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Zutrition: Analyzing and Evaluating Diets Fed to Captive Mammals at Capron Park Zoo

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Wildlife conservation education goals are accomplished in part by maintaining healthy captive wild animals in zoos worldwide. An essential part of achieving these goals is undertaking the vast responsibility of caring for these species through proper nutrition and management. Many of these animals found in captivity are endangered or threatened in the wild, which emphasizes the importance of providing these rare species in captivity with utmost care, paying close attention to the husbandry and welfare of each and every animal. One significant way to accomplish this is by meeting the nutritional requirements of each animal kept at zoos. Proper nutrition is imperative to prevent unwanted diseases and ailments that otherwise may not be a problem experienced by the species in their natural habitats.

Having a close association with Capron Park Zoo's veterinarian, Emma Kaiser, my mentor and my internship advisor, has given me the opportunity to explore the field of zoological medicine and research before I head off to attend The Ohio State University College of Veterinary Medicine in the fall of 2014. New research and discoveries are constantly being made in the field of nutrition, which is of utmost importance to be able to develop and grasp a greater understanding of these unusual animals and provide them with better care when kept in captivity. The objective of my project was to analyze, evaluate, and modify the pre-existing diets fed to mammals at Capron Park Zoo and create a hard-bound diet manual to be implemented for daily use by zookeepers within the Zoo. In addition to formulating the new manual with modified diets that will be used in the food preparation room, an Excel program was created for the Zoo to utilize on a regular basis. This program was created in order to help the Zoo's animal feed commissary stay organized and structured, therefore enabling any necessary changes to be easily made to the pre-existing diets in the program while also providing safe record keeping. As a result, even minute alterations of a diet can be tracked, printed, and implemented immediately after the changes are made. To execute this project, relevant literature was reviewed, in addition to information provided by AZA-accredited zoos that employ nutritionists at their facilities.

Aspects which had to be considered when assimilating the natural diets fed to the captive mammals located within Capron Park Zoo included adjusting nutritional requirements based on activity in captivity, having an in-depth knowledge of diets consumed when in their natural wild habitat, guaranteeing the proper balance of essential nutrients, vitamins and minerals, and lastly, ensuring both accessibility and affordability of feeds that would be fed to the animals within the Zoo. Daily consistency and accuracy are the basis for achieving a properly proportioned diet. Usage of terminology such as "slice", "scoop", and "piece" are confusing and often result in imprecision, as various interpretations of such vocabulary will indefinitely lead to inconsistent preparation of the meals by the zookeepers. Here is an example of the pygmy loris diet demonstrating the use of the previous terminology:

Pygmy Loris Diet Per Animal (1.1)

Daily: 1/8 Slice Canned Zupreem Primate Diet, 3 1/2 Leafeater Biscuit Soaked and Crumbled, 30 g Greens

MWFSu: 3/4 HB Egg (White Only), 4 Pieces Apple

TThSa: 2 Pieces of Novel Fruit of Novel Veggie, 8-10 Crickets (Keeper Gets)

W: 8 Pieces of Dry Cat Food, 10 Mealworms (Keeper Gets)

All units of feed in the newly formulated diets were converted to the metric system using grams and kilograms. By using metric units of grams and kilograms, this will help ensure the Zoo's consistency in daily food preparation regardless of who is preparing the diets. This consistency is key to properly managing the animals' overall nutritional health. Although for some species to be off by a "quarter of a slice" in their diet may not be detrimental, for others this may result in a harmful effect over time, such as obesity or the development of diabetes mellitus.

In addition to converting portions of food items into grams and kilograms, the pre-existing diets were rearranged for visual ease. By reformatting how diets are displayed within the Zutrition diet manual, reading and comprehending the diet sheets will become much easier. Prior to this conversion in spatial arrangement, similar food items were grouped together, instead of grouping them by day of the week. For example:

Douroucouli Diet Per Animal (1.1)

Daily: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit

MWFSu: 60 g Apple, 20 g HB Egg, 50 g Cooked Carrot, 25 g Chopped Greens

TThSa: 115 g Cooked Sweet Potato, 30 g Banana, 40 g Leafy Greens, 60 g Unpeeled Orange, 5 g Crickets (Keeper Gets)

This presentation, although spatially concise, makes it difficult for keepers to easily ensure that food items are not overlooked during food preparation, as one must look within the rows to see what is and is not included for each day. All of the animals' diets are made at once and by having to mentally combine rows of what should and should not be fed per day becomes cumbersome and inefficient. Reformatting this display by listing entire diets for each individual day of the week will allow a more precise and potentially faster method of making the diets for the animals at Capron Park Zoo. Here is the same example of the douroucouli's diet but in the new format that will be seen within the Zutrition manual:

Douroucouli Diet Per Animal (1.1)

Monday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 60 g Apple, 20 g HB Egg, 50 g Cooked Carrot, 25 g Chopped Greens

Tuesday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 115 g Cooked Sweet Potato, 30 g Banana, 40 g Leafy Greens, 60 g Unpeeled Orange, 5 g Crickets (Keeper Gets)

Wednesday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 60 g Apple, 20 g HB Egg, 50 g Cooked Carrot, 25 g Chopped Greens

