

**VHL University of Applied Sciences,
EAZA Nutrition Group & Royal Burgers' Zoo**



**8th European Zoo Nutrition Conference
22-25th January 2015
Arnhem**

ABSTRACT BOOK

Abstract Book Editors

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**Safari Meeting Centre
Royal Burgers' Zoo
Antoon van Hooffplein 1
6816 SH Arnhem**

Foreword

Dear Friends and Colleagues,

It is our great pleasure to welcome you to the 8th European Zoo Nutrition Conference organised by VHL University of Applied Sciences, the EAZA Nutrition Group, and Royal Burgers' Zoo.

The EAZA Nutrition Group (ENG) aims "to promote and support nutrition in zoological institutions as an essential component of their conservation mission". Nutrition of zoo animals remains a fascinating and challenging area. Although the past 20 years showed much progress in the development of scientifically based knowledge there are still many questions left unanswered. Specialists in this field remain scarce. Conferences like this, where experiences from practice and new scientific insights are shared, the organisation of workshops and courses, and the availability of an increasing number of publications, are activities vital to the continued progression of zoo animal nutrition.

The central theme of the 8th conference is "Feeding zoo animals for health, welfare and conservation". Of course this was always the underlying theme of our previous conferences. Nutrition is probably the most important factor for establishing healthy and viable captive populations, a huge responsibility for every person or institute keeping animals. Even more so when the results of our combined efforts are highly visible for the millions of people visiting zoos.

When organising the conference we followed the example set in the previous event in Zurich in 2012. This means that we have sought for a mixture of (applied) science and presentations based on practical experiences. The workshop before the conference and the activities during the zoo visit help satisfying the demand for basic and practical applicable information. With respect to costs, attendees of previous conferences emphasized that low conference expenses are very important, quite understandable given the present economic situation and financial status of many zoos. We did our best to keep costs at an absolute minimum. Royal Burgers' Zoo supported us in this effort. They offered us the congress dinner, for which we are extremely grateful, especially to the board of directors, the van Hooff family. Besides this we received all kinds of support from the whole Burgers' Zoo organisation. Our sincere thanks for this.

We gratefully acknowledge financial support via sponsorship by Arie Blok Animal Nutrition, Avian Bird Food Product, Gendika, Cargill Feed & Nutrition Switzerland, Kiezebrink International, Kreca, Masters Diervoeders, Mazuri Zoo Foods, Metazoa Diervoeders, Nijssen Fourages, Ocean Nutrition Europe, Ruto Frozen Fishfood, and St. Laurent. Please make a special effort to thank their representatives for being here at the conference and collect information from them; they help us feed animals optimally.

In addition to the above-mentioned institutes and companies, we are indebted to Sofieke Bouwman and her colleagues in the EAZA Executive Office who bore the considerable administrative burden of processing all your registrations. Furthermore we would like to thank Dr. Marcus Clauss who shared his experiences with the previous conference and advised us on many aspects.

Finally, thank you all for attending this year's conference.

Tjalling Huisman, VHL University of Applied Sciences
Dr. Andrea Fidgett, Chair, EAZA Nutrition Group

January 2015

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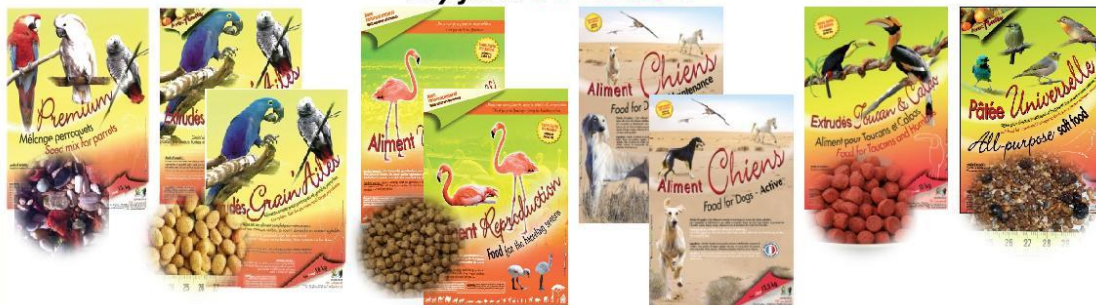


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Conference programme

Thursday 22nd January

EAZA Academy Workshop: *Diet assessment of herbivorous primates and reptiles*

Course lecturers e.o.: Dr. Marcus Clauss, Dr. Andrea Fidgett, Tjalling Huisman, Dr. Joeke Nijboer and Dr. Amy Plowman.

9:00 Opening

9:15 The Gastro Intestinal Tract of two herbivorous taxa, a comparative approach. What are the consequences of gut adaptation and digestive processes for diet design?

10:15 *BREAK*

10:30 Critical nutritional properties of herbivorous diets for primates and reptiles. Commonly used ingredients and which nutrients become critical when used/ overused?

11:30 Calculating diets: how to find, organize and calculate data.

12:15 *LUNCH BREAK*

13:00 Follow the recipe: Preparing diets

14:15 Working with Fauna nutritional software

15:00 *BREAK*

15:15 Fauna continued

16:15 Discussing outcomes
(until 17:00)

18:00 Registration & Icebreaker
(until 20:00)

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08:45 Welcome & Opening Remarks <i>Alex van Hooff, Director Royal Burgers' Zoo</i>	
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09:45 Feeding, nutrition and body condition of UK elephants <i>Andrea L. Fidgett, Catheryn Partington</i>	2
10:00 Hand rearing of baby elephants orphaned from birth <i>Vijitha Perera, Ayona Silva-Fletcher</i>	3
10:15 Calcium metabolism in elephants <i>Linda van Sonsbeek, Willem Schaftenaar</i>	4
10:30 Prevention of dental problems in elephants by diet composition <i>Jan Bos, Linda van Sonsbeek, S.C. Bos, H.O. Hoenderken</i>	5
10:45 Diet, feeding and dental health in herbivores – a review <i>Marcus Clauss</i>	6
11:00 Scientific poster pitches	
11:15 BREAK	
11:45 Ask a shark how to catch a fish! Current feeding practice of captive elasmobranchs <i>Dr Max Janse, Royal Burgers' Zoo</i>	7
12:30 A preliminary study of the foraging strategies of Titicaca water frog (<i>Telmatobius culeus</i>), with some implications for its captive breeding management <i>Arturo Muñoz, An Cools, Annelies De Cuyper, Pascal Boeckx, Geert P. J. Janssens</i>	8
12:45 Nutrition of teleost fish: dealing with diversity! <i>Dr Johan W. Schrama, Wageningen University (co-author Dr Max Janse)</i>	9
13:30 Using science to improve ex situ husbandry of amphibians <i>Rachael E. Antwis, Andrea L. Fidgett, Richard F. Preziosi</i>	10
13:45 LUNCH BREAK	
14:45 Influence of composition and nutritional quality of diets for giraffes (<i>Giraffa camelopardalis</i>) on dry matter intake and feed intake activity <i>Isabel Gussek, Karl-Heinz Südekum, Jürgen Hummel</i>	11
15:00 Investigations on the chemical composition of different seeds and fruits from bushes and trees in nutrition of exotic animals <i>Petra Wolf, Joseph Kamphues</i>	12

15:15	Comparing trace elements in bottlenose dolphin (<i>Tursiops truncatus</i>) in a European facility and in the wild <i>Angela Gimmel, Anja Müller, Annette Liesegang</i>	13
15:30	Animal fibre: A key nutrient to carnivores, but how to determine this dietary fraction analytically? <i>An Cools, Annelies De Cuyper, Jana Pauwels, Geert P. J. Janssens</i>	14
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	- Burgers' Bush: browse and browse quality	
	- Nutrition in education at Royal Burgers' Zoo	
	- Burgers' Ocean: behind the scene tour feeding the aquaria, light as a nutritional source, fish quality	
	- Burgers' Rimba: Body condition score	
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15:45	Does foraging ecology of terrestrial carnivores impact digestive physiology and metabolism? Insights from dogs and cats	23
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09:45	Behavioural effects of fruit-free diets for primates <i>Amy Plowman, Francis Cabana, Katherine Cowlard, Stephanie Britt, Enric Badia, Elizabeth Reeve</i>	30
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Investigating nutrient provision and digestibility of red-crested turaco (<i>Tauraco erythrolophus</i>) diet across several UK collections <i>Alex Hulbert, Kerry Hunt, Paul Rose</i>	40
Gastrointestinal passage in cheetahs fed a natural diet <i>D. Leemans, A. De Cuyper, A. Küntzel-Schmidt, L. Marker, M. Clauss, G.P.J. Janssens</i>	41
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Managing elephant obesity in captivity

Kibby Treiber¹, Adam Reppert¹, Dennis Schmitt², Ann Ward¹

¹Nutrition Department, Fort Worth Zoo, Fort Worth, Texas, USA

²Ringling Bros. Center for Elephant Conservation, Polk City, FL, US

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Obesity in captive elephants is implicated in the poor reproductive success of this declining population. In order to understand and manage the impact of obesity on elephant health and reproduction a standardized system for evaluating elephant fatness is required. Such a body condition scoring (BCS) system can also provide a management tool for establishing and maintaining a target condition in captive elephants. Several BCS systems have been developed internationally for Asian and African elephants. These systems agree well with each other in describing the degrees of the visual appearance of fatness but none have been rigorously validated against other measures of fat. A review of these systems and visual assessment of over 200 standardized photographic records of captive Asian elephants are being compared to longitudinal bodyweights, morphometric measurements and subcutaneous ultrasound with tissue imaging. Preliminary results support the validity of visual assessment to identify changes in bodyweight and degree of fatness. Visual BCS correlated strongly with ultrasound measurements of mid-pelvis depth and rib depth at mid-torso. Visual BCS also correlated to a modified body mass index. Objective ultrasound and morphometric measures showed variability comparable to the inter-scorer variability in subjective visual BCS assessment by trained scorers. Once validated, visual condition scoring systems allow for evaluation of the relationship between body condition and health risks or reproductive success in elephants. They can be used to determine how obesity is related to changes in circulating hormones and metabolites, which may predispose the elephant to health or reproductive risks. As the primary goal of visual BCS is to provide a management tool to avoid health risks, it is equally important to evaluate how management practices – for example diet composition, dietary energy, feeding schedule and exercise - may impact obesity and obesity-related risks. This knowledge can then be used to establish effective guidelines for improving the success of elephants in captivity.

KEYWORDS: Elephant, body condition, ultrasound

Feeding, nutrition and body condition of UK elephants

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The 2008 Defra-commissioned study of elephant welfare in the UK highlighted obesity as a major concern. To address this, the Elephant Welfare Group established a subgroup to look at all aspects of feeding, nutrition and body condition. The aim of this study was firstly to collate and analyse information on current diets and feeding practices across all UK elephant collections and, secondly, to trial a body condition scoring system. Collections were visited during a 6 week period in July and August 2012 and a nutritional husbandry questionnaire used to collect diet information. Elephants were visually assessed using a body condition scoring system developed by Wemmer *et al.* in 2006. The results from the feeding survey highlighted areas where improvements in diets could be made; including a reduction in the quantities of high energy fruits, vegetables and pellets. Since the Defra research, a number of improvements had been put in place and were highlighted, including the increased provision of browse. There was also evidence indicating that body condition scores had improved due to the increased focus on nutrition and obesity. No problems were encountered using the body condition scoring system, with assigned scores and collected profile photographs acting as a useful reference point for future comparison and to evaluate diet changes. All facilities holding elephants in the UK and Ireland agreed to self-report body condition at regular intervals.

