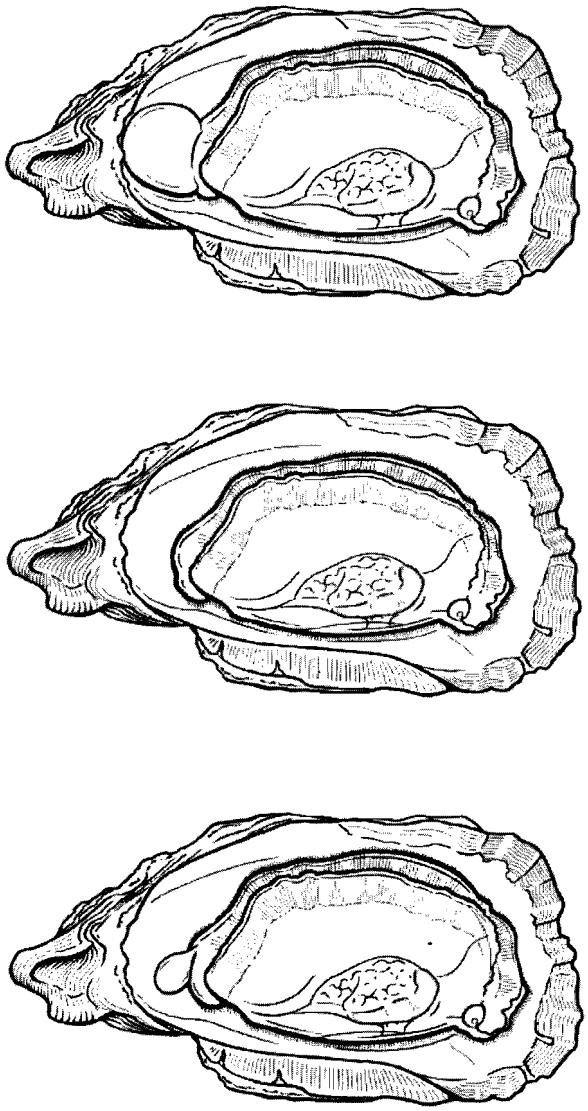


Figure 1. Depletion and regeneration of glycogen rich structure in the eastern oyster. Top – oyster removed directly from wild oyster bed and examined immediately showing large gelatinous structure in the region of the palps near the hinge. Middle – oyster after 2 days maintenance in aerated seawater without food, showing complete absence of the gelatinous structure near the palps. Bottom – oyster held 2 days without feeding and then allowed to feed on bacteria for 3 days showing some regeneration of the gelatinous structure thought to store glycogen. Illustrations by Alice Harvey, 2008

KIDNEY AND FEMUR MARROW FAT AS INDICATORS OF PHYSIOLOGICAL CONDITION FOR WHITE-TAILED DEER

M. Colter Chitwood, B.S.*[1], Suzanne Kennedy-Stoskopf, DVM, Ph.D.[2]
Christopher S. DePerno, Ph.D.[1], and John H. Harrelson, B.S.[1]

[1]North Carolina State University, Department of Forestry and Environmental Resources, Fisheries and Wildlife Sciences Program, Box 7646, Raleigh, NC 27695, mcchitwo@ncsu.edu

[2]North Carolina State University, College of Veterinary Medicine, 4700 Hillsborough Street, Raleigh, 27606, suzanne_stoskopf@ncsu.edu

Various physiological indices have been used to evaluate physical condition of white-tailed deer (*Odocoileus virginianus*). Specifically, kidney fat and femur marrow fat have been used as indicators of overall condition. Condition data are useful because when combined with population data, they allow an assessment of deer from the herd level down to the individual level. Studies have demonstrated that kidney fat and femur fat are reliable indicators of deer health, as they relate to nutritional status and habitat conditions. Though fat deposition can vary seasonally, the absence of subcutaneous fat, kidney fat, and femur fat suggests physiological stress. Therefore, our objectives were to establish baseline physiological condition data for white-tailed deer in the coastal region of North Carolina.

The Hofmann Forest comprises 78,000 acres of contiguous pocosin habitat in the coastal plain of North Carolina. Hofmann Forest is intensively managed for loblolly pine (*Pinus taeda*) but contains smaller tracts of natural forest which are generally dominated by pond pine (*Pinus serotina*) with interspersed long leaf pine (*Pinus palustris*). Deer densities in this part of North Carolina are above average and the pine-managed habitat may be unable to support high densities unless physiological condition is compromised.

In July 2008, we evaluated physical condition of 30 free-ranging females. Kidney fat was qualitatively evaluated in the field (poor, fair, good, excellent), then quantified using the kidney fat index (KFI). Similarly, femur marrow fat was qualitatively evaluated after cutting one femur laterally. The other femur was removed whole, frozen, and analyzed in laboratory to quantify marrow fat content; fat was extracted from a 2-gram sample of marrow taken from the center of each femur. Dry weight of fat was divided by dry weight of a parallel 2-gram sample of marrow to determine percent fat of the marrow, or marrow fat index (MFI).

Qualitative analysis of kidney and marrow fat resulted in overall fair-to-poor condition for female white-tailed deer; a total of 26 (87%) deer received fair or poor kidney scores and 28 (93%) received poor marrow fat scores. Similarly, quantitative analysis resulted in low fat contents for both fat indices; average KFI was 25.2% (range = 3.0% to 116.6%) and average MFI was 33.8% (range = 2.1% to 85.4%).

Our KFI and MFI scores are consistent with other studies. In late summer, female white-tailed deer are finishing lactating and often are in a stressed physiological condition.

Females tend to reach maximum fat deposition in mid- to late-winter and then metabolize the fat throughout gestation and lactation. However, habitat conditions and population density contribute to within-year and regional variation in fat scores. To determine the extent of variation in fat indices of coastal North Carolina white-tailed deer, an additional 30 females will be collected in March 2009. A seasonal comparison of kidney and femur marrow fat will provide baseline physiological information specific to the habitat of Hofmann Forest, and subsequent comparisons to the literature will identify regional variation in kidney and femur marrow fat indices.

HEALTH AND NUTRITIONAL EVALUATION OF GORILLAS ON DIETS WITHOUT COMMERCIAL BISCUITS

Ray L Ball, DVM, MRCVS*, Mary R. Port, CVT, Lisa Harris, Tonia Westfall
Busch Gardens Africa, 3605 Bougainvillea Drive,
Tampa, Florida, 33612
dr.ray.ball@buschgardens.com

Gorillas are generally considered browsers. While the western lowland gorilla is reported to consume more fruit than the mountain gorilla, green plant material is the majority of the diet in the wild. The gastrointestinal tract of gorillas is very similar to other hindgut fermenters, especially equid type animals (rhinos, elephants, horses, zebras). In managed care gorillas are typically fed a diet that consist of commercially grown fruits, leafy greens, vegetables, and a commercially manufacturer complete feed (biscuit or chow). Browse material contains essentially no starch while commercial leaf eater type primate biscuits can have typically 18% starch on a dry matter basis. Current recommendations are for 23% commercial feed but up to 55% of the diet is reported in some facilities. Antedotal reports often cite 75% of the diet as commercial chow.

Gorillas in managed care have had notable health issues, especially gastrointestinal and cardiovascular. While human nutritional requirement have been used as a guideline for gorilla nutrition, the feeding approach used in other hindgut fermenters was taken for gorillas. Our basic premise is that captive diets are potentially inflammatory or even allergenic and reducing these potential causes of inflammation (i.e. starches) will result in lowered levels of inflammatory proteins (i.e. ferritin, amyloid, C-reactive protein) and with a lowered incidence of health issues. An examination of the carbohydrate structure of plant materials support the notion that any browsing species would have little to no exposure to starches on any regular basis.

Three male gorillas at Busch Gardens Africa were transitioned from a traditional diet consisting of commercial primate biscuits to a "forage" based diet with only produce, vegetables, fruits, and browse. Typical as fed intake for a 210kg male was approximately 18kgs which corresponds very well with reports from wild gorilla intakes. Training and enrichment items were also limited so as not to include complex carbohydrates (starches) and limited sugars. Soy and wheat based items were not allowed. A multi-vitamin combination was also given to provide any mineral or vitamin shortage that the diet could not deliver. The diet was balanced on Zootrition™ and has been evaluated by two zoo nutritionist and found to be balanced. The two adults had a chronic history of diarrhea, parasitic, conditions and colitis that had generally been unresponsive to conventional therapies. The 7 yr old had some episodes but not as extreme. The diets were started in the fall of 2004. After the initial diet analysis was reviewed, the supplement was changed to include 2 adult multivitamins along with a 400mg selenium capsule. In May 2007, all 3 males were anesthetized for physical exams. Blood was collected to look at serum levels of selected nutrient and mineral levels along with a cholesterol profile.

Once established on the new diet, the first notable change was the consistency of the stool. Within a few weeks the chronic diarrhea in the two adult males improved by 90% as indicated by number of days that loose stool were reported to the veterinary staff. Fecal exams

have also become "benign" with only some ciliates noted. Loose stools when seen appear to have a strong association to some stressors introduced into the group. The weight gain in the juvenile male has been steady with an initial weight of approximately 70kgs at the beginning of the diet change to now 124kgs. Results of the serum analysis show do not raise any serious concerns about deficiencies but a more detailed analysis is ongoing. Notable results include the elevated parathyroid (PTH) levels. While the ionized calcium was held steady and total calcium was pretty consistent, an increase in PTH suggest that dietary levels may not be adequate and PTH is activated to pull calcium form the bone. This occurred in only one animal however and actually reduced in the growing juvenile suggesting his growth needs were met. Some consideration should be given to lactating females fed in this fashion. Another important observation was in a lactating female who was later converted to this chowless feeding. When this female starting to resume reproductive cycling, she developed pallor, lethargy with poor mucus membrane color. An additional iron supplement was given and this female continued to cycle regularly and was clinically normal. Iron requirements are known to increase in women who are lactating and resume menses and this is presumed to be the same situation. The fatty acid profile shows an increase in omega 6 fatty acid, linoleic acid (C18:2n6c) and the omega 3 fatty acid alpha-linolenic acids (C18:3n3c). Increasing alpha-linoleic acid decreases inflammation by reducing conversion of the omega 6 families of fatty acids to inflammatory fatty acids. The reduction of C20:3n6c and C22:4n6c, both suggest that the increase in omega 3s may have been enough to reduce the conversion of these inflammatory fatty acids from the parent linoleic acid.

The cholesterol profile was surprising. The "vegetarian" diet actually resulted in an increased in the total cholesterol in 2/3 gorillas and 3/3 in regards to triglycerides. The high density lipoprotein (HDL or "good cholesterol") dropped notably while the low density lipoprotein (LDL or bad cholesterol) showed an increase in two gorillas. The resulting cholesterol levels are still within a range reported earlier by Crissey, while the triglycerides are much higher in two of the animals. While the LDL did increase it is still considerably lower than the LDL value reported by Crissy in the same report in the two adult animals. Cholesterol is involved with coronary heart disease, which causes blockage of blood flow to the heart. Cardiac related mortality in gorillas is reported as mostly aortic dissection or myocardial fibrosis. Myocardial fibrosis may have a nutritional component as an increase in insulin growth like factor (IGF) can promote formation of myocardial fibrosis. While stabilizing lipid profiles is important for overall health, cholesterol does not seem to be a huge factor in the cardiac deaths reported. Sodium appears to be a more important factor for potential cardiovascular health issues in managed gorillas. Sodium intake appears to be severely restricted in wild gorillas and even this chow-less diet may have sodium in excess of what is required for gorillas.