Thursday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 115 g Cooked Sweet Potato, 30 g Banana, 40 g Leafy Greens, 60 g Unpeeled Orange, 5 g Crickets (Keeper Gets)

Friday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 60 g Apple, 20 g HB Egg, 50 g Cooked Carrot, 25 g Chopped Greens

Saturday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 115 g Cooked Sweet Potato, 30 g Banana, 40 g Leafy Greens, 60 g Unpeeled Orange, 5 g Crickets (Keeper Gets)

Sunday: 25 g N/W, 20 g Leafeater Biscuits Soaked and Left Whole, 20 g LS Banana Biscuit or LS Cinnamon Biscuit, 60 g Apple, 20 g HB Egg, 50 g Cooked Carrot, 25 g Chopped Greens

The final alteration Dr. Kaiser and I made to the diets found within the manual entailed converting meals fed *per group of animals* to meals fed *per animal*. Prior to this change, the manual was an assortment of diets fed to groups of animals housed together and others specifically stated that the diet was fed per animal. By changing the diet sheets to quantify meals fed per animal rather than per group made the Znutrition manual uniform and consistent, but also allowed fewer adjustments to be required in the future if an animal should be added to or subtracted from the species group, as the amount of food being prepared per animal would not have to be altered in the diet manual. Making these adjustments in the diet manual were essential, as zoos such as Capron Park Zoo frequently utilize new employees and volunteers to prepare food in the animal commissary. These alterations are in best interest of the animals, and they also function to make the process of training new volunteers and employees less confusing.

Diets between species of mammals differ extensively. This variation across species plays a role in the anatomic structures of their digestive tracts. The greatest differences can be seen between carnivores, herbivores, and omnivores, all of which are found at Capron Park Zoo. A carnivore's diet consists of meat, a source of highly degradable protein that is easily digested by the gastric system of the animal (Comparative Digestion 2010). The short, simple digestive process accomplished by a carnivore belies the anatomic appearance of their gastrointestinal tract. Carnivores have single, simple stomachs, so they are referred to as *monogastrics*. Enzymatic digestion occurs in both the stomach and small intestine of a carnivore and their cecum is basically nonfunctional (Comparative Digestion 2010). Some examples of carnivores at Capron Park Zoo include African lions, servals, an Amur leopard, and even slender-tailed meerkats. Although providing live prey to the carnivorous mammals is not feasible within a zoo environment, it must be guaranteed that the diets they are provided are a close approximation to the nutrients, vitamins, and minerals they would acquire in the wild. For example, the African lion diet fed to the male and female lions at the Zoo is as follows:

African Lion Diet Per Animal (0.2)

Monday: 1.75 kg Bravo, 325 g Beef Heart, Supplements: 2 Tbsp. Laxatone

Tuesday: 1.75 kg Bravo, 2 Chicken Quarters

Wednesday: 1.75 kg Bravo, 325 g Beef Heart

Thursday: 1.75 kg Bravo, 2 Chicken Quarters

Friday: 1.75 kg Bravo, 325 g Beef Heart

Saturday: 1.75 kg Bravo, 2 Chicken Quarters

Sunday: 1 Bone

African Lion Diet Per Animal (1.0)

Monday: 3 kg Bravo, 250 g Beef Heart, Supplements: 2 Tbsp. Laxatone

Tuesday: 3 kg Bravo, 3 Chicken Quarters

Wednesday: 3 kg Bravo, 250 g Beef Heart

Thursday: 3 kg Bravo, 3 Chicken Quarters

Friday: 3 kg Bravo, 250 g Beef Heart

Saturday: 3 kg Bravo, 3 Chicken Quarters

Sunday: 1 Bone

Unlike carnivores, herbivores only consume plants and or plant-like materials, which are composed of high starch and fiber (Comparative Digestion 2010). To accommodate the large amounts of cellulose consumed by these animals, they have large, long, convoluted digestive tracts with a functional rumen and/or cecum (Comparative Digestion 2010). The rumen and cecum are fermentation vats where millions of microflora are found. These bacterial anaerobes release volatile fatty acids, which are an essential source of energy for the animal. Some examples of Capron Park Zoo's herbivores include red kangaroos, Reeves's muntjacs, chinchillas, alpacas and Boer goats. Here is an example of an herbivore diet:

Red Kangaroo Diet Per Animal (5.1)

Monday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 75 g Raw Carrot, 250 g Apple, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Tuesday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 500 g Raw Sweet Potato, 350 g Leafy Greens, 2 Alfalfa Blocks, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Wednesday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 75 g Raw Carrot, 250 g Apple, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Thursday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 500 g Raw Sweet Potato, 350 g Leafy Greens, 2 Alfalfa Blocks, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Friday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 75 g Raw Carrot, 250 g Apple, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Saturday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 500 g Raw Sweet Potato, 350 g Leafy Greens, 2 Alfalfa Blocks, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Sunday: *Free Choice Grass Hay, (P.M.): 350 g Herbivore Mix, 375 g Monkey Chow, 75 g Raw Carrot, 250 g Apple, Supplements: 5 g Vitamin E, 1/2 oz. Strongid 2X, Daily for First Full Week of Each Month- 10 g Horse Bran*