KEYWORDS: *Elephant, nutrition, body condition*

Hand rearing of baby elephants orphaned from birth

Vijitha Perera¹ Ayona Silva-Fletcher²

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Feeding an elephant calf separated from the mother at birth is a difficult task. A neonate separated at birth poses more challenges to the nutritionist than a calf orphaned a few weeks or months after birth. In the absence of the mother elephant's milk, the immediate key issues include how to provide a suitable substitute for colostrum containing relevant antibodies and how to cope with 'separation stress'. Added to these problems is our lack of understanding regarding the changes in the composition of milk secreted by the mother as the calf develops. Sri Lanka, which has the highest Asian elephant density per land area, is facing a rising incidence of human-elephant conflict. An increasing number of elephant calves are being orphaned and abandoned at birth. On average about 200 elephants die and about 12-15 elephant calves become orphaned due to this conflict every year. Hand rearing of these calves is the primary purpose of the Elephant Transit Home (ETH), a facility for rehabilitation of orphaned Asian elephant calves prior to release back into the wild. Since its establishment in 1995, over 250 orphaned elephant calves have undergone rehabilitation at the ETH and 90 of them have been successfully introduced back into the wild. In this contribution we describe the successful rescue and hand rearing of the youngest baby elephant received at the ETH. The baby elephant named Kavindee was born on 09-01-2014 in the southern area of Sri Lanka. She was abandoned at birth as the villagers chased away the mother mistaking the sounds of labour as an imminent attack by an elephant. The calf was taken into care within 6 hrs of birth, given oral rehydration solution and kept in the vicinity for 36 hrs with the expectation that mother would return. When the mother did not return the calf was taken to the ETH and was successfully introduced to a feeding regime using a commercial human infant formula. The amount given was adjusted based on the calf's growth rate. The main challenge in the early stages was overcoming diarrhea, which may have been caused by the milk feed being of inappropriate composition for a newborn elephant, or an intestinal infection, or stress caused by the separation from the mother and transport stress, or a combination of all these factors. Based on extensive experience at the ETH, a change of diet was used as to overcome diarrhea and the calf was maintained during diarrheal periods by providing oral rehydration solution, Ringers saline, multivitamins, rice broth, fresh fruit juice and intravenous dextrose. Currently the 10-month-old calf is fed two and half liters of lactogen (50g milk powder/ liter) every three hours and she has joined the other calves at the ETH, freely roaming in the adjacent forest in between milk feeds. Based on our experiences and on our analyses of cases like the reported one, we suggest that it is important to consider nutrient supply, in particular the energy and protein quantity as the calf develops.

KEYWORDS: Baby elephant, hand-rearing, milk feeding

Calcium metabolism in elephants

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In captive elephants in Western Europe, clinical signs of hypocalcemia are seen, especially in Asian elephants. In 2008 and 2009, feeding trials were performed in both elephants species housed at 6 West European Zoos. The aim was to assess the effect of oral calcium and cholecalciferol supplementation on several parameters of calcium status in plasma and urine of captive Asian (*Elephas maximus*; n= 10) and African elephants (*Loxodonta africana*; n= 6) and to detect potential species differences. Calcium and cholecalciferol supplementation were investigated in a feeding trial using a crossover design consisting of five periods of 28 days each in summer. From days 28–56 (period 2), elephants were fed the Ca-supplemented diet and from days 84–112, elephants were fed the cholecalciferol-supplemented diet (period 4). The control diet was fed during the other periods and was based on their regular ration, and the study was repeated similarly during winter. Periods 1, 3 and 5 were regarded as washout periods. Species differences were seen. Asian elephants seem to respond more to the amount of calcium offered in the food, while African elephants seemed to respond more to vitamin D levels in the food/UV-B light. One explanation for this difference could be the difference in length of the digestive tract. Asian elephants have a longer small intestine compared with their African counterparts, therefore leaving more time for (passive) transport of calcium from the gut to the blood. Another possible explanation is the difference of vitamin D production in the skin. People with dark skin have a higher threshold for producing cholecalciferol under influence of UV-B light in comparison of people with a light skin. African elephants do have darker skin and in their natural habitat they receive more sunlight than Asian elephants. Therefore African elephants are suspected to have a higher threshold for syntheses of cholecalciferol as well.

KEYWORDS: *Elephant, calcium, cholecalciferol*

Prevention of dental problems in elephants by diet composition

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The dentition of elephants is unique in various ways: the dental formula, the process of development, the eruptive sequence and the influence of wear on replacement. Cheek teeth erupt from the caudal aspect of the jaw and progress forward, coming into wear sequentially, with one, or parts of two, molars in wear at any one time. Cheek teeth are worn down and have their roots reabsorbed. As they reach the front of the mouth, they are shed in sections and then replaced by the next tooth pushing from behind. Dental health is influenced by the feed quality and composition of the diet. Once the calcification process of the molars is completely underway, at about two years of age, sufficient and even tooth wear is important. This supports the continuing process of eroding away the chewing surface of the tooth at a uniform rate to facilitate the anticipated normal dental wear, growth and replacement. Problems of the molar teeth are in most cases due to impaction of in-use molar teeth that did not drift or erode away. Parodontitis occurs due to infections following impaction of food with or without fractures of the molars. Removal of the attached affected molar is in this case the only therapy. A major preventive measure against impacted molars is a diet that ensures a large amount of high-pressure chewing activity, such as lignified roughages or branches - but also regular dental checks of each individual elephant that are part of the daily routine and recorded periodically in dental charts. The diet of the African elephants (*Loxodonta africana*) in Ouwehand Zoo was reviewed and compared to the needs of elephants in the literature. A substantial amount of willow branches is part of the diet across the whole year. About 15-20 kg of willow branches are consumed daily per elephant. Elephants spend a lot of time peeling off the bark, which extends the foraging time. In an experimental design the elephants showed a strong preference for willow versus hay. They had a substantially increased bite rate consuming hay and willow versus only hay as forage.

Diet, feeding and dental health in herbivores – a review

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The integrity of the masticatory apparatus is considered one of the determinants of the longevity achieved by free-ranging animals. In ex situ populations, deterioration of dental health is often associated with old age, as pathological changes of teeth are most evident in old individuals. In domestic herbivores, such as horses or rabbits and rodents, dental treatments are commonplace in veterinary practice. Dental problems are most often discussed in relation to the abrasiveness of the diet, and the amount of mastication required per unit energy or nutrient on a particular food, but also sometimes with respect to feeding hygiene and the method of offering food. For free-ranging animals, the major abrasive components affecting teeth are considered either abrasives intrinsic to food, in particular the siliceous phytoliths found in monocot (grass) material, and external abrasives such as grit or dust that are inadvertently ingested, with higher loads in animals feeding close to the ground and living in arid (dusty) or volcanic environments. Therefore, grazers and animals from arid environments usually have hypsodont (high-crowned) teeth. Attrition (tooth-to-tooth contact) plays an additional role in dental wear, is higher on diets that need to be chewed more, and may depend on the posture during chewing. Animal husbandry need not necessarily aim at achieving similar dental wear as in free-ranging populations, but at preventing higher – and uneven – wear. Problems typically associated with feeding of herbivores ex situ are caries in cases of excessive dietary sugar levels; excessive/pathologic wear when diet items are presented in a way that external abrasives intake cannot be avoided (e.g., feeding directly on sandy soil); excessive wear when diet items are presented that contain higher amounts of intrinsic abrasives (e.g., monocot products; pelleted feed with siliceous flow enhancers) than occurring in the natural diet (affecting mainly animals with low tooth crowns that are 'browsers', as shown in both ruminants and rhinos); uneven wear when food is presented in a way that prevents the natural chewing position (e.g., offering hay to equids in hay racks, leading to chewing with a 'heads-up' position). While feeding techniques are easily modified to allow the feeding of staple diet items from the ground without grit contamination, the modification of diets to reduce the load of intrinsic abrasives might be more challenging, and require awareness also of food producers. Recent feeding experiments in rabbits and rodents indicate that diet abrasiveness actually does influence tooth wear, but that in animals with ever-growing teeth, tooth eruption rates usually match wear, suggesting that 'excessive tooth growth' is probably more linked to genetic factors of malocclusion than to diets of low abrasivity, and should be addressed by selective breeding.

KEYWORDS: Diet, teeth, chewing, abrasion, grit

Ask a shark how to catch a fish! Current feeding practice of captive elasmobranchs*Max Janse¹**¹Royal Burgers' Zoo, Antoon van Hooffplein 1, 6816 SH Arnhem, The Netherlands**Corresponding email: m.janse@burgerszoo.nl*

Elasmobranch or cartilaginous fishes are common species in public aquaria. An overview will be given on the current practice of elasmobranch feeding. There is always some sort of discrepancy between what a shark would like to eat and what can be provided in captivity. Pre-frozen food make it possible to have always the food available, while live food is difficult to provide, may cause ethical discussions and can be a source of pathogens. The disadvantage of pre-frozen food is the loss of vitamins and taste. So addition of extra vitamins are always necessary. Another concern is the diet: the food types which are commonly eaten by the species in the wild cannot always be provided in captivity. Alternative food items can cause problems of acceptance. Weaning to pre-frozen food and new food items may need individual 'feeding courses' for the animals. How to do this will be touched in the presentation. Definition of feeding ratio is the third important step in feeding practice. Different approaches are presented: 1. the combination of stomach research and gastric evacuation; 2. bioenergetics model; 3. watch your animal. A few species of elasmobranchs will be used as a practical example of what problems can be encountered and what possible solutions can be taken. Finally the feeding frequency is an important issue in elasmobranch nutrition. Disease related to nutritional will be covered on iodine, but also the meaning of not having any appetite. Goiter is a common problem in elasmobranch husbandry, this can be due to iodine deficiency, but also due to too high levels of nitrate in the water. Oral iodine should be given to prevent this problem. Feeding challenges in captive elasmobranchs not only deal with the food, but also with the environment.

KEYWORDS: Elasmobranch, nutrition, diet, frequency, iodine, force feeding

A preliminary study of the foraging strategies of Titicaca water frog (*Telmatobius culeus*), with some implications for its captive breeding management

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Of the more than 7300 species of amphibians in the world, nearly one-third (32%) are threatened. More than 168 species are believed to have gone extinct and at least 2469 (43%) have their populations declining. To try to save these species from extinction, several institutions and initiatives are working in captive management programs of amphibians around the world. In most cases there is a lack of knowledge about adequate nutrition and diets. Food restriction or a low quality food can have an impact on the immune system of an amphibian that shall be released into the wild later. Here we present a study case about a critically endangered, poorly known amphibian of the Bolivian Andes, the Titicaca water frog (*Telmatobius culeus*), endemic to Titicaca Lake, which in the last years had its population declined by more than 80%. We present information on the feeding ecology and nutrition of this species, comparing the contribution of all possible prey items in the diet of the frog in three localities of the lake, using ¹³C and ¹⁵N stable isotope composition of frog tissues and potential preys, and a Bayesian stable isotope mixing model (MixSIAR GUI and SIAR). We provide information on relative abundances of the preys used by *T. culeus* during one year and the nutritional values of each prey item to try to explain the use of these resources by *T. culeus*. We found that the order Amphipoda with the genus *Hyalella* is the most abundant prey species in the lake followed by different species of snails, flat worms, Coleoptera, Chironomidae and Trichoptera. We saw that relative abundances of these resources are not the same along the lake and for some species varied within seasons. Stable isotope based prey source apportionment showed that *T. culeus* uses mainly one of the most abundant macroinvertebrate groups of the lake, but also other less abundant such as flatworms, a previously unknown prey item for the frog. These patterns seem to indicate that *T. culeus* changes its foraging strategies and possibly nutritional metabolism to cope with varying conditions. Systematic variation in body condition between different localities was found, where the community structure of macroinvertebrates seems to be an indicator of a suitable habitat. These results show that this species uses different sources of macroinvertebrates and one fish species with variations among sites and seasons. These observations point to the diversity and specificity of amphibian diets in the wild. Gained insights in wild diet composition might be helpful in optimizing the diet of amphibians in captivity.

KEYWORDS: Amphibians, nutrition, stable isotope

Nutrition of teleost fish: dealing with diversity!

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Numerous fish species are kept in captivity for different purposes such as: the culture of fish for human consumption; ornamental fish in private aquaria; and fish in public aquaria and zoos for display and conservation purposes. Next to the species diversity also culture/husbandry conditions can differ strongly: like salinity; water refreshment; type of waste management; stocking density; compatibility etc. Next to meeting the nutritional requirements, the diet can also indirectly influence the fish through its impact on water quality by feed waste/spillage, faeces and metabolite excretion. In other words, the feed ratio and diet composition are important factors that determine the quality of the environment of captive fish. Optimal feeding/balanced nutrient composition is a prerequisite for the well-being (health and welfare) of captive animals. Compared to terrestrial farm animals and pets, many more fish species are cultured and kept as ornamentals. Moreover, these fish species have a high diversity in feeding ecology. In contrast to terrestrial farm animals and pets, nutritional research has a shorter history and has been spread over a wider range of species. Consequently, those aiming for a proper nutrition of fish often face the limited availability of information. In the presentation, various aspects of dealing with the diversity in fish species as well as husbandry conditions in relation to nutrition will be addressed like: differences in nutrient requirements between fish species; impact of physical condition feed/food type consumed (e.g. size & water content); individual differences between and within fish species; interaction between nutritional requirement and water quality; impact of feeding method and behaviour of fish; impact of fishmeal/oil replacement on diet formulations of fish feeds; impact of diet composition on water quality. For some issues comparison with terrestrial animals will be made.