While there are numerous details that need to be examined in regard to nutrition and health of managed gorillas, eliminating commercial feeds have proven so far to be a safe and successful practice. This practice has been expanded to orangutans and gibbons with good acceptance. Improved stool character is again the most notable improvement in both species so far.

BEHAVIORAL CHANGES IN CAPTIVE GORILLAS FOLLOWING THE INTRODUCTION OF A BISCUIT-FREE DIET

Richard A. Bergl[1*] MA PhD, Ray Ball[2] DVM, Kristin Owen[3], Sam Young[3], Aaron Jesue[1], Courtni Bean[1], Barbara L. Sherman[3] MS PhD DVM DACVB, Shana R. Lavin[4] PhD

[1]North Carolina Zoological Park
[2]Busch Gardens, Tampa Bay
[3]College of Veterinary Medicine, North Carolina State University
[4]Lincoln Park Zoo

Gorillas in captivity often exhibit a number of undesirable behaviors (e.g., regurgitation and reingestion, coprophagy). Captive gorillas also are susceptible obesity, gastro-intestinal and cardiac disease. These health problems may be exacerbated by low levels of activity relative to what would be seen in the wild. Both the behavioral and veterinary problems experienced by captive gorillas have been hypothesized to be related, at least in part, to the diets zoo gorillas typically receive.

Gorilla gastrointestinal tract morphology and short chain fatty acid profile are consistent with significant hindgut fermentation, and in the wild gorillas consume a diet high in green plant material. In captivity however, gorillas typically receive diets that contain large amounts of fruit (which differ significantly from the fruits they would consume in the wild) and commercially produced biscuits. The vast majority of wild gorilla diet items contain little or no starch, while commercial leaf eater type primate biscuits can have as much as 18% starch on a dry matter basis. The current recommendation from the gorilla Species Survival Plan is to offer primate biscuits as 23% of the diet as fed, and up to 55% of the diet is reported in some facilities. There is substantial evidence that diets containing these relatively high levels of rapidly-digested starch do not encourage good gastrointestinal health (e.g., gut flora biodiversity, intestinal epithelial cell cytotoxicity) in hindgut fermenters. Additionally, the high caloric density and associated low bulk typical of zoo gorilla diets is inconsistent with the low calorie, high bulk diets that gorillas consume in the wild. The gorilla gastrointestinal tract and gorilla foraging behavior are evolved to consume and process large volumes of food. As a result, captive gorillas likely never reach the point of satiety, despite the fact that they are consuming sufficient quantities of a nutritionally complete diet. Thus, captive gorillas likely have a significant behavioral drive to forage for food even once the prescribed diet has been completely consumed, which can lead to obesity and undesirable appetitive behaviors such as regurgitation and reingestion. Research on captive gorillas and humans that engage in regurgitation and reingestion suggests that a significant motivator for this behavior may be that individuals never reach satiety with the diet they are provided.

In order to investigate the impact of diet on captive gorilla behavior, we studied the effect of a significant change in diet composition on the four gorillas at the North Carolina Zoological Park. During the course of the study the gorillas were transitioned from a traditional zoo diet incorporating commercially produced biscuits and significant amounts of fruit to one that more closely approximates wild gorilla diets. This new diet contained large amounts of leafy green

vegetables and excluded commercially produced feeds and represented an almost 300% increase in diet by weight. The diet was formulated using Zootrition software and generally meets the nutritional composition recommended by the Gorilla Species Survival Plan's Standardized Guidelines.

We conducted behavioral observations over a four month period, resulting in a total of over 300 hours of data. Following the change to a biscuit-free diet we observed increased levels of activity including a 100% increase in time spent foraging. On the biscuit-based diet the gorillas spent significant time consuming grass growing in the exhibit. Consumption of grass reduced dramatically on the biscuit-free diet and was replaced by consumption of the prescribed diet. We also observed decreases in levels of undesirable behaviors. Following the diet change all gorillas exhibited some weight loss, however weights stabilized within three months of the diet change and some individuals have begun regaining lost weight.

Our data suggest that it is possible to feed a nutritionally complete diet to gorillas in the absence of commercially produced biscuits with favorable behavioral results. This diet more closely resembles the natural diet of gorillas and appears to foster a behavioral repertoire more representative of wild gorilla behavior. The reduction in undesirable behaviors and increase in activity level exhibited by the gorillas following the diet change may also have positive health benefits. We are currently analyzing serum samples collected from the gorillas for makers associated with inflammation and cardiac health. Though the biscuit-free diet is more costly than one based on prepared feeds it has the potential to improve both the behavioral and veterinary health of captive gorillas.

FIFTH CRISSEY ZOOLOGICAL NUTRITION SYMPOSIUM

CONUNDRUM II

Esther Finegan

Concentrates, described by Peter Van Soest as 'high quality, low fiber feeds... that contain high concentration of digestible energy', were developed to provide a balanced diet for fast growing, short lived production herbivores (cattle, sheep, goats) and omnivores (pigs), and more recently for companion animal carnivores (cats, dogs) and herbivores (horses). These concentrate diets, in the form of ground and mixed food components presented as pellets, cubes, biscuits, and less dense extruded kibble, are now fed to almost all zoo species. Concentrate diets are convenient to feed with little residue left to clear away later, and they provide some assurance that a balanced diet (based on current nutritional understanding) is being fed on a daily basis. However, concentrate diets can be consumed quickly and easily, and have been associated with obesity and stereotypic behaviors in zoo species.

A number of recent studies have suggested that feeding only fruit, vegetables, hay or browse branches to herbivores, or whole carcasses to carnivores, may be associated with less obesity and with reduction in many other health problems. Other studies, less often reported, suggest that that the transition from concentrates to unprocessed and more 'natural' foodstuffs may not always be successful. Are concentrate diets the solution or the problem?

HE'S NOT FAT, HE'S FLUFFY
KEEPING ANIMALS IN GOOD BODY CONDITION

Barbara Toddes, Nutrition Program Director, Philadelphia Zoo, Philadelphia PA

Maintaining collection animals in good body condition is the most valuable contribution a zoological animal nutrition professional can make to the field of captive animal management. Animals maintained at optimal body condition for age and stage of life are more active and healthier than over-conditioned or fat animals. The best way to maintain an animal at optimal body condition is to develop a diet and management plan that meets both the nutritional needs of the animal as well as the management needs of the people whom care for the animal. Everything an animal ingests, regardless of purpose, contributes to the overall nutrient and Caloric intake of the animal; therefore, for a diet plan to successfully maintain an animal at optimal it must include everything consumed.

Zoological institutions are constantly challenged to maintain animals in good body condition. Exhibits, social groups, need for behavior enrichment, need for ingested medications, hormonal implants, training and public programs all impact how, when and what an animal is offered to eat. Public perception of animal health, that a large over-conditioned animal is better cared for than an animal at optimal body condition coupled with the fear of rapid weight loss, by animal managers, if a highly valued animal becomes ill, all negatively influence captive animal diets. Meeting the challenge for appropriate and always nutritionally adequate diets is a daunting task and inevitably some animals will become over-conditioned.

Safely reducing the body weight of an animal back to an acceptable level often requires a strategy unique for the individual. Caloric management while providing a diet that satiates the animal are critical aspects of a weight loss as well as weight maintenance program. Exercise can greatly improve the success of a weight loss diet.

SUPERSIZE ZOO – HOW 'BIG' IS THE PROBLEM OF OBESITY IN ZOO ANIMALS?

A.L. Fidgett
North of England Zoological Society, Chester Zoo, Caughall Road, Chester, CH2 1LH, UK

Achieving optimal nutrition is a major challenge for zoos and aquariums. As for humans and companion animals, diet plays a vital role in maintaining health and fending off disease and is not simply a source of calories. However, our knowledge of the nutritional needs of zoo animals is miniscule and we must provide nutritional support for all stages of life. Historical assessment of zoo animal nutrition is hampered by few or no written records of feeding practices, with even less quantitative and qualitative data about feed ingredients and their nutritional contribution. Exceptions to this exist in some long-established zoos, but there are inherent difficulties in examining longitudinal data sets from zoos. Morbidity and disease have often proved a driver in developing our understanding of zoo animal nutritional requirements. Detailed nutrient recommendations are available for various levels of livestock, fur, pet and laboratory animal production and different life stages for the species in question. With so little known about wildlife species, extrapolation from domestic models can be useful, as a starting point at least.

Obesity is defined as an accumulation of excessive amounts of adipose tissue in the body, and has been defined as a greater than 15% increase above the ideal body weight for the individual. Obesity is an escalating global problem in humans, and current estimates suggest that by 2050 almost two thirds of adults in the United Kingdom will be clinically obese. Studies, from various parts of the world, have estimated the incidence of obesity in the pet population to be between 22% and 40% and most investigators agree that, as in humans, the incidence in the pet population is increasing. Human obesity is known to be associated with increased risk of type II diabetes mellitus, cancer, cardiac disease, hypertension, and decreased longevity. Obesity has similarly detrimental effects on health and longevity of dogs and cats, although data are more limited.

Obesity is an inappropriate but adaptive response to an obesogenic environment, which for zoo species is where conditions are outside of the norm over the evolutionary history of the species. Unless and until zoos are able to replicate the exact seasonal, temporal, spatial and nutritional complexity of diets encountered in the wild, animals will be faced with choices they have not evolved to make. We must make their dietary decisions and our challenge is making the right choices, feeding the mind as well as the body. This presentation will explore how big a problem is obesity in zoos, how can we quantify the extent of the problem and evaluate whether we are successful in dealing with it? What role do animal care staff have, in both positive and negative ways and are there cultural differences among institutions that impact animal care and are relevant to obesity?

A METHOD FOR EVALUATING URINE FOR THE PRESENCE OF UROLITHOGENIC COMPOUNDS AND THE INFLUENCE OF DIETARY MINERAL CONCENTRATION ON THEIR FORMATION

Sharon Freeman, PhD.[1*], Matthew Poore, PhD.[2], Gabrielle Young, DVM[3], and Kevin Anderson, DVM, PhD.[3]

[1] North Carolina State University, Field Laboratories Dept., Raleigh, NC, 27695-7643, Sharon_Freeman@ncsu.edu
[2] North Carolina State University, Dept. of Animal Science, Raleigh, NC, 27695-7621
[3] North Carolina State University, College of Veterinary Medicine, Raleigh, NC, 27695-8401

The goat population in the U.S. increased by nearly 280,000 between 1997 and 2002 (USDA, 2002). The increase in the population has also been accompanied by an increase in their popularity as show animals and pets. Pet and show goats are often fed diets high in supplemental feeds and low in forage. The supplements are often commercially-produced, pelleted diets that may not be properly balanced for goats, particularly in the area of mineral nutrition. Imbalances in calcium and phosphorus have led to a rise in the number of cases of urolithiasis. Additionally, show and pet goats are often castrated males (wethers) and if the castration has been accomplished before puberty, the urinary tract is reduced in size as compared to those of intact males, making these animals even more prone to urinary tract blockage (Smith, 2002).