Finally, there is the omnivore, an animal that consumes both plants and meat. Omnivores' gastrointestinal systems are closely related to carnivores but additionally, they have a functional cecum similar to the herbivores (Comparative Digestion 2010). The cecum, however, varies from a true herbivore as it is smaller and less developed (Comparative Digestion 2010). An example of an omnivore at the Zoo is the sloth bear. The following is the captive sloth bear diet:

Sloth Bear Diet Per Animal (1.1)

Bear Mix Ratio: 2 Propac Dog Food: 1 Laboratory Primate Biscuits

Monday: *2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM*

Tuesday: *2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM*

Wednesday: *2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM*

Thursday: *2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM*

Friday: *2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, 25 Mealworms, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM*

Saturday: 2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM

Sunday: 2 kg Bear Mix, 12 g Ground Flax Seed, 70 g Apple or Melon, 70 g Tomato or Kiwi, 70 g Cooked Sweet Potato, 70 g Grapes, 70 g Pear, 50 g Banana, 50 g Orange or Pineapple, 100 g HB Egg, Daily for First Full Week of Each Month- 40 g Horse Bran, 2 g Equine Cosequin w/MSM

When formulating these diets, care must be taken to address any pre-existing diseases or conditions that the animal may have. Three pre-existing diseases that we focused on during this project are hypothyroidism, diabetes mellitus, and inflammatory bowel disease. Hypothyroidism is the disease that occurs when there is a decrease in an animal's metabolic rate due to the suppression of thyroid hormone secretion (Peterson 2013). At Capron Park Zoo, a sloth bear and North American river otter currently have hypothyroidism, which has caused thinning and loss of hair, dry scaly skin, dull hair coat, weight gain, and low body temperature (Hypothyroidism 2009). Adjustment in diets for species with hypothyroidism includes making lower fat diets and supplementing with a thyroid replacement hormone of T3 or T4 (Hypothyroidism 2009). Another disease present at the Zoo occurs in both the fennec fox and DeBrazza's monkey and is known as inflammatory bowel disease. This is a chronic inflammatory gastrointestinal disorder that leads to the thickening of the GI tract and a decrease in digestive function (Inflammatory Bowel Disease 2014). Clinical signs that are observed with this disease include weight loss, diarrhea, vomiting and lethargy. Animals with inflammatory bowel disease should be fed a diet which is high in fiber, low in fat, is easily digestible, and hypoallergenic (Inflammatory Bowel Disease 2014). The last disease we looked at in this project is diabetes mellitus, which is present in one of the ring-tailed lemurs. Diabetes mellitus is the reduction of insulin secretion due to the dysfunction of pancreatic beta cells, resulting in hyperglycemia and glycosuria. The clinical signs of diabetes are weight loss, polyuria and polydipsia (PU/PD), and increased appetite. If this disease is not treated with daily insulin injections, the animal will die (Rucinsky 2010). To minimize the clinical signs of diabetes and also decrease the amount of supplemental insulin required each day, these animals should be fed a high protein, low carbohydrate diet in small, frequent meals (Rucinsky 2010).

Absence in knowledge of many of the natural diets of wild animal species often makes it difficult for zoos to find accurate information about nutritional requirements in captivity. This lack of information, therefore, makes it a challenge to assimilate proper diets for these animals. When searching for reliable literature resources, I was met with some hindrances. One problem was the lack of resources that directly discussed the husbandry and care of captive wild mammals. As these mammals' natural habitats become destroyed, these species are increasingly becoming endangered or threatened, reducing the ability for us to gain qualitative and quantitative knowledge of how, what, and when these species eat in the wild. I believe that it is imperative that associations, especially accredited zoos, establish an agreement to share any research, knowledge, or information regarding these species in order to try and establish the best way to care for these animals in captivity. During my research, I reached out to other zoos in the hope to receive responses from nutritionists regarding the dietary information from their zoo

animals. This, however, was not always successful. One zoo that exemplified how zoological associations could demonstrate teamwork was San Diego Zoo. Their professional nutritionist, Dr. Michael Schlegel, was very kind and more than willing to provide input for the project by providing data for the diets fed to meerkats, red ruffed lemurs, ring-tailed lemurs, sloth bears, and two-toed sloths at their zoo to compare to Capron Park Zoo's diets.

Upon completion of this project, in addition to the valuable information I have gathered from several resources, I have also been able to discover a little more about myself and my own personal values as I prepare myself to become immersed in the veterinary medical sciences this upcoming fall. The project has made me more aware of the varied opportunities this profession will be able to offer me. The need for professionals involved in the research and care of the vast array of animal species will now guide me in the direction of my schooling in veterinary medicine. Although my mentor and I did not perform any primary research during this project, the process of literature review and computer program creation reinforced the idea that a small action can in fact make a large difference. By analyzing, evaluating, and modifying the pre-existing diets fed to mammals located at Capron Park Zoo, this initiative enabled the Zoo to provide their animals with high quality care by giving them a useable guideline for developing consistent, well-balanced, nutritional diets.

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