Keywords: teleost fish; nutrition; feeding methods.

Using science to improve *ex situ* husbandry of amphibians

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Amphibians are currently undergoing global population declines and species extinctions in part due to habitat loss, environmental contamination, harvesting for the pet trade and food industry, and climate change. In addition, emerging infectious diseases such as chytridiomycosis, caused by the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*), are wiping out populations globally. While *ex situ* survival assurance populations for species most at risk are recommended the *ex situ* environment is inherently very different to the wild and often very specific conditions are required for survival and reproduction. Despite a wealth of anecdotal information available, quantitative assessments of different husbandry conditions on the physiology and health of amphibians are rare. We present two studies with relevance for *ex situ* conservation.

Study 1: UV and calcium influence on growth, body condition and reproductive success. One component of captive amphibian husbandry becoming increasingly discussed is the provision of ultraviolet radiation (UVR), required for the synthesis of vitamin D₃ and subsequent assimilation of calcium and phosphorous from the diet. We tested two methods of UV provision ('background UV' and 'background UV with UV boost') and two calcium gut loading diets (5% and 10%) fed to prey, to assess the effects on a range of fitness measures of the red-eyed tree frog (*Agalychnis callidryas*). We found no effects of either UV treatment or calcium diet on growth, body condition, or cutaneous bacterial communities of frogs. Subsequent to the UV boost, frogs experienced a significant increase in fungal load on their skin. Females in the background UV treatment had a higher average number of clutches and eggs, whereas females in the background UV with UV boost had a higher average clutch size. Provision of the UV boost was not demonstrated to provide any real advantages for *A. callidryas* in terms of growth or breeding success. In addition, there were no benefits of a 10% calcium diet over a 5% calcium diet.

Study 2: Carotenoid influence on cutaneous bacterial communities. Amphibians support symbiotic bacterial communities on their skin that play a key role in protecting amphibians from infectious diseases including chytridiomycosis. The conditions amphibians are maintained in *ex situ* conservation programmes may affect the composition of the bacterial community, which may be different in comparison to *in situ* populations of the same species, with implications for the suitability of populations intended for reintroduction. We investigated the effect of a carotenoid-enriched diet on the culturable bacterial community associated with captive red-eyed tree frogs (*Agalychnis callidryas*) and make comparisons to bacteria isolated from a wild population from the Chiquibul Rainforest in Belize. We showed carotenoid availability influences the overall community composition, species richness and abundance of the bacterial community associated with the skin of captive frogs, with *A. callidryas* fed a carotenoid-enriched diet supporting greater species richness and abundance of bacteria than those fed a carotenoid-free diet. We also found wild *A. callidryas* hosted more than double the number of different bacterial species than captive frogs with very little commonality between species. This suggests frogs in captivity may support a reduced and diverged bacterial community in comparison to wild populations of the same species, which could have particular relevance for *ex situ* conservation projects. Our results suggest that availability of carotenoids in the diet of captive frogs is likely to be beneficial for the bacterial community associated with the skin.

KEYWORDS: Amphibian, nutrition, health

Influence of composition and nutritional quality of diets for giraffes (*Giraffa camelopardalis*) on dry matter intake and feed intake activity

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Diets for giraffes can vary considerably in ingredient composition and proportions resulting in rations of different nutritional quality. With regard to recommendations and concerns related to nutrition, dry matter (DM) intake (DMI), nutrient composition of diets and feed intake activity were quantified for twelve groups of giraffes in German zoos. The DMI was estimated on five consecutive days during winter (6 groups) and summer (12 groups). To consider the heterogeneity of the groups, DMI (g/kg metabolic body size [BM^{0.75}]) was standardised to maintenance energy requirements by using factors depending on the status of performance of each individual. Time frames for roughage intake and rumination were evaluated via semi-daily observation periods of 60 minutes with minute-by-minute activity recording (one hour after feeding time in the morning, two hours before feeding time in the afternoon; total of six observation periods per animal). Chemical analysis was done for crude protein (CP), ash, crude lipids and fibre fractions (aNDFom [neutral detergent fibre; assayed with heat stable amylase, expressed exclusive of residual ash], ADFom [acid detergent fibre; expressed exclusive of residual ash], ADL [acid detergent lignin]). Gas production was measured at 24 hours in the Hohenheim gas test for estimating metabolisable energy (ME) for ruminants. For testing correlations (spearman's rho) and differences (Wilcoxon-Mann-Whitney test) SAS 9.3 was used. On average the roughage amount in the observed diets as consumed was 56% (± 11.5), thus not meeting recommendations of at least 50% roughage in all cases. Except in one case lucerne hay was offered for ad libitum intake, added with other forages (up to 14 % of diet DM) and varying amounts of browse (up to 13 % of diet DM) according to season and facility. Despite significantly higher contents of browse and other forages in summer diets ($p < 0.0001$), no difference in roughage intake between seasons was found. Obviously alternating roughage composition is compensated by an increasing intake of roughage available ad libitum. The mean content of nutrient- and energy-providing compounds in diets were 409 (± 38.8) g/kg DM aNDFom, 165 (± 10.3) g/kg DM CP and 10.1 (± 0.58) MJ/kg DM ME and an average DMI of 59.8 (± 8.10) g/kg BM^{0.75} was determined. DMI and aNDFom concentrations were positively correlated ($p = 0.006$), whereas CP and ME contents were negatively correlated with DMI ($p < 0.0001$). This comes along with a positive relationship of roughage content in diet with DMI and a negative relationship of concentrate and produce content in diet with DMI, respectively. In the observed giraffes, DMI seems to be primarily regulated by the energetic value of the diet, not by rumen fill; high amounts of roughage increased duration of roughage intake and rumination. Thus a quantity adjustment of high energy feeds would likely lead to positive effects on the roughage to concentrate-ratio in diets consumed by giraffes, without compromising DMI but with subsequent positive effects on rumen health and feed intake activity.

KEYWORDS: Giraffe diet, nutritional quality, dry matter intake

Investigations on the chemical composition of different seeds and fruits from bushes and trees in nutrition of exotic animals

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A high variety in feeds, offered to exotic animals to enable a typical feeding behaviour (as it can be observed in the wild), may result in a specific supplementation of the ration with some nutrients (for example: high vitamin C content in rose hips) and gives finally a good feeling to keepers to do the best for their animals. On the market, there are products (seeds/fruits) from foreign countries but also of bushes and trees of the indigenous vegetation. As known from other ingredients (like seeds), birds and some mammals ingest either the whole fruit or only certain parts (fruit shell, kernel). Therefore, it is necessary to know which part is really ingested. Moreover, the chemical composition is of interest, even these components are sometimes ingested in only small amounts.

Against this background the investigations were focussed on the chemical composition (crude nutrients, mineral contents) of the whole fruit or of that part of the fruit that is really ingested. Established methods (Weende analysis, atomic absorption spectrometry) were used to characterize the nutritive value of some "unusual" ingredients in pet bird feeding.

The following table gives an overview of the consumed portion of some fruits as well as of its chemical composition. (¹ portion of the whole fruit; K: kernel, S: shell)

		% ¹	DM g/kg FM	crude ash	crude protein	crude fat	crude fiber	NfE	sugar	Ca	P	
]-----in g/kg DM -----[
whole fruit	Chokeberry		961	21.8	48.6	14.2	89	826	237	5.01	1.45	
	Sallow thorn		955	22.3	135	187	164	492	23.0	0.84	2.04	
	Rowan		941	41.8	64.0	41.9	109	743	149	17.8	0.87	
shells	Rose hip	51.2	985	47.3	40.8	11.7	130	770	266	8.98	1.64	
	Blackthorn	39.5	681	43.5	57.4	19.3	178	702	33.1	11.1	1.07	
	Sabal	53.5	976	35.8	44.0	112	176	632	68.2	0.80	0.73	
seeds	Pine	K	47.7	962	43.6	350	347	91	168	---	0.45	9.58
		S	52.3	921	18.6	70.7	72.8	647	191	---	1.42	1.50
	Maple	K	58.8	930	64.9	297	146	100	392	---	9.52	7.21
		S	41.2	919	42.5	49.3	27.6	459	422	---	14.1	1.01

As known from conventional grains and seeds for other animals (e.g. granivorous pet birds) sallow thorn (whole fruit), pines and maple seeds (kernels) are rich in fat and also in protein at the same time; the other components have protein and fat levels that are somewhat lower than in grains and seeds for granivorous birds, as well as the energy contents (calculated to be 16-20 MJ ME/kg DM). In some ingredients (chokeberry, rowan, rose hip) higher sugar contents could be detected. The higher Ca-content of some fruits/seeds (rowan, rose hip, blackthorn and/or maple seed) should be underlined, and might be usefully regarding Ca supply of exotic animals fed these seeds to a high extent.

KEYWORDS: Seeds, fruits, exotic animals

Comparing trace elements in bottlenose dolphin (*Tursiops truncatus*) in a European facility and in the wild

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The objective of this study was to provide blood levels of trace elements of bottlenose dolphins (*Tursiops truncatus*) from a European facility, Kolmården Wildlife Park, Sweden and to compare them to levels of free ranging dolphins from Sarasota Bay, Florida (Bryan, 2007). Free ranging animals are known to eat a variety of different fish, mollusks and crustaceans, which change seasonally and regionally. In a captive environment this variety is often impaired. A small selection of fish combined with the loss of nutrients through freezing and thawing requires a correct supplementation with vitamins and trace elements. In Kolmården Wildlife Park, Sweden, bottlenose dolphins receive multi-vitamins tablets (Nya Seatabs) that in addition to vitamins include the following elements: Iodine (K-Jodid), magnesium (MgO), copper (sulfate), zinc (gluconate) and selenium (Na-selenint-pentahydrate). Blood was drawn during routine medical training and serum was shipped to the IDEXX Laboratory in Germany. A number of different trace elements were tested and the following compared to data measured in whole blood from free-ranging dolphins: Copper (Cu), zinc (Zn), arsenic (As), selenium (Se), strontium (Sr), molybdenum (Mo) and lead (Pb). Normal values for trace elements in bottlenose dolphins are not known; using the data from Sarasota Bay, Florida, is an attempt to create a baseline. Statistical analysis showed that zinc, selenium and strontium were significantly higher in free-ranging dolphins compared to animals in Kolmården, Sweden. The other elements were statistically indifferent. This could indicate that the supplementation of these trace elements might be too low and should be reevaluated. However, comparing trace elements in human whole blood and serum showed that zinc and lead levels are higher in whole blood, whereas selenium and copper levels are very similar. The same could be true for dolphins and thus zinc supplementation might be adequate. Selenium is an essential trace element, as is zinc. They both have antioxidative properties. Dolphins have a higher requirement of antioxidants, as their blubber mass contains unsaturated fatty acids. Fat is particularly susceptible to oxidation and thus uses antioxidants such as selenium and zinc to protect cells from oxidative injuries. Strontium is not an essential trace element, but is structurally very similar to calcium and has the same uptake and metabolic routes. It is found in soil and drinking water as well as in a large group of protozoa, the acantharea, that form a big part of the zooplankton in the ocean. A possible explanation for higher strontium levels in dolphins compared to humans could be that zooplankton is eaten by fish and then is consequently concentrated in fish-eating mammals like dolphins. Environmental strontium levels can be found in highly variable quantities depending on location. A lower variety in fish species and mineral losses through freezing and thawing could be factors that result in lower levels of zinc, selenium and strontium for the dolphins in Kolmården, Sweden. Other factors are regional differences in the concentration of environmental trace elements and the different specimen (whole blood, serum) used.