Much investigation into the role of dietary calcium and phosphorus in urolith formation has been completed in sheep (Stewart et al., 1990; Stewart et al., 1991); however, little work has been done in goats. Sheep data (Stewart et al., 1990) suggest that alkaline urine increases the risk of phosphatic urolith formation as does a low dietary calcium to phosphorus (Ca:P) ratio. Like sheep, goats have alkaline urine and are therefore at risk for the development of uroliths. The objectives of our study were: 1) to establish a means of reliably quantifying urolithogenic compounds in goat urine and 2) to investigate the role of dietary calcium and phosphorus in the formation of these compounds.

The relevance of this trial to the zoological industry is clear when the incidence of urolithiasis in captive giraffes is considered. Uroliths were reported as causing death in a giraffe (Wolfe et al., 2000). The similarities of feeding regimens (high supplement, low forage diets) and urine qualities (highly concentrated, alkaline urine) between goats and giraffes also make this work relevant to zoos that house giraffes. Previous work has shown that goats can be used as models for giraffes and that our urine evaluation technique has merit (Sullivan, 2006).

In the present trial, wether goats were fed 1% BW as orchardgrass hay and 3.5% BW as 1 of 4 pelleted supplements in replicated Latin squares (total diet CP formulated at 15%). Supplements varied in Ca and P concentration (0.3 or 0.6%) as well as Ca:P ratio (1:1 or 2:1). Following 14 d of diet adaptation, the goats were placed into metabolism cages for total excreta collection and to obtain fresh urine for microscopic evaluation. Twelve milliliters of fresh urine were processed according to manufacturer's directions (Urisystem, Fisher Scientific, Pittsburgh, PA). The resulting sediment was viewed at 40X magnification and scored for density and qualities of urolithogenic crystals.

It appeared that both Ca:P ratio and concentration of minerals were involved in crystal formation (Table 1). All the goats that received supplement with a 1:1 Ca:P ratio and 0.6% P had high crystal density scores. Most of the goats receiving the diets with Ca:P ratio of 2:1 (0.3% or 0.6% P) with no added salt had moderate to high density scores; however, some had low scores or no crystals present. Adding 2.5% salt seemed to benefit one goat but not the other that received it, as compared to a similar diet without salt. While these results are incomplete, they do indicate that the Urisystem procedure offers a good means of examining urine for the presence of urolithogenic compounds and assigning it scores relative to density and quality of the crystals.

Table 1. Changes in urolithogenic compounds in goat urine as impacted by diet.

Animal ID	Period 1 Diet[1]	Period 2 Diet[1]	Period 1 Quality[2, 3]	Period 1 Density[2, 4]	Period 2 Quality[2, 3]	Period 2 Density[2, 4]
8120	3	2	SB, SB, SB, SB	3, 3, 3, 2	SN, SN, SN, SN	2, 2, 2, 1
8033	3	2	N, N, N, N	2, 2, 3, 3	A, A, A, A	0, 0, 0, 0
8082	2	1	A, N, A, N	0, 1, 0, 1	B, B, SB, SB	3, 3, 3, 3
8169	2	1	NS, N, NS, N	1, 1, 1, 1	SB,SB, SN,SN	2, 2, 1, 1
8125	4	3	N, N, N, NS	1, 1, 1, 1	N, N, NS, NS	2, 2, 2, 2
8041	4	3	NBS, NBS, S, SN	3, 3, 2, 2	N, N, NS, NS	2, 3, 3, 3
8076	1	4	N, N, N, N	3, 3, 3, 3	N, N, NS, NS	1, 1, 1, 1
8173	1	4	N, N, N, NS	3, 3, 3, 3	SN, SN, SN, SN	2, 2, 1, 1

[1] Diet 1: Ca:P = 1:1, P = 0.6%; diet 2: Ca:P = 2:1, P = 0.6%; diet 3: Ca:P = 2:1, P = 0.3%; and diet 4: Ca:P = 2:1, P = 0.6% with 2.5% salt

[2] Scores are from 2 observers viewing 2 slides; observer 1 scores are first 2 and observer 2 scores are second 2

[3] S: amorphous, sandy crystals; B: blunt-ended, well formed crystals; N: needle-like crystals, A: crystals absent

[4] 0: no crystals present; 1: low density of crystals; 2: moderate density of crystals; 3: high density of crystals

REFERENCES

Smith, B.P. 2002. Large Animal Internal Medecine, 3rd ed. Mosby, Inc., St. Louis, MO, p.857.

Stewart, S. R., R. J. Emerick, and R. H. Pritchard. 1990. High dietary calcium to phosphorus ratio and alkali-forming potential as factors promoting silica urolithiasis in sheep. J. Anim. Sci. 68: 498-503.

Stewart, S. R., R. J. Emerick, and R. H. Pritchard. 1991. Effects of dietary ammonium chloride and variations in calcium to phosphorus ratio on silica urolithiasis in sheep. J. Anim. Sci. 69: 2225-2229.

Sullivan, K. 2006. The impact of nutrition on the development of urolithiasis in captive giraffes and meat goats. MS Thesis. North Carolina State Univ., Raleigh, NC.

USDA. 2002. Census of Agricultre. Accessed at http://www.nass.usda.gov/Census_of_Agriculture/index.asp on 04/14/07

Wolfe B. A., Sladky K. K., and Loomis M. R. 2000. Obstructive urolithiasis in a reticulated giraffe (*Giraffa camelopardalis reticulate*). Vet. Rec. 146: 260-261.

CALCIUM AND PHOSPHORUS METABOLISM IN REHABILITATING GREEN SEA TURTLES (*CHELONIA MYDAS*)

Elizabeth Stringer,[1*] DVM, Craig Harms,[2] DVM, PhD, Dipl ACZM, and Jean Beasley, MA[3]

[1]Environmental Medicine Consortium and Department of Clinical Sciences, College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough St., Raleigh, NC 27606; betsy_stringer@ncsu.edu

[2]Environmental Medicine Consortium and Department of Clinical Sciences, College of Veterinary Medicine, Center for Marine Sciences and Technology, North Carolina State University, 303 College Circle, Morehead City, NC 28557; craig_harms@ncsu.edu

[3]Karen Beasley Sea Turtle Rescue and Rehabilitation Center, 822 Carolina Blvd, Topsail Beach, NC 28445; loggrhead@aol.com

Calcium and phosphorus are essential for numerous cellular and extracellular functions. Biochemical analysis is routinely used to assess the physiological status of calcium and phosphorus in animals. However, ionized calcium may be a better indicator, as this is the physiologically active form.

Our study examined a population of rehabilitating juvenile green sea turtles (*Chelonia mydas*) that had markedly inverted Ca: P ratios on pre-release blood work. A clinical diagnostic investigation was conducted to assess ionized calcium and Vitamin D levels in the affected animals.

Animals were initially admitted for various injuries and illness and had been held in captivity for between 7 and 329 days while undergoing treatment and rehabilitation. Turtles were individually housed in indoor saltwater tanks with negligible exposure to natural or artificial UVB light. Other sea turtle species in the facility (loggerhead [*Caretta caretta*] and Kemp's ridley [*Lepidochelys kempii*] sea turtles] did not have the marked Ca: P ratio inversion problem. Four months prior to this investigation, the quantity of squid in the diet of the green turtles was sharply restricted, based on markedly inverted Ca: P ratios, their tendency to consume squid to the exclusion of other food items, and a nutritional analysis of the diet components. The revised diet consisted primarily of bluefish, leafy greens, and occasionally shrimp. A calcium supplement (tablet) was provided in the fish every day, and a multi-vitamin was given in the same manner three times per week. Potential causes for the failure of the revised diet to correct the inverted Ca: P ratios were assessed during the investigation. The failure is believed to be related in part to the food preparation for the smaller green turtles compared with the larger loggerhead and ridley turtles, but may also reflect different dietary and UVB requirements for green turtles.

Blood was collected from the dorsal cervical sinus from each animal. A point-of-care analyzer (i-STAT) was used to measure ionized calcium and blood gas data. Complete blood counts and biochemistries were performed to assess overall health and obtain current calcium

and phosphorus concentrations, and serum 25-hydroxy Vitamin D concentrations were determined.

Initial evaluation indicates that green sea turtles are able to maintain adequate iCa levels despite markedly inverted Ca: P ratios, and that serum Vitamin D correlates positively with Ca: P ratios. We plan to obtain blood from wild green turtles incidentally captured in commercial fishing nets along the North Carolina coast for comparative analysis. These animals are normally extracted from the nets and released as part of a fisheries observer program. Values obtained from these animals can then be used to determine target values to achieve in the rehabilitating animals through ongoing diet and management modifications.

NEW INSIGHTS INTO TRACE MINERAL INTERACTIONS IN RUMINANTS

Stephanie Hansen*, PhD and Jerry Spears, PhD
Department of Animal Science
North Carolina State University
Campus Box 7621 Raleigh, NC 27695
slhansen@unity.ncsu.edu

Ruminant diets often contain high levels of iron, generally due to the consumption of soil or feedstuffs which contain naturally elevated iron concentrations. Increased levels of dietary iron can negatively impact the absorption of other essential trace elements, including manganese and copper. It is well documented that excessive dietary iron reduces copper status of cattle, although the mechanism by which this antagonism occurs is unclear. Additionally, a deficiency of copper, a common occurrence in zoo ruminants, can induce a secondary deficiency of iron. The common link among the absorptive pathways of these trace elements has not been fully elucidated in ruminants; however, our laboratory has recently identified in cattle several proteins known to be essential to iron metabolism in rodents. Among these proteins are the cellular iron importer divalent metal transporter 1 (DMT1), the iron exporter ferroportin, and the multi-copper ferroxidase hephaestin. We examined the regulation of gene and protein expression of these proteins in young calves fed either 60 or 800 mg iron/kg DM for 56 days. Hepatic gene expression of the iron regulatory hormone hepcidin was increased ($P < 0.05$) in calves receiving high dietary iron. Additionally, high iron tended ($P = 0.13$) to decrease duodenal protein levels of DMT1 and reduced ($P < 0.05$) ferroportin protein levels, though no effect on hephaestin was observed. Increased dietary iron resulted in greater ($P < 0.05$) concentrations of liver iron and reduced concentrations of duodenal manganese. Reduced concentrations of duodenal manganese may be due to reduced levels of DMT1, a protein known in rodents to transport both iron and manganese, or due to competition between excessive amounts of dietary iron and considerably lower concentrations of dietary manganese for transport via DMT1. Collectively, our data suggest that high dietary iron may negatively affect manganese absorption, and because the iron content of ruminant diets is often high, further research is warranted.