KEYWORDS: Trace elements, bottlenose dolphin, blood levels

Animal fibre: A key nutrient to carnivores, but how to determine this dietary fraction analytically?

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Recent research in carnivores has shown the importance of the animal fibre fraction in the diet. In general, this animal fibre fraction is described to contain undigested prey parts such as fur, hair, skin, cartilage and bones, but also insect exoskeletons. Together with the interest in this animal fibre fraction, the question rises how it can be quantified. When performing the commonly used techniques for plant-derived fibres such as acid detergent fibre (ADF) or total dietary fibre (TDF) on animal matter, often only small percentages of fibres are detected. However, these methods were developed for plant-derived materials and it is questionable what their value is when applied to animal matter. The TDF analysis is nowadays the standard method for measuring fibre in pet diets. However, the digestion part in this analysis is focused on starch digestion (addition of α -amylase and amyloglycosidase). Additionally, a correction for Kjeldahl nitrogen at the end of the analysis is done. This in order to correct for the undigested proteins left in the residue. However, taking a closer look at the molecular structure of animal fibres, the presence of a significant percentage of nitrogen (2 to 21%) is shown. It is, therefore, not surprising TDF underestimates the animal fibre fraction. Considering the difference between herbivorous and carnivorous digestion, the following experiment adapted the TDF analysis with a carnivorous *in vitro* digestion. Three potential animal fibres were selected and analysed in quadruplicate. A sample of chitin (insect and shellfish derived fibre), pure collagen (structural protein in connective tissue) and chondroitin sulphate (structural component in cartilage) were weighed and phosphate buffer was added. A carnivorous *in vitro* digestion using pepsin (2h incubation) and pancreatin (4h incubation) at the appropriate pH was performed. After digestion ethanol was added and the mixture was incubated overnight to allow precipitation of soluble fibres. Subsequently, solutions were filtered, dried overnight and weighed. Afterwards the residue was incinerated and weighed again. After correction for the added enzymes by subtracting the blank, the method recovered $99.9 \pm 5.5\%$ of chitin, $32.4 \pm 4.9\%$ of collagen, and $26.3 \pm 6.1\%$ of chondroitin sulphate. For collagen this result is markedly higher compared to previously reported results (0.1% for TDF, and 0.7% for ADF). Comparing the results of chondroitin sulphate to the TDF and ADF results of chicken cartilage (13.1% TDF, 1.1% ADF) the present results seem more logic. These first results seem promising not only for determination of animal fibre in carnivorous diets. In conclusion, by adjusting the digestion procedure and nitrogen corrections in the analytical procedures for plant fibres, a higher fraction of animal fibres was recovered. The next important challenge is to further optimize this method for analysis of animal fibres in entire omnivorous and carnivorous diets.

KEYWORDS: Animal fibre, carnivorous diets, nutrient value

A combination of enclosure design and feeding management create an optimal display effect for porcupines (*Hystrix leucura*)

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Porcupines – although interesting both in terms of their external appearance and behavior – are often neglected by zoo visitors due to poor visibility, both due to enclosure design and a lack of motivation for the animals to use that enclosure space where they can be observed by visitors. We used the characteristic that porcupines do not jump down even from moderate heights to modify one part of the enclosure barrier in the form of a large stone platform (30 m²) of approximately 0.8 m height, onto which the animals can easily climb from the inside enclosure via ramps and stairs; there is no visible barrier, but the height prevents animals from escaping towards the visitor side. Rather than feeding the animals their diet of browse, vegetables and pellets at fixed times, only browse and the herbivore pellet ration every morning is provided by animal keepers onto the platform. The other diet items are placed, in specified amounts on a daily basis, in receptacles accessible to visitors, who can put them onto the platform. Since the animals do not know at which time food is given (the principle of an automatic randomizing food dispenser), they immediately run up on the platform as soon as visitors approach. Food amounts and feeding times are scattered irregularly through the day, mimicking a natural foraging behavior. The benefit of this kind of visitor feeding compared to vending machines or food sold at the entrance is that the animals still get a balanced diet and an appropriate quantity, and are thus not getting overfed and become obese. As a result, the porcupine exhibit has become one of the most frequented visitor attractions at our zoo. Animal keepers check the receptacles and enclosure regularly during daily routines to ensure that animals receive their food on visitor-poor days. Problems encountered during the development of the display included a lack of restraint on the part of visitors who reached onto the platform to touch the animals or pull quills. Another problem arose by pushing and shoving at the platform's brim when feeding, which led to few falls and an injury risk for visitors. Therefore, a single-strand low electric wire was mounted on the platform close to the brim, not only to keep animals in, but to keep visitors out. While the mode of animal presentation may be less suitable for large zoos with very high numbers of visitors per day, it represents an attractive option that may set smaller zoos apart. The activity pattern of the porcupines in Zoo Goerlitz has increased by more than 100% since the modification of the feeding management.

KEYWORDS: *Porcupine, feeding management, enclosure design*

Large scale production of willow silage

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Browsers such as giraffes and okapis are difficult to feed in captivity, particularly during fall and winter in cold climates or droughts in warm climates, when fresh browse is not available. Browse silage has been suggested as a suitable substitute for fresh browse, but it is currently not widely used by zoos, likely due to the labor intensive and thereby costly production process. To reduce labor and costs a trial involving automated large-scale harvest was initiated. In a pilot study we found that it was possible to 1) harvest and bale willow automatically, 2) produce silage of acceptable quality from willow (roughly 33% dry matter, 10% crude protein, 42% NDF and 41% in vitro digestibility), and 3) get giraffes to eat willow silage, at least in the small amounts offered. Willow, of the clone Inger (*Salix triandra* x *S. viminalis*), was harvested on the 1st of October 2014. The plants harvested were regrowths from stems cut in February 2014, with an average height of 162 cm, average width at point of cutting of 1 cm (range 0.65 – 1.9 cm) and a stem:leaf ratio of 8.3 on a dry matter basis. Dry matter content of the harvested plants was 41.9%, where dry matter content of leaves, main stems, and small stems (diameter of 0.1 – 0.5 cm) were 40.3%, 42.9% and 30.5%, respectively. Roughly 0.7 hectares was harvested using a custom-built willow harvester (JF Energy Harvester, Ny Vraa Bioenergy I/S, Denmark). During the harvesting process, the willow was cut into 2-3 cm pieces and transferred to a wagon driving alongside the harvester. The cut willow was baled into ~800 kg round bales in an MP 2000 Compactor (Orkel AS, Norway). After baling, Rondotex®Evolution round bale net wrap (RKW SE, Germany) and 20 layers of 0.025mm RaniWrap stretch wrap (Rani Plast, Finland) was wrapped around the bales. Approximately 9 tons of cut willow silage (≈ 3.8 tons DM) was produced in less than 2 effective working hours. Using this method, it is possible to produce large quantities of willow silage – enough to serve as a significant part of the forage offered to captive browsers during periods when provision of fresh browse is challenging.

KEYWORDS: Browse silage, harvesting method, forage

Format FAUNA™ - diet management software for healthy animals

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We all want to feed our animals well. Yet within zoos and aquariums, different stakeholders concentrate on different aspects of feeding; some may be mostly concerned with the nutrient content, others with the way food is presented. The physical and behavioural health of animals may be a principal focus and sustainability, efficiency and costs are becoming increasingly significant drivers. Sharing knowledge about best feeding practices can improve global management of living collections, with anecdotal descriptions replaced by meticulous observation, documentation and analysis. Recording and cataloguing feeding practices and the outcome of adjustments, along with the means for systematic retrieval of said records at some later point in time, would represent a significant advance in the evaluation and dissemination of effective feeding practices. Format FAUNA™ has been specifically designed for zoos and aquariums in response to a direct request from the zoo community. Colleagues from EAZA, AZA and ISIS, working alongside Format International, an industrial partner specializing in animal feed formulation software, have developed FAUNA software to allow better audit and prediction of food use and expenditure within zoos, and the collation of best feeding practices between zoos. Feedback has shaped and will continue to shape FAUNA's evolution. Offering integration with Zoo Information Management Software (ZIMS), it is the first ZIMS complimentary program developed and offers the necessary animal data fields for non-ZIMS subscribers. Our vision is a zoo diet management system for all those concerned with feeding animals well, encompassing features associated with feeding, formulation, inventory management and auditing.

KEYWORDS: Zoo, nutrition, software

Avian Digestion

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Avian feeding strategies, gastrointestinal tract morphology and metabolic capabilities are diverse, and have been interrelated during their evolution. Among all avian organ systems, the gastrointestinal tract demonstrates the highest degree of diversity, from the most simple (nectarivores) to the most complex (herbivores). Gastrointestinal tract patterns of structure and function often are more similar among species with comparable feeding strategies, rather than taxonomic relatedness. As part of an ongoing project, the gastrointestinal tract of 121 specimens representing 71 species from 19 Orders was removed intact, from tongue to vent, and systematically arranged on laminated 1 x 1 cm grid for visual documentation. Measurements (cm) of multiple structures, including the esophagus, total intestine and cecae (when present) were recorded. Structures of the headgut, including the characteristic horny beak, which develops as a rhamphotheca enclosing the upper and lower jaws, have been well described in the literature. Prehension, sorting and some mechanical processing of food may occur in the buccal cavity and pharynx. Movement of ingested material from the buccal cavity to the glandular stomach is the primary function of the esophagus. Temporary storage, softening and swelling of ingesta occurs in an enlarged region of the esophagus (crop) in several species; however, there are no endogenous digestive enzymes secreted into the crop. Any digestion that may occur in this region is related to enzymes already in the food, or those produced by symbiotic microorganisms established in region. Chemical (HCl) and autoenzymatic digestion is initiated in the proventriculus, and continues in the muscular ventriculus where ingesta is stored and mechanically reduced in particle size resulting in increased food particle surface area. Autoenzymatic digestion and absorption of digestive endproducts occurs along the small intestine. Among the species examined, there was a positive relationship of total intestinal length (cm, log₁₀) to bird body mass (g, log₁₀) ($y = 0.4555x + 0.7016$; $r^2 = 0.867$; $n=109$). The form, function and even presence of ceca is widely variable among avian species. Microbial (alloenzymatic) fermentation of carbohydrates that resist digestion by endogenous (autozymatic) enzymes occurs in the ceca of omnivorous and herbivorous species, whose ceca are among the most specialized. Well developed ceca were described in 100% of the omnivorous ($n=10$) and herbivorous ($n=2$) species studied. Although present, ceca may serve in a glandular or lymphoepithelial, rather than intestinal role. Ceca were described in 70% and 75% of the faunivorous and non-herbivorous florivores, respectively. Nutrients contained in diets offered to birds maintained in managed environments cannot be used unless they are ingested and digested. Gastrointestinal tract morphology provides insights into species adaptations to assimilate ingested foods to support their metabolic demands. When collected using standardized methods, and presented in a consistent format, comparative gastrointestinal tract morphology can serve as a valuable reference to formulate and improve science-based feeding programs for both captive and rehabilitation animals, as well as understanding of comparative species digestive processes.

KEYWORDS: *Aves, gastrointestinal tract, diet formulation*

Nutritional disorders of the skeleton in emus and rheas

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Keeping of emus (*Dromaius novaehollandiae*) and rheas (*Rhea americana*) under environmental conditions in Europe is frequently discussed. There are risks for animals' well-being due to the lack of husbandry experience as well as due to the fact that species-specific complete diets are not available continuously. Therefore, home-mixed diets are fed that are often unbalanced and lead occasionally to nutritional disorders of skeleton. In the following examples of such nutritional disorders are described.

Case report 1: Due to a supply shortage, an owner of a small zoo fed emu a home-mixed diet (ingredients: pelleted diets for piglets as well as for rabbits, a supplementary feed rich in protein, CaCO₃). The hatched emu chickens could be adapted very quickly to this diet and showed high growth rates in the first weeks of life. At the age of 3 to 4 weeks, 13 of 37 chickens showed a reluctance to rise or move. One week later these chickens showed ataxic moving activities as well as slight thickening of the distal tibiotarsus and proximal tarsometatarsus that increased in the following 14 days. At the same time the long bones developed rotational deformities (bones turned outwards and caused a „paddling movement“).

Nutritional case history: In a critical examination of mangers a macroscopic difference between the offered feed (pelleted) and the refusals (white-grey fines) could be observed. Crude fiber and starch of the refusals were lower, but crude ash and calcium contents were higher compared to offered ration. Data of blood chemistry showed slightly lowered mineral contents and X-rays underlined the bad posture of the legs.

Assessment: Due to the different prepared feedstuffs of the home-mixed ration (pelleted as well as meal) the ingredients of the diet could not be mixed well, so the emus could prefer the pelleted components (Ca-content in the real intake lower than in the offer; furthermore a protein content of 22% was measured) and refused the mineral supplement. This selective ingesting behaviour, the high growth rate of emu chickens and the insufficient mineralization of skeleton encourages the occurrence of the observed clinical signs (like perosis).

Case report 2: 3 of 15 young rheas (3 months) showed unphysiological postures of the necks vertebral column. The „diet“ was based on corn, pelleted alfalfa, apples, lettuce and white bread in the first 8 weeks of life; afterwards a pelleted complete diet was fed.

Clinical history: The X-ray of vertebral column showed complete healed up fractures of individual vertebrae.

Nutritional case history: Before feeding the complete diet the owner observed a selective ingesting of corn and white bread, whereas the other components were refused. The preferred components are characterized by very low mineral contents (especially calcium, copper).

Assessment: Due to an insufficient mineralization of the skeleton and a high mechanical stress (rough handling to applicate a deworming drug) fractures of the vertebral column occurred. After feeding the complete diet these fractures healed up due to the improved mineral supply by the ingested commercial complete diet.

KEYWORDS: Nutritional disorder, emu, rhea

Investigations on effects of different fibre sources on energy intake and excreta quality in nectarivorous birds

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Obesity belongs to one of the most frequent problems in lorikeets housed as companion pet birds, which are mainly fed with so-called “lory soups” (commercial diets in powder form based on finely ground cereals and bakery byproducts in different water-to-powder ratios). Higher portions of water reduce the energy content of lorikeet diets, but are combined with an undesirable decrease of the typical low dry matter content of the excreta. According to dietetics in dogs or cats it is recommended to add components rich in fibre to these diets. Thus, the aim of this study was to examine possible effects of different fibre sources on energy intake as well as excreta quality in adult lorikeets.

Investigations were carried out with 6 Goldie’s lorikeets (GL; *Trichoglossus goldiei*: 40-50g BW; 1-4y) and 6 rainbow lorikeets (RL; *Trichoglossus haematodus haematodus*: 120-140g BW; 1-12y). During each 13d experiment (5d adaptation, 8d collection) the birds were kept individually in metabolism cages (50 x 30 x 39 cm) and were fed twice a day at 0800 and 1400h with “lory soup” (control) ad libitum. This control diet was supplemented with finely ground (particle size < 0.2 mm) apple pulp (21.3%), oat bran (10.0%) or dried carrot (54.2%) to obtain a fibre level of 5% (DM). Body weight of each lorikeet was determined at the beginning and end of each collection period. Samples of food offered/refused and excreta were taken and analysed (nutrients: proximate analysis; starch/sugar/uric acid: enzymatic test kits). Organic matter (OM) digestibility was corrected for uric acid content of excreta. A modified formula for calculating the digestible energy content of mixed feeds for poultry (1) was used initially. ME content was calculated (ME= DE - energy_{urine}).

Feed, energy and water intake and OM digestibility and excreta quality in adult lorikeets:

diet			“lory soup” (L)	L + apple pulp	L + oat bran	L + carrot, dried
dry matter (% as fed)			18	21	21	21
feed intake (g DM/100g BW/d)	GL		13.3 ± 2.17	24.6 ± 1.24	23.8 ± 1.44	22.6 ± 1.71
	RL		8.24 ± 1.50	14.3 ± 1.61	14.8 ± 2.12	14.9 ± 1.96
energy intake (kJ ME/kg KM ^{0.75} /d)	GL		860 ± 148	1293 ± 87	1363 ± 95	1321 ± 94
	RL		699 ± 101	989 ± 112	1059 ± 134	1084 ± 92
OM digestibility (%; corrected for uric acid)	GL		81.8 ± 2.67	82.0 ± 1.40	81.0 ± 1.27	84.5 ± 0.75
	RL		83.0 ± 3.47	80.3 ± 3.55	80.7 ± 3.13	85.7 ± 3.84
DM content of excreta (%)	1:3*	GL	7.70 ± 1.12**	16.4 ± 0.37	15.8 ± 0.40	10.1 ± 1.15
		RL	8.63 ± 0.99	9.73 ± 1.56	9.29 ± 0.64	7.03 ± 0.34
	1:5*	GL	13.0 ± 2.12	16.0 ± 4.96	15.5 ± 3.11	4.33 ± 2.42**
		RL	8.15 ± 1.40	9.68 ± 1.01	8.73 ± 0.70	6.61 ± 0.71

* relation powder : water

** besides water intake by the liquid diet additional water intake by bowl

Including fibre-containing ingredients in the diet caused (unexpectedly) a markedly increased feed and energy intake above the energy requirement of lorikeets in maintenance (2) which resulted in corresponding weight gains. OM digestibility was reduced only when oat bran was included (3). DM content and consistency of faeces were positively influenced when fibre sources were added.

Addition of different fibre sources to a complete diet for lorikeets (“lory soup”) does not end up in a reduced energy intake as intended (the most interesting finding was the 1.8fold higher feed intake after including fibre ingredients that was presumably not an effect of palatability or reduced energy density), but some of it (added apple pulp, oat bran) improve excreta quality.

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KEYWORDS: Lori, energy, excreta, nectarivorous

Food intake rates of mammals and birds and the influence of body mass

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The bite size (BS) and bite rate (BR) of an animal determine its food intake rate. Food ingesting behaviour makes up a large part of the daily routine of mammalian and avian herbivores, since they have to ingest large amounts of fibrous forage to meet their daily energy demands. Hence, they have to solve the dilemma of conflicting interests in their daily activities between foraging, social behaviour, sleep or predator avoidance. In this study, the role of body mass (BM) in this context was quantified and mammals and birds were compared regarding the influence of BM on instantaneous food intake rate (IFIR) (the first minutes of a meal), BS and BR. Because birds do not chew their food, it was hypothesised that they can increase their IFIR above the upper limit of similar-sized mammals which chew their food.

The species for this study were chosen to increase the existent data available from the literature and to add two new species (Ostrich (*Struthio camelus*), Rabbit (*Oryctolagus cuniculus*)). Bite size and BR were estimated and IFIR was calculated in this study for six species, i.e. three mammals (rabbit, goat and horse; n per species = 3) and three birds (chicken, goose and ostrich; n per species = 3). Animals were fed with fresh grass (vegetative growth, perennial ryegrass and mixtures of other C₃-grasses) only for measuring IFIR, while the rest of their daily intake consisted of their normal diets. To ensure that the animals had to crop the food naturally, the grass was fixed between wooden boards. The first two minutes of foraging were recorded to measure the IFIR [g dry matter/min]. Bite size [mg dry matter/bite] was calculated by dividing the ingested amount of food by the number of bites performed during foraging. During the feeding trials, the animals were filmed for later analysis of the BR [bites/sec].

Combining our own findings with literature results suggested that there is no difference between mammals and birds regarding IFIR, BS and BR. The IFIR (mammals $BM^{0.95}$, birds $BM^{0.82}$) and BS (mammals $BM^{0.83}$, birds $BM^{0.87}$) increased with increasing BM. The factor 'non-chewing' did not increase the IFIR of birds when consuming tall forage because of comparable handling times in mammals and birds. The most influential factor for IFIR seems to be BS. Yet it is difficult to state which factor influences IFIR most, i.e. the mouth/bill length, width, volume or perhaps the basal metabolic rate of the animal.

KEYWORDS: Bite rate, bite size, non-chewing

Does foraging ecology of terrestrial carnivores impact digestive physiology and metabolism? Insights from dogs and cats

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Compared to the behaviour and morphology of terrestrial carnivores, relatively few comparative studies have been performed on the digestive physiology and metabolism. Energy expenditure and requirements in carnivores have been linked to feeding strategies and to body size. Regarding digestive physiology, variation in efficiency of protein and fat digestion among studied canids, felids, hyenids, mustelids, ursids, and pinnipeds is low. For the small domestic cat (*Felis catus*), however, fat digestion is less efficient than that in the larger dog (*Canis familiaris*). For these latter two species, more digestive physiological and metabolic traits have been described. In this review, we linked the traits to the differences in foraging ecology of their close relatives, i.e. grey wolves (*C. lupus*) and wildcats (*F. silvestris*). Cats hunt mainly on small vertebrate prey of about 1% of their body mass (e.g. rodents, lagomorphs, birds) and opportunistically switch between prey type during the year. The average kill rate that a cat requires to sustain is about six average prey per day. The prey typically have high population densities and remain fairly common. Wolves predominantly hunt in packs on large ungulates (e.g. moose, deer, wild boar) but also opportunistically feed on smaller mammals (e.g. beavers, lagomorphs, rodents). Wolves can ingest large meals up to 22% of their body mass. The kill rate of wolves is lower than that in cats. It is estimated that a wolf pack needs to kill a white-tailed deer (*Odocoileus virginianus*) or moose (*Alces alces*) approximately once every 4 or 6 days, respectively. The interval between consecutive ungulate kills can be considerably larger and be even up to weeks due to seasonal fluctuations in prey availability and vulnerability. To cope with such feast-or-famine lifestyle, digestive physiological and metabolic traits are required, which have been found in dogs. For example, dogs can efficiently switch to peripheral use of ketone bodies during fasting making them less dependent on amino acid catabolism for glucose. Such conservation of body protein is a vital coping strategy also observed in other animals adapted to seasonal food shortage. Cats, however, are less capable of conserving protein as they maintain high activities of amino acid catabolizing enzymes for gluconeogenesis. Furthermore, in contrast to cats, dogs can efficiently synthesize nutrients such as arginine, niacin, taurine, vitamin A and long-chain polyunsaturated fatty acids from dietary or endogenous precursors, which is functional to allow physiological and metabolic processes to continue also during long periods with low intake of these nutrients. At present, such traits are not well studied in other large carnivorous species. It may be expected that cougars (*Puma concolor*) and tigers (*Panthera tigris*), which also need to withstand seasonal food shortages like wolves, have therefore developed or preserved similar dog-like traits rather than the traits shown by their small Felidae family member, i.e. the domestic cat.

KEYWORDS: *Carnivores, nutrient requirements, evolutionary adaptations*

Do feeding strategies differ between large and small wild carnivores?*Annelies De Cuyper¹, Myriam Hesta¹, Marcus Clauss² and Geert P.J. Janssens¹**¹Laboratory of Animal Nutrition, Department of Nutrition, Genetics and Ethology, Faculty of Veterinary Medicine, Ghent University, Belgium**²Clinic for Zoo Animals, Exotic Pets and Wildlife, University of Zurich, Switzerland*

In general, wild carnivores spend a high amount of energy when hunting their prey. It is hypothesized that hunting energy expenditure becomes a determining factor for prey size in relation to carnivore size: smaller prey is easier to catch, but at a certain point, the energy cost per prey exceeds the energy gain in terms of nutritional value. A relatively large prey size would logically imply a large relative meal size (unless the larger prey has to be shared among so many individuals that meal size drops to levels of solitary predators of relatively small prey). Increasing meal size implies decreasing feeding frequency (i.e. the time between meals), consequently decreasing hunting behavior which is triggered by hunger. This suggests that the choice for a specific range in prey size by carnivore species may have co-evolved with adaptations in meal size, feeding frequency and feeding selectivity. In the literature, it has been suggested that wild carnivores switch from small- to large-prey-feeding at a body mass threshold of about 20 kg. A literature review was performed from January to August 2014 using Web of Knowledge, Pubmed and Google scholar to identify potentially eligible studies reporting feeding habits of wild carnivores. The literature search yielded 690 potentially eligible studies of which already 118 (37 species) were confirmed eligible and extracted with data. Per carnivore species, data on prey species, prey mass (kg), most frequent prey (%), food intake (kg/day/carnivore), feeding frequency (1 kill/x days) and pack size were extracted. Curve fitting was performed on the relationship carnivore mass vs. mean prey mass of most common prey; carnivore mass vs. mean food intake and carnivore mass vs. feeding frequency and provisional regression equations were derived. So far, carnivores ranging in mass from 0.73 kg to 200 kg were included in the dataset. Carnivore mass had only a weak tendency for a relation with absolute prey mass ($P = 0.084$) and the prey mass to carnivore mass ratio did not increase with carnivore mass, hence not supporting the theory that larger carnivores hunt for relatively larger prey. Food intake could significantly be predicted by carnivore mass ($P < 0.001$) but there was only a weak tendency for a relationship between carnivore mass and feeding frequency ($P = 0.06$). Results suggest that given a typical carnivore size, assumptions can only be made on food intake so far. However, caution is warranted, especially when using data on food intake and feeding frequency since quantitative estimates in the literature are often obtained through different methods and may influence these variables. Moreover, inclusion of more studies is warranted to make more robust statements, which will help to identify feeding strategies for carnivores in captivity to maintain their normal digestive function and satiation.