NORTH CAROLINA ZOO GORILLA CHOW-FREE DIET: A KEEPER'S PERSPECTIVE

Aaron M. Jesue[1*]

[1]North Carolina Zoological Park
4401 Zoo Parkway
Asheboro, NC 27205
aaron.jesue@nczoo.org

Since June 27, 2008, the gorillas at the North Carolina Zoological Park have been offered a new diet that is aimed at correcting problems with captive gorillas: heart disease, lowering cholesterol, and managing geriatric animals. With any new change, the gorillas and keepers both had to adjust to a new system. The zoo's gorilla troop consists of 1.3 gorillas: Nkosi, 17 year old male silverback, Donna, 40 year old female, Katie, 35 year old female, and Hope, 34 year old female. We believe that it was best to transition the gorillas for about one month from a diet that consisted of more fruit, more vegetables, and a commercial chow. These foods could lead to obesity or other health concerns. In others, especially male silverbacks, heart disease called fibrosing cardiomyopathy has been diagnosed. This has severely effected the captive population. Our goal was to address these health issues and come up with a diet that would be important for any gorilla for any stage in their life. The current diet is designed to mimic a wild gorilla diet and encourage foraging. The previous diet was changed to remove most of the fruits, vegetables, and all chow. Leafy greens and more browse items were added to make their diet high in fiber and low in sugar and starch. The number of feedings per day changed from two (fed once in the morning and once in the evening) to four (once in the morning, public feeds at 11:30am and 1:30pm, and once in the evening). Being fed more throughout the day encourages the gorillas to forage for their food and be more active. The gorilla keepers have adapted to the new diet and assisted in the data collection (prior to the new diet and after it had been implemented), measuring food waste, weighing each gorilla weekly, submitting weekly fecal samples for analysis, and managing increased workloads. The gorillas overcame an initial transitional period of one month. They were observed being aggressive with one another, refusing to eat half of their new diet, training for only apples, fluctuating weights, and dealing with numerous medical procedures. During the last five months, the gorillas have increased their activity levels, stabilized their weights, increased their foraging, and increased the amount of food they have consumed. The keepers will continue to monitor behavior, adjust the diet items as needed, and continue reviewing the effectiveness of the new diet.

FIFTH CRISSEY ZOOLOGICAL NUTRITION SYMPOSIUM

CONUNDRUM III

Kimberly Ange- van Heugten

Incoming Fall semester freshmen in the animal science major at North Carolina State University have listed companion animals as their primary species of interest since 1996 (Moore et al, 2008a)*. These numbers were collected via a written survey distributed to students at freshman orientation. A second survey, which included transfer students, was given to graduating seniors (Moore et al., 2008b)*. These surveys asked students to pick species preferences among companion animals, horses, beef cattle, dairy cattle, small ruminants, and swine. Students were also allowed to choose the option of "other" and write in their own examples of species preference. The "other" category has been recorded as the 3rd and 4th most preferred group of the seven choices since 1996. This "other" group was typically identified by students as exotic and zoo animal species.

Students were also asked via the freshman survey to write down their career goals. From 74 to 89 percent (56 to 141 students per year) of these students from 2001 to 2008 reported that their career goal was to become a veterinarian. Since 2001, only one student among the 918 students who filled out the survey listed "animal nutritionist" as his/her career goal.

The conundrum: How can we encourage students who are obviously interested in comparative species and veterinary medicine to focus more on the nutritional management and needs of these animals at an earlier point in their academic careers?

Literature Cited: * (The posters from these presentations originally presented at the American Society of Animal Science 2008 National convention are available for viewing during the current conference poster exhibition)

JA Moore, WL Flowers, & RL McCraw. 2008a. Species preference of incoming animal science freshmen at North Carolina State University. JAS. 86E (Supp 2):99.

JA Moore, WL Flowers, & RL McCraw. 2008b. Changes in species preference reported by animal science graduating seniors at North Carolina State University. JAS. 86E (Supp 2):99.

LIPID KERATOPATHY IN CAPTIVE MORAY EELS

Alison Clode, DVM, DACVOa*, Craig Harms, DVM, PhD, DACZMa
aDepartment of Clinical Sciences, North Carolina State University
College of Veterinary Medicine
4700 Hillsborough Street, Raleigh NC 27606
abclode@ncsu.edu

Background

Although eels are not believed to rely heavily on their sense of sight, their ocular anterior segment anatomy is uniquely modified for their environment. Specifically, eels have a relatively transparent spectacle external to the cornea, which protects the globe and eliminates distortion caused by movement of water over the surface of the eye by a 'streamlining' effect. The spectacle and cornea are structurally similar, consisting of an outer epithelial lining over collagenous stroma. Between the spectacle and cornea is the subspectacular space, filled with a loose layer of connective tissue and mucoid material. While essentially optically clear, the spectacle in healthy individuals has a mild peripheral vascular network that does not appear to adversely impact vision.

Lipid keratopathy, as described in other species, is lipid deposition within the cornea resulting in crystalline opacification, without preceding corneal disease (as is typical of corneal degenerations). Circulating lipid levels are elevated in affected individuals, either secondary to underlying systemic lipid abnormalities, or in association with excessive dietary intake. Lipid keratopathy involving both the spectacle and the cornea has been previously reported in green moray eels. In all species, therapy consists of identifying and treating the underlying metabolic abnormality and decreasing dietary lipid intake. In addition, surgical removal of the lipid has been previously performed in eels.

Purpose

The purpose of this report is to describe the clinical presentation, diagnosis, and nutritional and surgical treatments of lipid keratopathy in captive moray eels.

Methods

Between 2005 and 2008, six green moray (G1 through G6), two reticulate moray (R1 and R2), and three spotted moray (S1 through S3) eels maintained in captivity for variable periods of time received complete ophthalmic exams as part of routine physical exams. Under general anesthesia with MS-222, fluorescein dye staining, slit lamp biomicroscopy, and (when possible) indirect ophthalmoscopy were performed. A clinical diagnosis of lipid keratopathy was made when crystalline opacification was noted in the spectacle and/or cornea of one or both eyes, with variable vascularization. Surgical removal of severe lipid deposition in the superficial spectacle in both eyes (OU) and superficial cornea in the right eye (OD) was performed in G1. Histopathologic evaluation of the spectacle and corneas of G1 and G4 was performed to identify microscopic characteristics of lipid keratopathy.

Serum triglyceride (TG) and cholesterol (CHO) levels were measured in each eel at initial evaluation (time 1), and in two eels (G3 and G4) five weeks later (time 2). Normal values,

extrapolated from reports in both eels and other aquatic species, were defined as CHO <300 mg/dl, and TG <150 mg/dl.

Results

Of the eleven eels examined, lipid keratopathy was diagnosed in 7 (G1 through G5, R2, S2). Time 1 serum CHO levels were elevated (mean 714 mg/dl, range 198 – 1313 mg/dl) in all but two (G5, S3), only one of which had very mild lipid keratopathy (G5). Additionally, serum TG levels were elevated in all eleven (mean 712 mg/dl, range 256 -1657 mg/dl).

At time 1, the diet consisted primarily of mackerel (42.3 – 48.4% fat) and a combination of squid and smelt (12.7-39.5% fat). Subsequently, the diet was gradually changed to primarily lower-fat squid (8.3 -11.4% fat) and capelin (7.0-23.3% fat). At reevaluation 5 weeks later, ocular lipid OU in G3 was markedly reduced, and unchanged in G4. Serum CHO levels were unchanged (G3 1004 to 1018 mg/dl; G4 943 to 958 mg/dl), while serum TG levels actually increased in G3 (774 to 1025 mg/dl), and were unchanged in G4 (454 to 497 mg/dl).

In conjunction with dietary modifications, surgical removal of lipid depositions in the spectacle and cornea in G1 led to increased ocular clarity and improved feeding behavior for up to 11 months of follow-up. G1 died 3 months after a move to another aquarium's giant ocean tank where it could not be closely monitored and eventually went off feed. Gross findings included multifocal lipid deposits in the heart and liver, and histology revealed a fungal myocarditis as the presumed cause of death. G4 died subsequent to anesthesia and surgical correction of a traumatic ocular wound, with significant fat deposition around the heart and gastric ulceration identified at necropsy. Both eels were male. Histopathologic evaluation of ocular specimens from G1 at the time of surgery and G4 at postmortem were supportive of lipid infiltration within the spectacle/cornea, via identification of presumed intrastromal cholesterol clefts and lipid-filled macrophages. These were absent in the eyes of G1 at postmortem.

Discussion

Previous reports of lipid keratopathy in other species link ocular deposition of lipid to increased blood lipid levels, frequently associated with elevated dietary fat intake. Eels in this report were initially being fed high-fat diets in conjunction with a presumed decrease in activity associated with captivity, potentially predisposing them to development of lipid keratopathy. While decreasing the dietary fat intake did not lead to a decrease in blood CHO or TG levels in two eels reexamined shortly after dietary modifications (G3 and G4), G3 did experience marked improvement in the severity of the ocular lesions. Additionally, the ocular lesions in G1 improved significantly following a combination of surgical correction and dietary modification. Eels with comparatively lower plasma cholesterol (198 – 506 mg/dl) and triglycerides (256 – 548 mg/dl) were either recent acquisitions (G6, S2, S3) or had reduced feeding over a prolonged period associated with being held in a smaller off-exhibit tank for management purposes (G1) or for treatment of a cephalic bacterial granuloma (G5).

Conclusion

Lipid deposition in the spectacle and cornea of captive moray eels appears to be one manifestation of excessive dietary lipid intake.

THE EFFECTS OF OBESITY ON TRICAINE METHANESULFONATE ANESTHESIA RECOVERY OF FISH

Eric T. Anderson, DVM

NCSU College of Veterinary Medicine
4700 Hillsborough Street
Raleigh, NC 27606
E_Anderson@ncsu.edu

An eight-year old Sandan Kohaku koi was presented to the North Carolina State University's College of Veterinary Medicine for evaluation of buoyancy problems. Following routine anesthesia with tricaine methanesulfonate (MS-222) at standard dose for physical examination and blood collection for hematology and chemistry evaluation, the koi experienced a prolonged anesthetic recovery. Subsequent to the diagnostic procedures, the patient's condition deteriorated and within 24 hours the animal died. Necropsy of the patient confirmed bacterial granulomas within the pneumatic duct and kidneys, lymphocytic branchitis, and severe rectal prolapse. In addition to these lesions, there was also a moderate to severe amount of intra-coelomic adipose tissue, which was considered to be excessive and indicative of obesity. Though the previously mentioned disease processes may have had some effect on the fish's recovery, the majority of the prolonged recovery was believed to be due to the fish being markedly overweight. MS-222 is highly lipophilic and therefore would be expected to distribute rapidly into adipose tissue creating a depot of drug that can be released gradually back into the blood stream by passive gradient driven diffusion once administration of the anesthetic is stopped and the fish is placed in fresh water for recovery. This could explain the prolonged recovery from anesthesia. On the basis of this case I am proposing to test the effects of obesity on the recovery rate of koi anesthetized with tricaine methanesulphonate in koi by comparing anesthetic recovery times of fish fed high caloric diets, and with increased coelomic adipose tissue as measured ultrasonographically, with those of fish with normal coelomic adipose tissue.

THE EFFECTS OF BODY FAT ON MARKERS OF GLUCOSE AND LIPID METABOLISM IN COMMON MARMOSETS

Michael L. Power[1,2*], Mark A. Paulik[3], Suzette D. Tardif[4,5]

[1] Smithsonian National Zoological Park, Washington DC
[2] American College of Obstetricians and Gynecologists, Washington DC
[3] GlaxoSmithKline, Research Triangle Park, NC
[4] University of Texas Health Science Center, San Antonio, TX
[5] Southwest National Primate Research Center, San Antonio, TX

In the marmoset colony at the Southwest National Primate Research Center there are a number of marmosets that we consider obese. This is based on both body mass and estimates of fast mass. Obesity is generally considered to be a health concern. The consequences of obesity undoubtedly differ among taxa, however. To appropriately manage weight in a captive species we need objective criteria to evaluate what is a healthy versus unhealthy weight. In this study we examine serum parameters of glucose and lipid metabolism in common marmosets that varied in weight over a large range.