KEYWORDS: *wild carnivores, prey size, meal size*

Digesta passage rate in three species of felids in captivity.*Jesenia Vásquez-Vargas¹ & Andrea Brenes-Soto²*¹*Animal Science Department*²*Zoo and Wild Animal Nutrition and Management Program, Animal Science Department, University of Costa Rica, San José, Costa Rica**Corresponding email: brenes.andrea14@gmail.com*

Felids are the biggest predators from the Neotropics; several species are endangered because of habitat loss and poaching, among others. Confiscated animals (adults and orphans) are commonly kept in captivity; their adequate management should include an accurate nutrition program to assure good health status and reproductive output. Jaguar (*Panthera onca*, n=5), ocelot (*Leopardus pardalis*, n=5) and margay (*Leopardus wiedii*, n=5) from four zoos and rescue centers in Costa Rica were used for this study. Animals were fed with diets including beef and horse meat, whole chicken and/or chicken giblets. Digesta passage was monitored using colored beads as markers (n=10 per animal). Fecal samples were scored and collected daily until total recovery of the markers, to determine mean retention time (MRT), transit time (TT) and maximum retention time (T_{max}) in hours. Physical characteristics of feces were scored using an established index of 1 (dry, tough) to 3 (high moisture). Variables analyzed included food intake, enclosure area and environmental conditions (temperature and humidity). Average daily food intake (dry matter) was 494 ± 152 g for jaguars, 187 ± 55 g for ocelots and 108 ± 41 g for margays. MRT were numerically higher in jaguars and margays (76 ± 11 and 62 ± 36 h, respectively) compared to ocelots (48 ± 24 h), but TT were similar in ocelots and margays (34 ± 13 and 34 ± 21 h) as opposed to jaguars (43 ± 10 h). T_{max} was 58 ± 13 h, 48 ± 17 h and 53 ± 20 h for jaguars, ocelots and margays respectively. There was a significant effect of environmental temperature ($p=0.04$), whereas species, food intake and enclosure did not show statistical differences. Regarding fecal scores, type 2 (creamy consistency, well defined) were found most often (58 to 62% of the total observations) in the three species. Animals fed with diets including more than 50% of whole chicken or chicken giblets showed feces type 1 and 2, but when beef and/or horse meat was included at 50% of the diet, feces type 3 was observed, in the three species. The results indicate that among the species investigated and diets fed, there is no systematic variation in digesta passage, but that fecal consistency may vary depending on whether whole prey or meat was offered.

KEYWORDS: *Felid, passage rate, nutrition*

Dietary factors associated with faecal consistency and other indicators of gastrointestinal health in the captive cheetah (*Acinonyx jubatus*)

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Gastritis and other gastrointestinal diseases pose significant risks to captive cheetah survival and welfare. Multiple factors are thought to be associated with these diseases, but to date a comprehensive epidemiological survey of disease risk factors has not been conducted. A survey on diet and health parameters was completed by caretakers of 184 captive cheetahs housed in 86 international facilities. Comparisons were made among diet types with respect to disease status (as diagnosed by a veterinarian) and observed faecal consistency reported as observed “always” or “often” in the past 4 weeks. Health factors included current non-specific gastrointestinal disease presence (yes or no), current specific gastrointestinal diseases (e.g. acute gastritis or gastroenteritis), and current non-gastrointestinal diseases (e.g. cancer or renal disease). Additionally, keeper observations of vomiting or diarrhoea in the past 6 months was recorded. Predictor variables included prophylactic treatments in the past week (e.g. vaccination or de-worming), source of current diet fed (e.g. commercially available or raw-meat based), nature of current diet fed (e.g. whole or partial carcass), types of meat fed (e.g. pork or beef or commercial [moist, semi-moist, or dry]), components of meat fed (e.g. hides, long bones, or ribs), daily amount fed (kg, as fed), macronutrients, feeding frequency, history of dental disease (yes or no), type of routine veterinary care provided (e.g. annual physical examination or vaccination), and individual nutrient variables estimated from the Zootrition© database. Commercial diets were defined as those available from a commercial supplier as a pre-packaged diet, whereas raw meat diets included only diets that were prepared by the housing facility as homemade recipes. When faecal consistency was analysed according to diet, extremely dry faeces were most common in cheetahs fed carcasses, but was still of low incidence (15%). Contrastingly, cheetahs fed commercially prepared diets had the highest prevalence of liquid faeces “always” or “often” (9%). Cheetahs fed raw meat diets had the highest prevalence of soft faeces with no shape (22%), as well as and firm and dry faeces (40%). Evaluation of risk factors for current diagnosis of gastrointestinal disease revealed that, when cheetah age and continent were controlled for, feeding of muscle meat at least once per week ($P < 0.001$) was the only variable that maintained a significant protective effect. Diet type (as defined above) did not exert any influence on the health parameters investigated. However, feeding of ribs at least once per week, versus less frequently, reduced the odds of diarrhoea ($P = 0.020$) and feeding of long bones (limbs) at least once per week, versus less frequently, was associated with a lower odds of vomiting ($P = 0.008$). No effect on vomiting was found for ribs, or on diarrhoea for long bones. In the final multivariate analysis involving chronic gastritis as the outcome, where age, sex and continent were controlled for, cheetahs fed muscle meat at least once per week had reduced odds of suffering from chronic gastritis ($P = 0.005$). The only factor identified as increasing the odds of chronic gastritis was feeding of horse “often” or “always” ($P = 0.023$). Previous studies

endorsed the beneficial role of animal fibre in carnivore gastrointestinal health, and the present study adds to the evidence of the modifying and positive effect of carcass component feeding. The findings of the current study build on existing empirical research to support a recommendation towards a greater inclusion of skeletal components. Current husbandry guidelines advocating the use of supplemented raw meat diets are likewise supported, but the use of horse meat, as well as commercially-prepared diets for captive cheetahs warrants caution until further research is conducted.

KEYWORDS: Cheetah, diet, gastrointestinal disease

Seasonal body weight changes and feed intake in spectacled bears (*Tremarctos ornatus*)*Kerstin Gerstner¹, Annette Liesegang¹, Jean-Michel Hatt², Marcus Clauss², Cordula Galeffi³**¹Institute for Animal Nutrition, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland ²Clinic for Zoo Animals, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland**³Zurich Zoo, Zurich, Switzerland**Corresponding email: kgerstner@nutrivet.uzh.ch*

Susceptibility to obesity, probably due to adaptations to a seasonal environment, is known in captive spectacled bears. After successful reduction of the body mass to approximate ideal weight by adapting the diet of the bears at Zurich Zoo cyclic body weight changes became noticeable. We hypothesized that their body mass and feed intake might vary seasonally. Body mass was recorded at least monthly. Food was partially offered by computer controlled feed stations, installed in November 2011 as enrichment devices to induce searching and locomotion in the bears; this part of the daily food consumption was recorded. Several individual time slots (15-60 min each) per day were provided to each bear wearing microchip transponders that are recognized by the feed stations. If the bear visited the feed station within one of these time slots, it received pelleted feed and the computer recorded a successful visit; unsuccessful visits (when the bear approached a box outside of its allocated time slot) were also recorded. The amount of a single portion provided by the feed station was adapted by modulation of the duration of the output. The pelleted diet in the feed stations was provided additionally to a daily ration containing fruits and vegetables. Formulas developed for dogs were used to estimate the metabolizable energy (ME) content of the diet and maintenance requirement of the bears depending on their individual body weight. The body weight showed seasonal changes with maximum weights in springtime and minimum weights in autumn. Daily feed intake showed a high variance but although the exact daily intake of the additional diet (app. 13.4 MJ ME per male bear & day) is not known, the measured feed intake from feed stations and the calculated walking distances showed a peak in autumn. Exemplary results of one day of the male bear in a phase with low (BM_{low} October 2012, 130.2 kg) and high body mass (BM_{high} , April 2013, 146.2 kg) were: food intake from feeders (BM_{low} 596.46 g; BM_{high} 278 g), maintenance requirement according to actual body weight (mean; BM_{low} 19.27 MJ ME; BM_{high} 21.02 MJ ME), energy intake from pellets (BM_{low} 8.2 MJ ME; BM_{high} 3.8 MJ ME). Although there is a high human influence on the kind and amount of diet provided, a seasonal effect was shown for body weight and feed intake in spectacled bears in human care with close to ideal body weight. We hypothesize that seasonal body mass fluctuations (without long-term trends of body mass change) indicate a dietary management regime that prevents obesity.

KEYWORDS: *Seasonality, omnivore, captivity*

Associations between nutrition, gut microbial communities, and health in nonhuman primates

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The primate gastrointestinal (GI) tract is home to trillions of bacteria that play major roles in digestion and metabolism, immune system development, and pathogen resistance, among other important aspects of host health and behavior. GI and autoimmune diseases such as obesity, diabetes, Crohn's disease, and ulcerative colitis, all correlated with shifts in microbiome composition, have been dramatically on the rise globally for at least the last 50 years. The Human Microbiome Project was established with the goal of better understanding the role microbial communities play in health and disease. While the research community has made substantial progress in understanding the role microbial communities play in human health and disease, much less attention has been given to host-associated microbiomes in nonhuman primates (NHPs). In an effort to bridge this gap, my collaborators and I established the Primate Microbiome Project (PMP). The overall goal of the project is to develop a systematic map of variation in microbiome structure and function across all primates and to relate this to primate health, evolution, behavior, and conservation. We have begun exploring host-associated microbiomes in NHPs, including red-shanked doucs (*Pygathrix nemaeus*) and mantled howling monkeys (*Alouatta palliata*), among other species. Some primate species, such as the red-shanked douc, fail to thrive in captivity due to health issues (e.g., gastrointestinal). Maintenance of many primate species in captive settings is hindered by critical gaps in our understanding of their natural diet and the enteric microbial adaptations that facilitate the digestive process. By comparing wild and captive animals within the same species, we hope to determine whether shifts in gut microbiota are linked with health (e.g., gastrointestinal) in captivity. Microbes can act as indicators for health of the host, thus broad primate microbiome surveys may allow for the development of predictive biomarkers for certain primate diseases, including those linked to diet.

KEYWORDS: *Gastrointestinal tract, host-associated microbiomes, nonhuman primates*

Behavioural effects of fruit-free diets for primates

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Since 2003 we have been continually reviewing and improving primate diets at Paignton Zoo and more recently at Newquay Zoo; one of the most notable changes has been to remove all fruit from the diets. Monitoring of the physical health of the primates since then has shown that the fruit-free diets are beneficial for maintaining healthy weights, reducing dental disease, promoting GIT health, as indicated by improved faecal consistency and reduced incidences of diarrhoea, and stabilising Ca:P ratios. Other zoos that have carried out similar changes have also reported beneficial effects on the behaviour of primates, but to date there only appears to be anecdotal evidence for this. Therefore, during 2012-2013 we investigated behavioural effects as we changed our last remaining fruit-containing primate diets to be completely fruit-free. This included diets for pygmy slow loris (*Nycticebus pygmaeus*), four species of lemur (*Varecia variegata*, *V. rubra*, *Lemur catta* and *Eulemur coronatus*) and three species of Callitrichid (*Callimico goeldii*, *Saguinus imperator* and *Cebuella pygmae*) at Paignton and Newquay Zoos. We were also able to conduct similar observations on the gorilla (*Gorilla gorilla gorilla*) group at Longleat Safari Park as they were also converted to a fruit-free diet during 2014. The removal of fruit from diets resulted in a lower level of non-structural carbohydrate, especially sugar, and increased fibre levels. In general when fed fruit-free diets the species studied displayed significantly less aggression and self-directed behaviour than when they received their original diet. In addition, in some cases desirable behaviour such as foraging, species-specific feeding and overall feeding time increased. These effects were more substantial and consistent amongst the lemurs than the other species. In fact for the Callitrichids, initial observations within the first three weeks of the diet change showed opposite effects, but a month later the effects were similar to those of the other species. These results indicate that fruit-free diets are not only beneficial for physical health but also have positive effects on behaviour and welfare for a range of primate species.

KEYWORDS: Lemurs, callitrichids, non-structural carbohydrate

Health impacts of current *Nycticebus* feeding practices in captive settings

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Asia's low lorises (*Nycticebus* spp.) are heavily impacted by the illegal wildlife trade in Southeast Asia. When lorises are confiscated they are placed in a rescue centre where they are fed diets high in fruit and low in exudates. This happens to also be commonplace in American and European zoological institutions. Captive populations suffer through many health issues such as dental problems, facial abscesses, obesity and renal impairment as well as poor reproductive performance. Exudates, nectar and insects form the majority of their diet in the wild, and currently no nutritional recommendations are available for lorises. The published success rates of *Nycticebus* rehabilitation attempts hover around 11%. Released lorises were never seen feeding on exudates. There is a clear need to review the feeding practices to cater for lorises' physiological, morphological and behavioural needs. A survey study was conducted with all AZA and EAZA zoos which hold *Nycticebus* spp. asking for details about their loris diets and occurring health issues. Results will be combined with data acquired from rescue centres from Southeast Asia (Thailand, Vietnam, Cambodia, Laos, and Indonesia). 49 surveys were sent via SurveyMonkey to zoos and thus far a total of 30 have replied. Diets were analysed via Zootrition to provide a basis for comparison. Diets with differing proportions of food categories (dry pellet, wet pellet, fruit, veg, insects, animal products) were compared with the occurrences of health afflictions to see if a correlation is present. Looking at results thus far, the majority of diets do not represent the wild feeding ecology of wild lorises. Diets are generally high in fruits and concentrate feeds and some include dairy and meat products, which may actively contribute to health issues in captivity. 15 surveys (50%) admitted to health issues being diagnosed in their lorises. Average weight of adult lorises (n=69) is 574g, with a range between 326-805g, which is significantly greater than the average wild weight of 430g (male (t[68]=4.76, p=0.000). The average amount of daily energy provided by the diets are significantly higher than the 41 Kcal needed to maintain an average body weight (t[29]=5.19, p=0.001) with a mean difference of 31.41. This study is an indication of a possible major flaw within current loris husbandry practices, which may conceivably be the causal factor in the rampant health issues and low breeding success found in captive lorises. Diets should consist of acacia gum, arthropods and nectar with little amounts of vegetables and solid pellets to avoid diet related health issues.

KEYWORDS: *Nycticebus*, gum feeding, health issues

A low-energy and high fiber diet as an intervention for abnormal behaviour in chimpanzees (*Pan troglodytes*)

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AAP, Rescue Centre for Exotic Animals, provides a home for chimpanzees retired from biomedical research. During their time in the laboratory, the chimpanzees had developed several types of abnormal behaviour, in particular regurgitation and reingestion (R/R). After arrival at AAP in 2006, the abnormal behaviour remained present and caused deleterious effects in a few individuals. In 2011, an intervention program was started to reduce or abolish this abnormal behaviour. In one group of seven animals, a combination of two methods that were simultaneously started was used: an increase of low-energy/high-fiber contents in the diet and predictability of the feeding moments, and an increase in provision of cognitive and behavioural enrichment items. Before and during the intervention this group, as well as a control group that received no altered diet or enrichment, was observed four days per week. Observation data indicated that R/R had decreased approximately tenfold after this intervention. Total time spent on foraging, and on using enrichment increased significantly in this diet group. Body weights of all individuals had increased and blood parameters stayed within normal limits. The preliminary results of this study show that the composition and form of a diet and the predictability of feeding have a positive effect on normal feeding behaviour and result in reduction of time spend on abnormal behaviour in chimpanzees

KEYWORDS: *Behaviour, chimpanzees, fiber diet*

Preference for, intake and leaf composition of temperate browse fed to three Proboscis monkeys (*Nasalis larvatus*) at Apenheul Primate Park

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The proboscis monkey (*Nasalis larvatus*) is a leaf-eating primate and as a foregut fermenter has specific dietary requirements to maintain a healthy gastrointestinal system. There is little to no information on the (seasonal) composition or intake of the main component of the diet of these monkeys; leaves. For a selection of the browse species that were harvested and offered to three proboscis monkeys during the research period, May through June 2012 ("spring leaves", American oak (*Quercus rubra*), blackberry (*Rubus fruticosus*), common hazel (*Corylus avellana*), beech (*Fagus sylvatica*) and forsythia (*Forsythia spp.*)), we measured the composition (DM, ash, CP, NDF and ADF). Changing levels of nutrients were detected during the research period in the samples of American oak (n=3), blackberry (n=2) and common hazel (n=5). For American oak and common hazel it was possible to show a change in nutrient composition during Spring where protein decreased and fibre increased over time. Spring leaves were higher in CP levels when compared to other published values on temperate browse; DM (with the exception of one American oak and one common hazel sample) and NDF levels were lower. In cooperation with the keepers, an average daily intake of leaves per proboscis monkey of 278 ± 183 grams DM was determined. The proboscis monkeys have shown very irregular preference for European plant species. An adaptation of the "cardinal dominance index" was explored as a method to help predicting which temperate browse species will be preferred by these animals and to be able to attribute a value to this preference (dominance index). From all the browse species offered and that were suitable for statistical analysis, the preference could be ranked from more preferred to less preferred; hawthorn (*Crataegus spp.*), catalpa (*Catalpa spp.*), juneberry (*Amelanchier lamarckii*), blackberry, American oak, cotoneaster (*Cotoneaster spp.*), beech, common hazel and birch (*Betula pendula*). From the five previously analysed browse species the corresponding dominance index values and nutrient values were combined in a linear regression analysis, and preference (index value) and ADF showed a significant positive relation ($F = 25.982$, $p = 0.015$, $R^2 = 0.896$). An insight in preference and intake during this 8-week period in spring can offer Apenheul Primate Park the opportunity to focus their harvesting and growing management on species that are more preferred. The dominance index seems to be a useful tool for determining preference of browse when browse species can be offered during a longer period of time in different, but reoccurring combinations. Furthermore, knowing preference or palatability can be an important tool for developing or adjusting diets when intake is too low.

KEYWORDS: Primate nutrition, temperate browse, preference test

Zoo animal nutrition: a historical approaches and some general rules

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When Hans Wackernagel (1925-2013) - the former nutritionist and vice director of Basle Zoo and (as a former visitor of Ratcliffe's zoo nutrition program at the Philadelphia Zoo) the first promoter of complete, pelleted feeds for zoo animals in Europe - gave a lecture at the 1st EAZWV Student Summer School in Basle in 2007, he noted that the times of momentous improvements in zoo animal nutrition were probably past. He corroborated his claim with examples of how drastic zoo nutrition changed with the introduction of vitamin premixes into animal feeds, and with the advent of commercially available household freezers. Zoo nutrition has come a long way.

As any field, zoo nutrition is influenced by the different approaches originating from the background and expertise of those practicing it. As every human feeds at least him-/herself, an anthropocentric approach, with high value put to meat, grain, colourful fruits/vegetables and other energy-dense products, and a disregard for high-fibre items, comes naturally. The introduction of pelleted feeds opened the zoo community to expertise from those who knew how to produce these feeds - manufacturers with a tradition in production animal feeding. This expertise was invaluable for the application of proper mineralisation and vitaminisation, but can also still be traced in the default inclusion of grain products in many pelleted products. Attempts to imitate natural diets were often compromised by a simplistic view of what these diets consist of. Those educated in nutrition as a set of biochemical requirements that need to be met sometimes overlook physical and behavioural needs linked to food and feeding. Those responsible for writing down diets often feel safer when recommending what has been done before, if no drastic damage was evident, than changing a tradition. We are in a lucky age insofar as we can survey all these approaches and integrate them into feeding practice.

A wealth of case reports, experimental and epidemiological studies regarding zoo animal nutrition are available. Assessing the natural diet, characterising it - beyond simplistic labels - in terms of biochemical nutrient content, as well as physical and behavioural properties, and assessing markers of nutritional status in free-ranging animals as guidelines for ex situ specimens, has become the conceptual gold standard. We can even afford to wonder, at times, whether compromised habitats actually still offer correct information on the 'true' diet a species evolved on. Sometimes, improvements in animal welfare or health may be immediately evident, but in other cases, only future retrospective evaluations of longevity or other epidemiologic indicators will tell whether new approaches lead to a measurable physiologic improvement. However, even in the absence of such improvement (and, of course, in the absence of deterioration), presenting animals in conditions more resembling their natural environment, including zoo diets that resemble the natural diet and can be easily justified to visitors in biological terms has become an important objective. Combining the expertise of past approaches and experiences into guidelines that can be easily communicated to responsible personnel is the major future challenge in zoo animal nutrition.

KEYWORDS: *Husbandry, diet, history*

The importance of knowing the difference between barley and wheat: a personal history of a zoo nutritionist

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Ancient civilizations like in Mesopotamia (3000-2000 BC), Egypt (2000 BC), China (1400 BC), the Greece and Roman Empire already kept exotic animals. In mediaeval times 'zoos' were established in Florence, Palermo, Naples, London and many other cities. In the Renaissance more zoos and menageries started. Royals and other nobility were often the founders. The history of modern day zoos started probably with the building of Schönbrunn near Vienna which opened in 1752. Throughout the whole history of keeping exotic animals feeding these animals with their specialized digestive anatomy and particular diet preferences properly remained a challenge. Many animals must have suffered from nutritional diseases and died prematurely. Some evidence for this can be found on ancient pictures and paintings depicting animals with clear signs of nutritional deficiencies. Nutritional science for humans and livestock made impressive progress since the 19th century. However feeding exotic animals remained a huge challenge. It is estimated that before 1970 more than 25 - 50 % of the animals dying in zoos died because of nutritional problems. In the last few decades, zoo animal nutrition science and practice have made a lot of progress, which undoubtedly increased the health and welfare of zoo animals significantly.

In 1977 I started as a nutritionist in Rotterdam Zoo. I was hired because during my interview I could prove that I knew the difference between barley and wheat (some other topics were also covered). I have stayed in that position for over 36 years and have seen a lot of changes in zoo animal nutrition both inside my own zoo but also in Dutch zoos and zoos abroad. The body of knowledge and experience has increased tremendously, and I am proud to have had the opportunity to contribute to this. A highlight in my career was the organization of the first European Zoo Nutrition Conference in Rotterdam in 1999. Another highlight was my PhD research on fiber intake and faeces quality in leaf-eating primates. This project was finished in 2006.

In my presentation, I will give examples of typical zoo diets used in Rotterdam in the seventies and eighties of the previous century and the improvements we made at that time. Furthermore, I will demonstrate some newer developments like high-fiber pellets for browsers and low sugar diets for primates. Also some results of managing iron in black rhinoceros diets making use of blood value monitoring and iron analysis of food items will be presented. And finally I will give my opinion on how a nutritional program could be set up. and which challenges exotic animal nutrition will face in the future.