Methods

The animals in this study were 65 adult common marmosets (33 males, 32 nulliparous females) that originated from three different sources – two national primate research centers and one commercial vendor. These animals were assigned to on-going projects assessing obesity propensity. They were singly housed and fed, ad lib, a commercial marmoset diet (Purina Mazuri gelled diet; primary ingredients: glucose, casein, ground wheat, corn flour, dehulled soybean meal, gelatin, porcine fat, dehydrated alfalfa meal, dried beet pulp, egg yolk solids, dried whey, soybean oil; 22% protein, 6% fat; 4.47 kcal/g dry weight) and 3-5 days per week were given one small slice of fruit or 1-3 raisins in the afternoon.

Estimates of lean and fat mass were obtained through quantitative magnetic resonance (QMR) scans, using an EchoMRI unit (EchoMRI; Echo Medical Systems, Houston, TX) designed for marmosets. Unsedated animals were placed in a plastic tube, which was then inserted into the magnetic chamber. Scans took less than 2 minutes.

Glucose metabolism (glucose, HbA1C) and lipid (HDL, LDL, VLDL and triglyceride) parameters were measured in blood samples collected into a heparinized syringe from unsedated animals that had been fasted overnight.

We examined the associations among parameters with correlation. We operationally defined obesity as being above the 90th percentile in fat mass (n=6), and compared circulating glucose and lipid metabolism parameters between obese and nonobese individuals by ANOVA.

Results

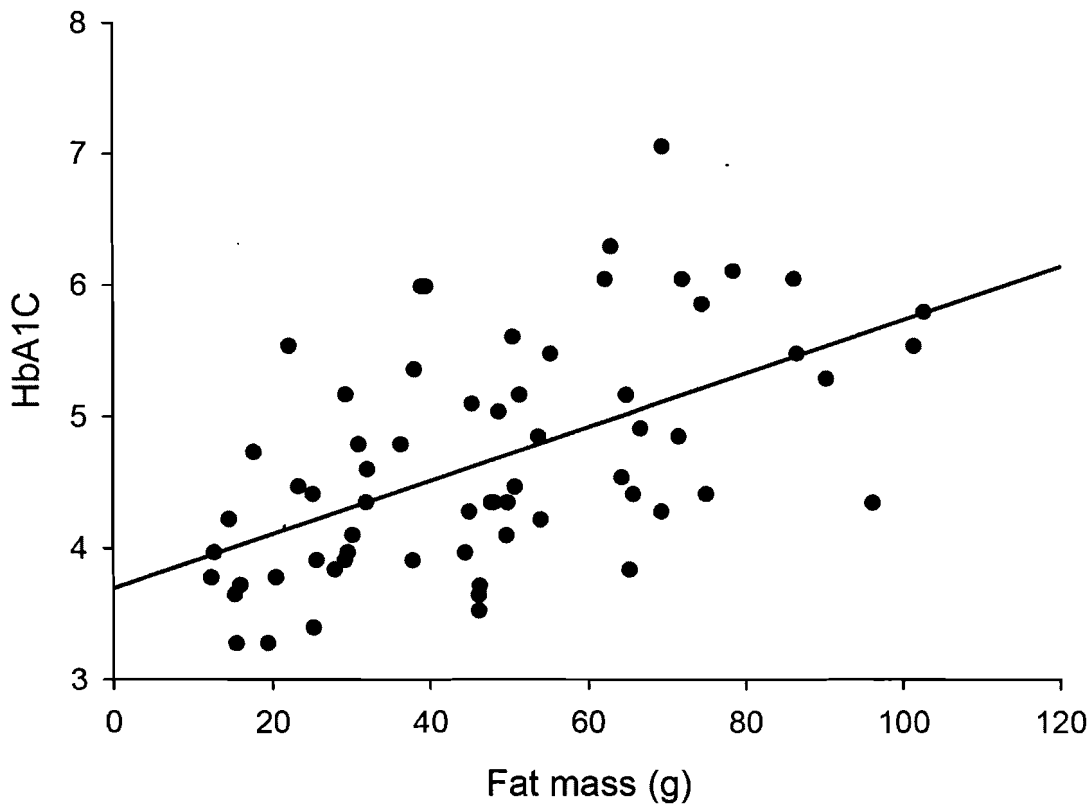
Fat mass was positively correlated with glucose (r=.351), HbA1c (r=.552; Figure 1), triglycerides (r=.424), and very low density lipoprotein (VLDL; r=.552). Fat mass was negatively associated with low density lipoprotein (LDL; r=-.339). Fat mass was not associated with cholesterol or high density lipoprotein (HDL).

Obese animals by our definition had significantly greater blood concentrations of: glucose, HbA1C, triglycerides, and VLDL. There was no significant difference in cholesterol, HDL and LDL.

Conclusions

Although we cannot definitively say that common marmosets that accumulate large amounts of fat suffer a health deficit, they do display characteristics that, in humans, imply impaired glucose metabolism and dysregulation of lipid metabolism that is associated with cardiovascular disease.

Figure 1. Glycosylated hemoglobin (HbA1C), a measure of long term serum glucose levels, increased with increasing fat mass.



FIFTH CRISSEY ZOOLOGICAL NUTRITION SYMPOSIUM

CONUNDRUM IV

Eric van Heugten

Obesity of captive animals can often be linked to behaviors resulting from housing or management situations (temperature, space restriction, etc.) and lack of exercise. For example, group housing of animals may encourage dominant animals to consume excesses of preferred yet less nutritious foods, leading to obesity. Even without dominance issues, individuals may preferentially select food items that are high in sugars and fats, restricting the consumption of items we consider more nutritious.

How do we restrict food intake or nutrient intake in group housed animals to reduce body weight of the group or targeted individuals that are obese? Can we strategically use management, housing alterations, dietary modifications, etc. that will allow us to restrict intake to select animals only? How can we encourage feeding behaviors to increase movement and exercise?

POTENTIAL IMPACT OF SEASON AND DIET CHOICE IN FECAL GLUCOCORTICOID STRESS MONITORING IN AFRICAN HERBIVORES

Sathya K. Chinnadurai, DVM, MS
Resident – Zoological Medicine
North Carolina State University
North Carolina Zoological Park
sathya_chinnadurai@ncsu.edu

Fecal glucocorticoid metabolite (FGM) assays are a popular means of monitoring adrenal activity (i.e., physiological stress response) in wildlife. In addition to stressors, interspecies differences in diet, fecal composition and habitat can affect FGM levels. We validated a commercially available radioimmunoassay (MP I^{125} corticosterone RIA, Solon, Ohio, USA) for measuring FGMs of several South African herbivores, including giraffe *(Giraffa camelopardalis)*, impala *(Aepyceros melampus)*, nyala *(Tragelaphus buxtoni)*, kudu (*Tragelaphus strepsiceros)*, wildebeest (*Connochaetes taurinus)*, and zebra *(Equus burchelli)*. These herbivores are important in South African parks and reserves for ecotourism, as a prey base for predators, and serve an integral role in ecosystem processes. Our biological validation compared samples collected during the wet and dry seasons and showed that the technique was sensitive enough to detect biologically significant changes in FGM production associated with seasonal change. Samples collected during the dry season (June-August) were higher in FGM than those collected in the wet season (December-February), though differences were only significant for browser species. This data suggests that seasonal changes in diet availability may affect FGM levels and that the effect of season is more pronounced in browsing species than in grazing species.

PROXIMATE COMPOSITION OF WILD MOUNTAIN GORILLA MILK

CHRISTOPHER A. WHITTIER[1*], LAUREN A. MILLIGAN[2], MICHAEL POWER[3], FELICIA B. NUTTER[4], AND MICHAEL R. CRANFIELD[5]

[1]Environmental Medicine Consortium and Department of Clinical Sciences, North Carolina State University, Raleigh, North Carolina

2Department of Anthropology; University of California, Santa Cruz, California

[3] Nutrition Laboratory, Smithsonian National Zoological Park, and Research Department, American College of Obstetricians and Gynecologists, Washington DC

[4]The Marine Mammal Center, Sausalito, California

5Mountain Gorilla Veterinary Project Inc, Baltimore, Maryland

Correspondence to: Christopher A. Whittier, DVM, 804-A Smiley Street, Sausalito, CA 94965.
E-mail: chris_whittier@hotmail.com

ABSTRACT

Little published data is available for the composition of milk from nonhuman primates and is especially lacking from great apes. Such data is important for better understanding the role maternal diet plays in milk composition, the comparative ecology and evolution of mammalian milk production, and the nutritional requirements of infants. For many great ape species this data has added relevance because of the necessity for hand raising infants orphaned from poaching and the bushmeat trade. The basic composition of wild mountain gorilla (*Gorilla beringei beringei*) milk was characterized from samples (N = 5) collected opportunistically during field procedures. Gorilla milk was similar in composition to human milk but lower in overall total dry matter, fat, and total energy while higher in total protein.

EVALUATING DIET PREFERENCES IN PIGS WITH POTENTIAL APPLICATION IN ZOO SPECIES

Brynn Seabolt[1], Eric van Heugten[1], Kimberly Ange-van Heugten[1]
[1]North Carolina State University Department of Animal Science and Interdepartmental Nutrition Program, Raleigh, NC 27695-7621, USA

Taste, smell and somatosensing are complex processes involving many different receptors and transduction mechanisms. Feeding zoo species presents many complications, including preference for the consistency of the diet. For example, captive cheetahs are commonly fed commercial soft diets that closely mimic wild diets. However, these diets lack bones, which have abrasive teeth cleaning properties. Dental diseases often result (Marker and Dickman, 2004). Steps need to be taken to attract these animals to abrasive diets that may decrease mortality. In addition, consumption of nutritionally complete diets ensures that animals meet their nutritional requirements. Therefore, maximum palatability of these diets is vital.

Flavors have been used in livestock feeds since the 1960s to enhance palatability and attract animals to their feed. Dried distillers grains with solubles (DDGS) is a byproduct of the ethanol industry that is being fed to livestock species for its cost effectiveness. Pigs are easy livestock animals to work with and are readily obtained, thus were chosen as a model for this research. Studies show that DDGS can be included in piglet diets without affecting growth performance (Whitney and Shurson, 2004). However, other studies have shown that DDGS may be an unpalatable feed ingredient in piglet diets (Hastad et al., 2005). Addition of feed flavors to pig diets containing unpalatable ingredients has effectively recovered feed intake (Duran et al., 2000), indicating the potential for feed flavors to mask unpalatable ingredients in animal feeds.

Two experiments were conducted to evaluate the effect of adding flavor to DDGS containing diets on piglet performance and diet preference. In Exp. 1, 192 pigs (6.7 ± 0.1 kg BW) were allocated to 48 pens with 4 pigs each, blocked by weight. Pens were randomly assigned 1 of 6 treatments; 0% DDGS, 0% DDGS with flavor, 10% DDGS, 10% DDGS with flavor, 20% DDGS, 20% DDGS with flavor. Pigs were adjusted to a commercial complex Starter 1 diet (without DDGS) for 7 d. Starter 1 diets are formulated to provide newly weaned pigs with feed that is energy dense, highly digestible and palatable. Pens assigned treatments with flavor received a flavored Starter 1 diet for 7 days. Pens assigned treatments without flavor received a non-flavored Starter 1 diet. On day 7, a diet phase change occurred, and Starter 2 diets were allocated to their respective pens. On day 21, another diet phase change occurred, and Starter 3 diets were allocated to their respective pens until the end of the trial at day 35. Starter 2 and 3 diets included DDGS at 0, 10, or 20%. These diets are less complex than Starter 1 diets and mostly contain corn and soybean meal. As pigs grow, their digestive tracts mature and are more capable of digesting these less complex and cheaper diets. Pigs were weighed and feed intake was measured weekly. In Exp. 2, 108 pigs (9.0 ± 0.16 kg BW) were given a choice between a control diet (0% DDGS and no flavor) and a diet containing either 0% without flavor, 0% with flavor, 10% without flavor, 10% with flavor, 20% without flavor or 20% with flavor. To determine preference, feed disappearance was measured for two days and preference was calculated as intake of the test diet as a percentage of total intake. In Exp. 1, average daily gain (ADG) decreased with DDGS inclusion during the Starter 2 phase (P=0.06). Average daily feed intake (ADFI) decreased (P=0.03) during the Starter 2 phase. ADFI was significantly increased with flavor supplementation only during the Starter 1 phase (P=0.02), immediately after

weaning. In Exp. 2, preference was lower with inclusion of DDGS in both flavored and non-flavored diets. Preference for the non-flavored diet containing 20% DDGS was different from 50% on day 1, day 2 and overall. However, preference for flavored diets was different from 50% on day 1, day 2 and overall, regardless of inclusion level of DDGS.

These results show that a 2-day assay provides a quick means of measuring palatability of different feeds. While this flavor was not effective at increasing preference, there is evidence from this research that flavors do have the potential to positively affect feed intake when no dietary choice is given, especially in newly weaned pigs. This is a period during which stress levels are extremely high for piglets, as they are removed from their mothers, relocated, mixed with piglets from other litters, and switched from an all milk diet to a dry, pelleted diet. It is a period during which feed intake is minimal, often leading to anorexia which can precede onset of disease. Flavors may be capable of recovering feed intake more quickly during this stressful time, or masking less palatable ingredients. In addition, using byproducts such as DDGS can add value by replacing traditional ingredients, allowing for more cost effective feed formulation. While research with flavors and taste additives has been conducted with zoo species (Moore et al., 2005; NRC, 2003), this research is limited. We expect taste perception to be both species and diet specific; therefore it is logical that a 2-day double choice preference test will have direct applications to identify opportunities that can increase intake of complete feed.

References

Duran R, F Paboeuf, P Jenneskens, J Brenes, F Fort, M Plans & E Roura. 2000. Feed intake in fattening pigs is depressed after dietary inclusions of 5% rapeseed or 10% canola meals but can be sustained by feed flavor (Luctarom®36987Z) supplementation. Proc EAAP-51st An Meet. 6:349.

Hastad W, JL Nelssen, RD Goodband, MD Tokach, SS Dritz, JM DeRouchey & NZ Frantz. 2005. Effect of dried distillers grains with solubles on feed preference in growing pigs. J Anim Sci. 83(2):73.

Marker LL. & AJ Dickman. 2004. Dental anomalies and incidence of palatal erosion in Nambian Cheetahs (*Acinonyx jubatus*). J Mammalogy. 85(1):19.

Moore BD, KJ Marsh, IR Wallis & WJ Floey. 2005. Taught by animals: how understanding diet selection leads to better zoo diets. Int Zoo Yrbk. 39(1):43.

(NRC) National Research Council. 2003: *Nutrient Requirements of Non-human Primates*, 2nd ed. Washington, DC, USA: National Academy Press.

Whitney MH & GC Shurson. 2004. Growth performance of nursery pigs fed diets containing increasing levels of corn distiller's dried grains with solubles originating from a modern midwestern ethanol plant. J Anim Sci. 82(1):122.

INVESTIGATION OF RETINOL STATUS AND METABOLISM IN TWO TOAD SPECIES

Alejandra Renjifo-McComb[1,4*] B.S., M.S. Candidate, Ryan DeVoe[2,3] DVM, MSpVM, DACZM, DABVP, and Jean-Marie Luginbuhl[1] M.S., PhD

[1] Department of Animal Science, North Carolina State University
[2] North Carolina Zoological Park
[3] North Carolina State University Department of Clinical Sciences, College of Veterinary Medicine
[4] alejandra_mccomb@ncsu.edu

The vitamin A status of the Puerto Rican Crested Toad (*Peltophryne lemur)* population housed at the NC Zoological Park will be assessed using two blood plasma analysis procedures. Traditional vitamin A analysis with laboratory equipment (High pressure liquid chromatography [HPLC]) will be compared to Retinol binding protein enzyme immunoassay, a micro-analysis technique that can be conducted without analytical instrumentation. Evaluation of toads fed vitamin A through three different feeding practices will be conducted to determine if differing circulating retinol levels are observed. The three treatments to be used include vitamin-dusted crickets, vitamin gut-loaded crickets and oral-vitamin dosing.

Reverse-phase HPLC will be used to determine if beta-carotene 15,15'-dioxygenase activity is present in captive cane toads (*Bufo marinus*). This enzyme is responsible for the conversion of the carotenoid beta-carotene to retinal. Samples of small intestine, liver and kidney will be evaluated. Findings from both aspects of this research will aid to further the understanding of retinol metabolism in amphibians species.

FIFTH CRISSEY ZOOLOGICAL NUTRITION SYMPOSIUM

CONUNDRUM V

Michael Stoskopf

BIRD BEAK CONUNDRUM

Researchers are trying to find the cause for deformities being spotted among Northwest birds. Misshapen and overgrown beaks are turning up, most commonly among birds of prey and crows, both living and dead. Could there be a nutritional foundation to this problem? If so, what are possibilities?

More details – most common in raptors and crows but possibly also affecting other species such as chickadees and even a report of a hummingbird. Numbers seen range in 100's total, not thousands.

Has been seen along the entire N. pacific coast (Northern California through Alaska) but is concentrated in the Cascade Mtn Region of Washington.

Beaks can be as much as twice the normal length.

Affected birds have very poor body condition, presumably from difficulty feeding.

No evidence of infectious disease (inflammation, etiologic agents etc) has been found.

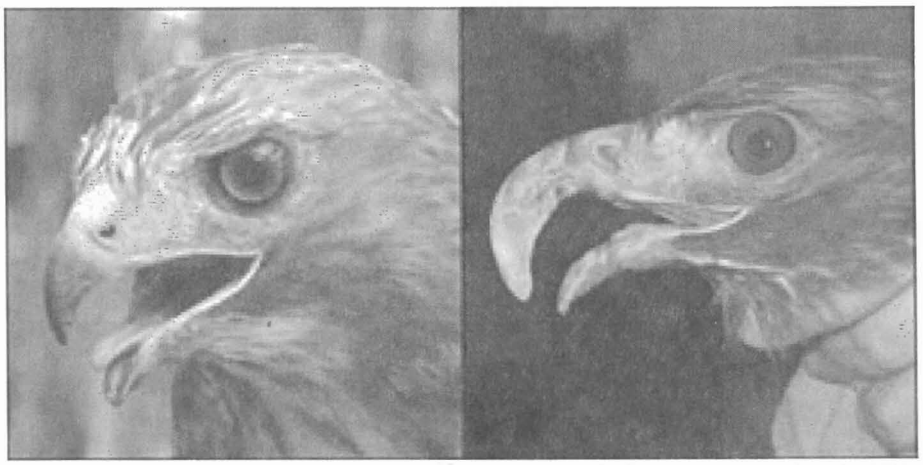


photo courtesy of WSA-VTH

GETTING THE WEIGHT OFF: THE STORY OF WEIGHT LOSS IN 1.1 OCELOTS (LEOPARDUS PARDALIS) AT THE NORTH CAROLINA ZOOLOGICAL PARK

Brigitte Thompson
Zookeeper I Mammals – Sonora Desert Exhibit
North Carolina Zoological Park
4401 Zoo Parkway
Asheboro, NC 27205
brigitte.thompson@nczoo.org

The North Carolina Zoological Park currently houses 1.1 ocelots (*Leopardus pardalis*). During their annual exams in 2006, both were diagnosed by the senior veterinarian as being obese. A strict diet was developed using items found in their normal diet in addition to weight reducing food normally used for domestic cats. By reducing the amount of extra calories found in their normal diet along with controlling their enrichment items both cats lost a significant amount of weight and are now at a weight that classifies them as being healthy. With a little time, patience and some excellent team work this seemingly impossible task became a reality and the North Carolina Zoological Park is home to two healthy ocelots.

This presentation will cover the history of both animals including how they became part of the Zoo's collection and when they gained the weight. It will also show the process of changing the diet of the cats and the challenges that came about while changing it. Operant conditioning methods that were used during the time of the program will be shown along with visual representation of the ocelots' physical appearance before and after the weight loss program.

A DIETARY COMPARISON OF ORNAMENTAL *CYPRINUS CARPIO* COMMERCIAL DIETS

Maria E. Serrano, DVM, Michael K. Stoskopf, DVM, PhD, Dipl. ACZM

Environmental Medicine Consortium and Dept of Clinical Sciences
NC State College of Veterinary Medicine
4700 Hillsborough Street
Raleigh, NC 27606
meserran@ncsu.edu

Nutrition plays an essential role in the health of a fish. To fulfill these nutritional requirements, many diets, home made and commercial are formulated and fed to captive ornamental fish. A particularly large array of commercial "complete" diets targeted at the Koi and goldfish markets can now be easily purchased at retail stores and through the internet. We focused our efforts on Koi because it is a valuable species kept by private enthusiasts and is also found routinely in research, aquarium, and zoo settings.

With such a large selection of available foods, selecting an appropriate diet can be overwhelming for fish owners, and the concept of determining how much to feed fish of a particular diet is also challenging. We examined dietary information from labels of 53 commercial diets intended for ornamental *Cyprinus Carpio*, or Koi to evaluate how well the dietary information provided on the label would support appropriate decision making by Koi owners both in selecting a diet and in determining the correct amount to feed. We looked at products offered by 17 different companies, totaling 53 different Koi diets. Each diet was categorized base on label or promotional literature as either, a seasonal food, a growth enhancer, a color enhancer, or a staple complete diet. The study will report variations in proximate analysis and selected trace nutrients relative to cost and assess the recommended feeding rates.

NUTRITIONAL MANAGEMENT OF AN OBESE SPECTACLED BEAR (*TREMARCTOS ORNATUS*)

Karen J. Lisi, MEM, MS *[1], Tracey L. Barnes, BA[1], Belinda Reser[1], and Mark S. Edwards, PhD[2]
1. Smithsonian National Zoological Park, 3001 Connecticut Ave, NW, Washington, DC 20008
lisik@si.edu, barnestl@si.edu, reserb@si.edu
2. California Polytechnic State University, Animal Science Department, 1 Grand Avenue, San Luis Obispo, CA 93407 msedward@calpoly.edu

The last of the lineage of short-faced bears (subfamily *Tremarctinae*), the Andean, or spectacled bear (*Tremarctos ornatus*) is endemic to the tropical Andes and the sole extant bear species in South America. Much of spectacled bear behavior is related to food selection and abundance and the bears have been known to move significant latitudinal and altitudinal distances and across several types of vegetation in search of food and in response to seasonal ripening. [1,2] In the wild, spectacled bears demonstrate a preference for terrestrial and epiphytic bromeliads; these plants are available year round and thus provide a staple when ripe fruit is unavailable. [2,3] Spectacled and other omnivorous bears have enlarged molar grinding areas and particularly strong jaw muscles to assist in mastication of vegetation. [4] In addition to a wide range of plant material, an estimated 4% of the diet consists of animal matter. [5] Spectacled bears do not hibernate due to year-round food availability throughout their range. [6]

In December, 2006, a fifteen year old male spectacled bear was received into quarantine at the Smithsonian National Zoological Park (NZP). Detailed diet information and a list of approved food enrichment items were provided with the shipment. The base diet was analyzed (Zoo Diet Analysis Program, Allen and Baer) and although diet components were appropriate for this species, the quantity of food was excessive, providing 7570 kcal ME/d. This determination was based on historic diet records for spectacled bears, as well as the estimated maintenance energy requirement of adult inactive dogs [7]: $95(BW,kg)^{0.75}$. Due to poor oral health, the animal had been prescribed long-term medications, and these were noted to be well accepted with vehicles such as honey, molasses, syrup, and jam.

A medical examination was conducted during the quarantine period in January, 2007. Additionally, Nutrition staff assessed body condition, recorded physical measurements, and determined total body fat content by bioelectrical impendance analysis [8]; the clinical record is provided in Table 1. At 222.5 kg, the animal was deemed grossly obese, with a body condition score of 9 on a 1-9 point scale. A weight reduction plan with a specified timeline was developed and presented to NZP veterinarians and animal care staff. The overall goal was gradual but continuous weight loss of 1% of initial BW/week, with a maximum of 2.0% and minimum of 0.5% of initial BW/week [9], to reach an initial summer target BW = 170kg (Figure 1). Fish was found to be an adequate vehicle for medication, and all sugar-based food items were eliminated.

Communication, education, and setting distinct achievable goals, while meeting the animal's husbandry, behavioral, and nutritional needs were key components to successful weight reduction in this specimen. Seasonal target BW ranges were further refined over the following 12 month period (Figure 2) through regularly scheduled body weights, visual body condition assessments, and diet modifications including clearly defined food enrichment.

Literature Cited

1. Rios-Uzeda, B., H. Gomez, and R.B. Wallace. 2006. Habitat preferences of the Andean Bear (*Tremarctos ornatus*) in the Bolivian Andes. J. Zool. 268(3):271-278.
2. Nowak, R.M. 1999. Walker's Mammals of the World, 6th Ed., Vol I. Johns Hopkins University Press, Baltimore, MD.
3. Troya, V., F. Cuesta, and M. Peralvo. 2004. Food habits of Andean bears in the Oyacachi River Basin, Ecuador. Ursus 15(1):57-60.
4. Sacco, T. and B. Van Valkenburgh. 2004. Ecomorphological indicators of feeding behavior in the bears (Carnivora: Ursidae); J.Zool. 263:41-54.
5. Peyton, B. 1980. Ecology, distribution, and food habits of spectacled bears, *Tremarctos ornatus*, in Peru. J. Mammal. 61:639-52.
6. Paisley, S. and D.L. Garshelis. 2006. Activity patterns and time budgets of Andean bears (*Tremarctos ornatus*) in the Apolobamba Range of Bolivia. J. Zool. 268(1):25-34.
7. National Research Council. 2006. Nutrient Requirements for Dogs and Cats. National Academy Press, Washington, DC.
8. Farley, S.D. and C.T. Robbins. 1994. Development of two methods to estimate body composition of bears. Can. J. Zool. 72:220-226.
9. Small Animal Clinical Nutrition, 4th Ed. 2000. Eds: M.S. Hand, C.D. Thatcher, R.L. Remillard, and P. Roudebush. Mark Morris Institute, Topeka, KS.
10. Lundberg, D.A., R.A. Nelson, H.W. Wahner, and J.D. Jones. 1976. Protein metabolism in the black bear before and during hibernation. Mayo Clin. Proc. 51:716-722.
11. Farley, S.D. and C.T. Robbins. 1995. Lactation, hibernation, and mass dynamics of American black bears and grizzly bears. Can. J. Zool. 73:2216-2222.

Table 1. NZP Department of Nutrition clinical record, male spectacled bear quarantine exam.

SUB

1. Body condition evaluated in both lateral and sternal recumbency.
2. Smooth transition from neck into shoulder.
3. Visual evidence of any skeletal landmark lacking throughout.
4. Ribs palpable with heavy pressure. Unable to palpate spine of scapula, spinous processes, tuber ischii, or tuber coxae due to thick layer of subcutaneous adipose tissue.
5. Head of tail difficult to locate due fat layer adjacent to this anatomical landmark.
6. Oral health is compromised, and follow-up procedures are indicated to address.

OBJ

1. Tip of nose to base of skull = 34 cm; base of skull to head of tail = 152 cm; tail = 9.5 cm
2. Right fore leg circumference at elbow = 52.5 cm
3. Right fore foot length = 19 cm; right hind foot length = 23 cm
4. Neck girth = 76.5 cm; chest girth = 132 cm; abdominal girth = 177 cm
5. Axial skin fold thickness = 11.8 mm; inguinal skin fold thickness = 7.5 mm
6. Bioelectrical impendance analysis (BIA) was measured: Resistance = 122
7. Total Body Fat, % = 48.2
8. Body weight recorded = 222.5 kg.

ASMT

1. Specimen is grossly obese (30% over target BW) (BCS = 9 on a 1-9 scale).
2. Total Body Fat measurements (48.2%) exceed those of temperate species bears (*Ursus americanus*) during early winter (31-45%) [8,10,11]

PLAN

1. Diet modifications required to facilitate weight loss, as well as address oral health issues.
2. Initial target BW = 170 kg.

Figure 1. Weight reduction plan for male spectacled bear, with initial seasonal target body weight ranges.

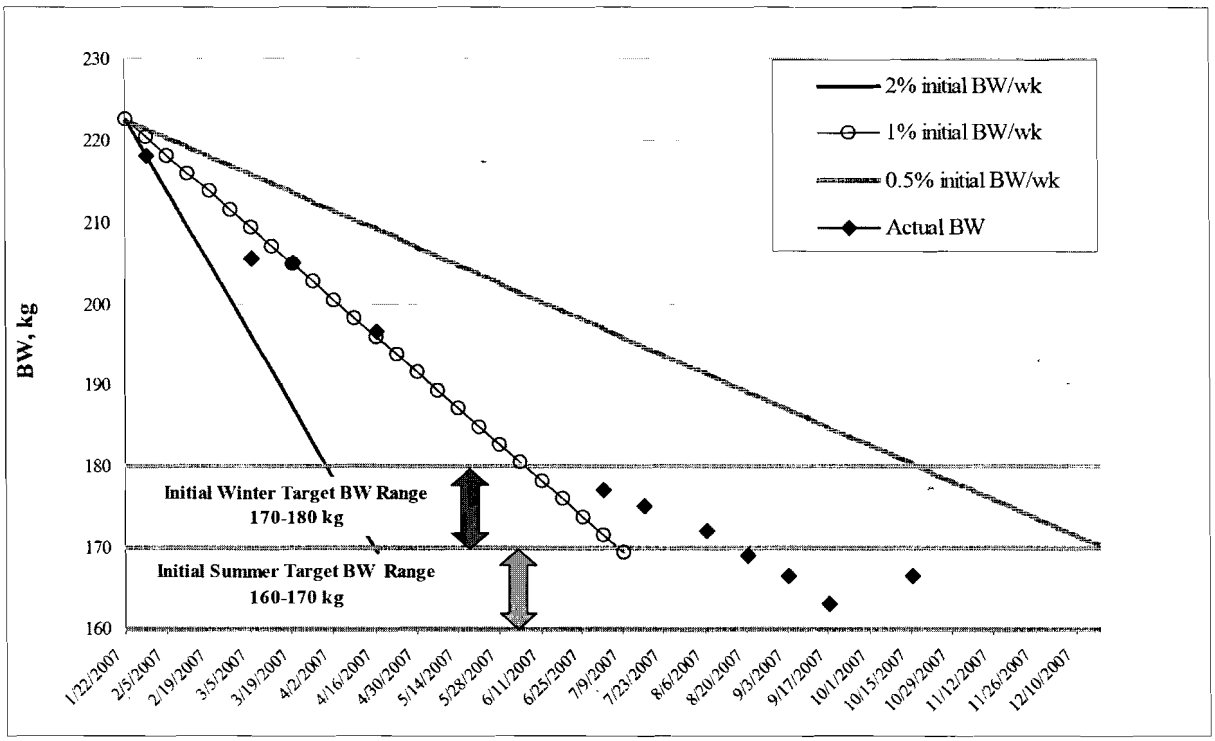
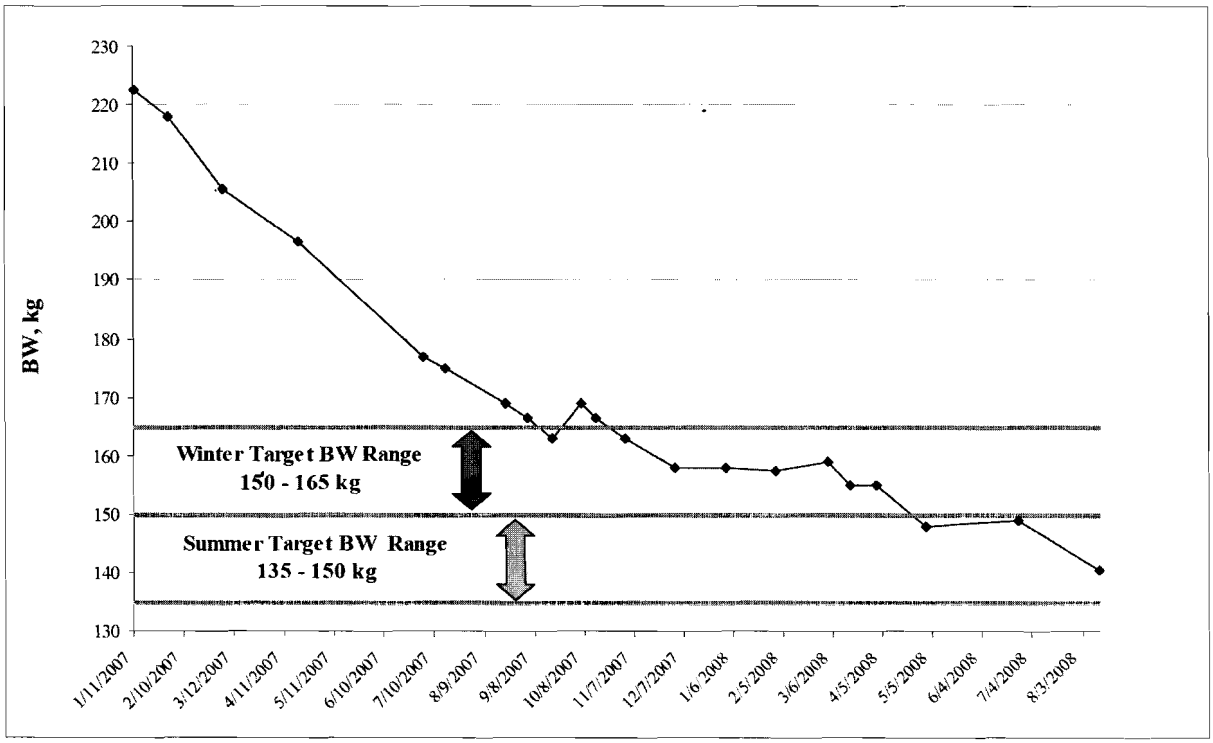


Figure 2. Revised seasonal target body weight ranges for male spectacled bear.



CANINE "BIGGEST LOSER" WEIGHT MANAGEMENT PROGRAM

Crystal L. Baker[1], R. Douglas Cope[2], Kimberly Ange-van Heugten[1]

[1]North Carolina State University Department of Animal Science and Interdepartmental Nutrition Program, Raleigh, NC 27695-7621, USA
[2]Denton Animal Hospital, Denton, NC 27239, USA

It is estimated that at least 20 to 40% of the canine population in the USA is clinically obese (Gossellin et al., 2007). Obesity in canines has been linked to numerous health problems such as heart disease, diabetes mellitus, degenerative joint disease, herniated inter-vertebral disks, high blood pressure, decreased reproductive performance and decreased immune function (Ange and van Heugten, 2002). The scientific approach taken by a veterinarian to diagnose obesity is often more critical of a pet's weight and body condition than the pet owners' (Gossellin et al., 2007). It appears that many pet owners do not understand the health reasons that make it necessary to regulate their companion's weight. To determine a pet's body condition many veterinarians use a standard Body Condition Scoring (BCS) model developed by Purina Mills Inc. This BCS model characterizes canines from 1 to 9 with 1 being emaciated and 9 being obese. Ideal BCS falls between a score of 4 to 5.

A study was completed to determine if adequate exercise and dietary changes could healthily reduce an obese pet's weight. Ten clinically obese dogs with BCS ranging from 8 to 9 were selected to participate in this study. The study participants ranged in starting weight from 16.6 to 126.7 lbs. Due to this wide range in weights, all weight loss and subsequent diet changes were calculated on a percentage of the pet's total body weight. All the dogs were individually owned and volunteered to participate in the study by Denton Animal Hospital (Denton, NC) clients. This study began by taking a canine blood sample to measure electrolytes, T4 and thyroid function, cholesterol metabolites, enzymes used to measure kidney and liver function and general immune function (white and red blood cell count). The obese canines were then placed on a diet of the recommended amount of Purina OM (overweight management) for a period of ten weeks. The amount of OM food given was calculated via Purina's diet software program. This program allowed the veterinarian to enter the canine's current weight, diet desired, and % body weight loss desired per week and the program personalizes a feeding schedule for the canine. Included in this program were the amounts of treats allowable to each dog. For the purpose of this study, treats were limited to carrots and light biscuits. The diet was reevaluated every week and changes were made to ensure an optimum amount of weight loss per week of 2 to 3% (Blanchard et al., 2004). All of the dogs lost weight with a range of 4.4% to 19.0%. The average weight loss was 11.0%. Canines also decreased an average of one BCS. Due to lack of pet owner compliance for second blood draws, a second blood work panel at the end of the study was not completed for the planned health comparisons. However, results indicate that obese canines can rapidly lose weight by their owners establishing a relationship with a veterinarian and following diet and exercise programs. Although more research is needed to establish blood work parameter changes associated with the noted weight loss, it is likely that the dogs in this study are healthier as a result of the decreased BCS.

Acknowledgements: The authors would like to thank Purina Mills Inc. for their financial and experiment design assistance with this project.

Literature Cited

1. Ange K & van Heugten E. 2002. Obesity Part 1: The reasons why obesity in companion animals is not a laughing matter. Animal Science Facts ANS 02-1002C, NC Coop Ext Service. p. 1-4.

2. Blanchard G, Nguyen P, Gayet C, Leriche I, Siliart B & Paragon BM. 2004. Rapid weight loss with a high-protein low- energy diet allows for the recovery of ideal body composition and insulin sensitivity in obese dogs. J Nutr. 134:2148S-2150S.

3. Gossellin J, Wren JA & SJ Sunderland. 2007 Canine obesity –an overview. J Vet Pharmacol Therap. 30 (1): 1–10.

DEVELOPING A GLUTEN-FREE DIET FOR CALLITRICHID PRIMATES

Liz Koutsos [1], Michael L. Power, [2,3,*]

[1] ; [2] Smithsonian National Zoological Park, Washington DC; [3] American College of Obstetricians and Gynecologists, Washington DC

Many callitrichid monkeys are susceptible to intestinal tract pathologies, leading to diarrheas, weight loss, and in the worst cases wasting syndrome. The causes for these pathologies are unknown; but the leading hypotheses are infectious agents, anxiety and stress due to captive conditions, and food allergens. Common marmosets are among the callitrichid species that appear to be especially susceptible to wasting syndrome. In common marmosets the condition is called chronic lymphocytic enteritis (CLE), and is characterized by segmental inflammation of the small intestine, often near the ileo-cecal junction. The intestinal villi are shortened and broadened by the inflammation, significantly reducing absorptive surface area. In end stage disease the small intestine epithelium resembles that of the colon. Thus it is not surprising that animals lose body mass and essentially starve to death.

Not all cases of CLE in marmosets lead to wasting. Indeed, in many instances the CLE is subclinical and does not outwardly appear to affect the animals and is only detected on necropsy. However, research has shown that apparently healthy common marmosets can vary significantly in their ability to digest single-item, homogenous diets (Myers and Power, 2004) and that low digestive ability is associated with low vitamin D status (Jarcho et al., 2005), possibly related to nutrient malabsorption due to subclinical CLE.

A number of investigators have proposed that CLE is analogous to celiac disease in humans (Ludlage and Kansfield, 2003), a disease caused by an allergic inflammatory response to gluten. The evidence for this hypothesis is not overwhelming, however, gluten is certainly an evolutionarily novel for these small monkeys. They certainly have no need of it in the diet, and possibly some individuals would have an immune response to its ingestion. A gluten-free diet for callitrichid monkeys could have some benefit. Producing such a diet from readily available diet ingredients provides something of a challenge. Grains are widespread in our food processing system, and many grains contain gluten. This poster describes the development of such a diet.

The diet was formulated to match the nutrient concentrations of the Mazuri Hi-Fiber Callitrichid Gel Diet. Diet ingredients known or suspected to contain gluten were removed and theoretically gluten-free ingredients substituted. The diet was then assayed for gluten using an enzyme immune assay.An initial formulation of a diet that theoretically was gluten-free turned out to contain a significant concentration of gluten. Individual ingredients were tested for gluten. Those that tested positive were removed and gluten-free ingredients substituted. The second formulation resulted in a diet that tested below the detection limit of the assay.

The diet was offered to golden lion and golden headed lion tamarins at the National Zoological in addition to their regular food. The diet appeared to be palatable. Animals sampled the new diet, and ate small amounts. We plan to conduct more extensive tests of palatability and digestibility on common marmosets at the Southwest National Primate Research Center.

The two diet ingredients that tested positive for gluten were brewers yeast and spinach powder. That brewers yeast would contain gluten makes intuitive sense in hind sight. The yeast is grown on a grain substrate. Why spinach powder would contain gluten is not so obvious. We assayed store-bought frozen spinach and the result was negative for gluten. We hypothesize that the positive gluten result for powdered spinach was due to contamination in the grinding process from grains ground in the same equipment. This type of gluten contamination is probably quite common, and thus is a concern when developing gluten-free or low gluten diets. Even theoretically gluten-free ingredients can contain gluten. Relying on selecting supposedly gluten-free ingredients may not produce a gluten-free diet; actual testing for gluten is a necessity.

Jarcho MJ, Power ML, Tardif SD. Investigating the interplay among digestion, serum 25-hydroxyvitamin D and bone mineral in the common marmoset monkey. Third Annual Sue Crissey Memorial Zoological Nutrition Symposium, 2005,

Ludlage, E. and K. Mansfield. 2003. Clinical care and diseases of the common marmoset (*Callithrix jacchus*). Comp Med 53:369-382.

Myers EW, Power ML. Does variation in digestion among individuals play a role in nutritional health of the common marmoset? Second Annual Sue Crissey Memorial Zoological Nutrition Symposium, 2004, 47-49.

DIETARY RECOMMENDATIONS FOR FOUR SPECIES AT NORTH CAROLINA ZOOLOGICAL PARK

Crystal L. Baker[1,*]; Kimberly D. Ange-van Heugten[1], MS, PhD, PAS; Ryan DeVoe[2,3] DVM, MSpVM, DACZM, DABVP

[1] Department of Animal Science, North Carolina State University
[2] North Carolina Zoological Park
[3] North Carolina State University Department of Clinical Sciences, College of Veterinary Medicine
*clbaker@ncsu.edu

Nutrition research in exotic mammalian species has increased dramatically over the last several decades. However, information for many species is still very sparse. Previous research relies heavily on studies with comparative species and therefore species specific dietary research is a vital function at most zoological parks. A nutritional analysis of four species at the North Carolina (NC) Zoological Park was conducted. These species included: 1.0 geriatric polar bear (*Ursus maritimus*), 1.1 sea lions (*Zalophus californianus*), 2.0 juvenile harbor seals (*Phoca vitulina*), 1.2 Arctic foxes (*Vulpes lagopus*). The daily consumption for these species was monitored and recorded over five days (four days for the Arctic foxes). Feedings were viewed and actual dietary intake was observed. Diets consumed by each individual animal and each species as a group were analyzed for nutritional content using the computer program Zootrition®, St. Louis, MO. Analyzed diets were compared to estimated nutrient requirements for each species. These requirements were obtained from published research and known nutrient requirements for domestic relatives to each species. In general all diets met or exceeded estimated requirements. However, several dietary recommendations were advised. They included: 1) the possible dietary addition of lutein and grapeseed to prevent ocular pathologies in pinnepeds, 2) changing commercial feeds to optimize fecal consistency, 3) using different commercial feeds with known ingredients and guaranteed analyses to ensure estimated nutrient requirements are met, 4) re-evaluating the high fat percentage in the geriatric polar bear diet; 5) re-evaluating the supplements given to the sea lions and seals since the juveniles may be over supplemented while the older animals may be under supplemented and 6) having a commercial lab analyze the NC Zoo fish that are fed to these species for both macro and micro nutrients in order to best compare diet analyses to estimated requirements. Despite these recommendations, it should be noted that all the animals studied at the North Carolina Zoo were generally healthy and they readily consumed their diets. Future species diet analyses are planned at NC Zoological Park to ensure optimal animal health.

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Mazuri® Koi Platinum Wheat Nuggets 50D0

Mazuri® Koi Pond Nuggets 5M78

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Mazuri® Waterfowl Maintenance 5642

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