Evaluation of mineral concentration in a diet for howler monkeys in captivity

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Minerals make up a minor part of the diet weight but play a critical role in the health of every animal. The aim of the present study was to evaluate the concentrations of calcium, magnesium, sodium, potassium, copper, zinc, iron, phosphorus and selenium of a diet for a mixed howler monkey (*Alouatta palliata* and *A. Pigra*) troop held in a Mexican zoo. Howler monkeys are folivore primates, and because the specificity of their diets, it is complicated to keep them in captivity. The diet offered in the zoo consisted in a mixture of pellets for leaf-eater primates, fresh alfalfa, lettuce, red apples, oranges, papaya, bananas and watermelon. All animals (4 *A. palliata* and 2 *A. pigra*) were fed the same diet. The structure of the troop was not changed during the study; monkeys were routinely kept in groups of 3 and 2 animals, and one animal was kept alone. Nutritional adequacy of the diet was also evaluated according to the nutritional requirements of non-human primates. The mineral evaluation was made once a month during 3 months (500 g of each diet item). Mineral analyses were determined by atomic absorption spectroscopy (for Ca, Mg, Fe, Cu, Na, K, Se and Zn) and by colorimetric determination (for P). In the present study only the potassium contribution covered the NRC requirements for non-human primates; according to these requirements, the diet was deficient in calcium, phosphorus, magnesium, iron, selenium and sodium; while the concentration of zinc was elevated. In a parallel study, the feed intake of each monkey was evaluated, showing lower values as the recommended in the literature. The absorption of minerals can be reduced if high amounts of fibre are consumed or if the contribution of minerals in the diet is low; also, the absorption of these elements is slower in the cecum and colon than in the small intestine. Based on the composition of the tested diet and its mineral concentration, it seems reasonable to suggest a new diet, where more leaf-ingredients are included and a better supplementation of minerals. The feed rations and intake for all captive animals should always be checked in order to diagnose possible nutritional impact on certain health problems and to optimize rations.

KEYWORDS: *Howler monkeys, mineral concentration*

UVb radiation impacts vitamin D₃ status but not growth in the nocturnal leopard gecko

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A sufficient vitamin D status of reptiles in captivity is important to facilitate normal growth and reproduction. In diurnal reptile species like bearded dragons (*Pogona vitticeps*), UVb radiation increases vitamin D synthesis but for nocturnal species like leopard geckos (*Eublepharis macularius*) the impact is unknown. In this study, 18 newly hatched leopard geckos from three breeders were randomly allocated to a UVb exposure group (n=9) and non-exposure group (control, n=9). All groups were provided with an UVb fluorescent tube (Reptisun 10.0 UVB 32Watt 120 cm, Zoo med laboratories Inc., San Luis, USA) mounted 45 cm from the bottom of the terrarium. In the control group, glass was placed between the tube and the terraria, the glass blocking the UVb radiation. The UV-tubes were turned on from 12:00 till 14:00 each day, with an average intensity of 52 $\mu\text{W}/\text{cm}^2$ without the glass and 0 $\mu\text{W}/\text{cm}^2$ with glass directly underneath the tube. Animals were supplied with *ad libitum* feed consisting of crickets, grasshoppers and mealworms, dusted with a mineral supplement containing vitamin D (16,000 IU/kg). Feed intake, body weight, snout-vent length and total length were measured once a week. After about 190 days a 0.45 mL blood sample was obtained from tail vein under gas anaesthesia (sevoflurane). Plasma vitamin 25(OH)D₃ and 1,25(OH)₂D₃ were analysed by ID-XLC-MS/MS. Data were analysed using ANOVA with treatment, breeder and gender as independent variables. Animals remained free of clinical symptoms of vitamin D deficiency. Treatment groups did not differ in selection of specific insects and had similar total insect intake ($P>0.100$). Furthermore, treatment did not affect body mass and size ($P>0.10$). Blood collection was successful in 6 animals per treatment. UVb exposure resulted in increased 25(OH)D₃ concentration (71.3 ± 7.3 vs 37.0 ± 4.6 nmol/L; $P=0.005$) but did not impact 1,25(OH)₂D₃ concentration (33.5 ± 4.1 vs 33.0 ± 4.1 nmol/L; $P=0.907$). Animals from one breeder had lower food intake, body weight and size and 1,25(OH)₂D₃ concentrations ($P<0.05$). Females and males did not differ in measured parameters ($P>0.10$). Other studies found higher plasma 25(OH)D₃ concentrations in control and UVb exposed leopard geckos (UVb at 120-207 $\mu\text{W}/\text{cm}^2$; 46 and 144 nmol/L) and in control and UVb exposed corn snakes (*Pantherophis gutatus*) (UVb at 10 $\mu\text{W}/\text{cm}^2$; 57 and 196 nmol/L). 1,25(OH)₂D₃ remained constant, regardless of 25(OH)D₃ status, which reflects the very tight control of 1,25(OH)₂D₃ synthesis by the kidney in conditions of calcium homeostasis. It can be concluded that the nocturnal leopard gecko can synthesize vitamin D₃ when exposed to UVb. The diet, including the vitamin D₃ supplement was sufficient to support growth and prevent clinical signs of vitamin D deficiency in leopard geckos within the studied period. Additional studies are required to evaluate the health benefit of UVb exposure and increased vitamin D status in leopard geckos.

KEYWORDS: Vitamin D, leopard gecko, nocturnal animal

Effect of browse supplementation on nocturnal behaviour in captive giraffe (*Giraffa camelopardalis*) – a pilot study

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Captive giraffes (*Giraffa camelopardalis*) are known to perform oral and locomotor stereotypies. However, many studies do not consider the behavioural repertoire of these animals during the time when animals are confined to night quarters. At two zoological institutions, a total of 6 captive giraffes were observed via camera trap technology throughout the diurnal and nocturnal periods to record feeding, ruminating, and stereotypic behaviours. The effect of browse enrichment was assessed overnight to determine how behaviours may be altered in the presence of natural forage. Results need to be interpreted with caution due to a high proportion of time when animals were out of camera range. For the observed time, licking behaviour, an oral stereotypy, was significantly higher at night compared to daytime at both facilities, while tongue play increased at the same time, but not significantly. The provision of browse enrichment during the night decreased the rate of tongue playing, but not significantly, while significantly reducing pacing behaviours. Across treatments and institutions, observed oral stereotypies tended to decrease with increased feeding time. Apart from a short-term effect of enrichment, this study indicates relevant differences in the frequencies of behaviours observed during day- and nighttime, suggesting that assessing nighttime behaviour specifically may be important in many species.

KEYWORDS: *Turaco, husbandry guidelines, diet survey*

Composition and quality of diets for giraffes (*Giraffa camelopardalis*) in twelve German zoos

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In the context of a comprehensive study about giraffe nutrition, feeding of giraffes was monitored in German zoos. The focus was on amounts and type of feedstuffs and the nutritional diet quality. During 18 documentation periods in twelve zoos (summer = 12, winter = 6) feedstuffs were weighed on five consecutive days. Feed samples were taken and chemical analysis was done on ash, crude protein (CP), crude lipids (CL) and fibre fractions (aNDFom [neutral detergent fibre; assayed with heat stable amylase, expressed exclusive of residual ash], ADFom [acid detergent fibre; expressed exclusive of residual ash], ADL [acid detergent lignin]). Gas production was measured at 24 hours in the Hohenheim gas test for estimating metabolisable energy (ME) for ruminants. Regarding roughages lucerne hay (11 facilities), grass-clover hay (1 facility), fresh lucerne-grass mixture (5 facilities), fresh browse (12 facilities), dried browse (4 facilities), frozen browse (1 facility) and other fresh forages (3 facilities) were used. In case of pelleted feeds lucerne meal products (7 facilities), browse-containing products (3 facilities) and compound feeds (11 facilities) of different specifications (for herbivores, ruminants, browsers, horses) were provided to the animals. Energy concentrates comprised rolled oats (5 facilities), wheat and oat flakes (3 facilities), wheat bran (2 facilities), broken maize grain (2 facilities), carob bean (1 facility) and sugar beet pulp (7 facilities). Soybean was the protein concentrate in six facilities, fed either as solvent-extracted meal or as whole bean. Additionally linseed (3 facilities) and mineral feeds (4 facilities) were added to diets. Except in one facility produce constituted a variable proportion of the ration. The roughage proportion ranged from 31 to 78% of diet dry matter (DM) with an average of 56% (\pm 11.6). Taken individually, the amount of browse in diets was 6.6% (\pm 4.33). In case of pelleted feeds and energy/protein concentrates the percentage ranged from 18 to 68% of diet DM with an average of 40% (\pm 11.5). The mean share of produce in diet was 3.6% (\pm 3.75) with a range from 0 to 18% of diet DM. Regarding the nutritional quality of diets following mean contents of crude nutrients were analysed: CP = 165 (\pm 10.3) g/kg DM, ash = 90.7 (\pm 10.7) g/kg DM, CL = 32.8 (\pm 7.93) g/kg DM. The average ME content was 10.1 MJ/kg DM (\pm 0.58). Regarding fibre fractions mean contents of 409 (\pm 38.8) g/kg DM aNDFom, 286 (\pm 51.5g/kg DM) ADFom and 83.2 (\pm 19.5) g/kg DM ADL were determined. Lucerne hay seemed to be an almost obligate forage provided for ad libitum intake, but amounts of browse differed depending on facility and season. Furthermore considerable differences in choice and quantity of energy rich feedstuffs including produce were detected. Overall the diversity of chosen feedstuffs offered in varying quantities resulted in diets of distinctively different nutritional quality.

KEYWORDS: Giraffe feeding, feedstuffs, diet quality

Investigating nutrient provision and digestibility of red-crested turaco (*Tauraco erythrolophus*) diets across several UK collections

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Turacos (Musophagidae) are commonly-seen captive tropical birds of six distinct genera, with the 14 species of *Tauraco* being most often exhibited in zoological collections. Turacos are renowned for their unique non-structural, copper based feather pigments and specialised dietary strategy. Nutritional provision for captive turacos needs to be well-planned to ensure that birds stay healthy and properly coloured. The *Tauraco* genus inhabits the rainforest and tropical woodlands of west, east, southern and central sub-Saharan Africa, foraging in the high canopy for predominantly folivorous and/or frugivorous food items. The current ISIS population, as of September 2014, showed 929 individual birds from this genus kept globally, indicating the impact that nutritional research can have on turaco management and individual bird welfare. Using a study population of 5.5.2 red-crested turacos (*T. erythrolophus*) housed at five collections in the United Kingdom, the nutrient composition of the diets as stated on the diet sheets, from all five collections, was calculated and were compared against current husbandry guidelines (using Zootrition for analyses of important nutrients contained within each diet). Digestibility of important nutrients was calculated using directly collected samples and laboratory analysis from four collections (housing five groups of turacos in total) and evaluated by measuring the food intake and faecal output. Weights of given food were recorded (corrected for water loss) and faecal samples were collected daily by keepers; samples were then pooled to give an average digestibility for each zoo. Comparison of calculated levels of protein, NDF and ADF between collections and published husbandry guidelines showed no significant difference (for protein $t = -1.67$, $P = 0.155$; for NDF $t = 1.10$, $P = 0.320$; and for ADF $t = 1.95$, $P = 0.343$). However a comparatively large variance within the ADF samples suggests that care should be taken with this result. A significant difference in calculated dietary copper (Cu) levels was noted between collections ($\chi^2 = 186.9$, $P < 0.001$), which is something to consider when feeding turacos to maintain good plumage colouration. However there was no significant difference in the digestibility of Cu between the groups sampled. No difference in digestibility was noted between protein, NDF and Cu (tested with a one-sample t-test), and between each collection's ADF digestibility (tested with a one-sample Chi-squared). Analysis of the calcium to phosphorous ratio (Ca:P) for the diets from all five collections showed there to be no significant difference from the published ratio in current husbandry guidelines ($t = 1.75$, $P = 0.156$). It can be seen that diets fed at these five collections did not differ significantly from those published in husbandry guidelines for this turaco species, except for amount of copper. Overall amounts of fibre within diets presented were low and it is suggested that re-evaluation of diets over the longer term is performed to see if this was an artefact of the experimental design or whether diet composition needs to be altered to improve the amount of fibre available to the birds. Collection of wild data on foraging behaviour and food selection, or collaboration with turaco keepers from institutions in the tropics, is recommended as a way of improving feeding regimes in husbandry guidelines and updating feeding practice for this and other *Tauraco* species.

KEYWORDS: Turaco, husbandry guidelines, diet survey

Gastrointestinal passage in cheetahs fed a natural diet

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It has been speculated that whole carcass feeding could have a beneficial effect on cheetahs, also by slowing gastric emptying and thereby reducing the production of putrefactive compounds from protein fermentation. This study was set up to identify the typical total tract passage time of cheetahs fed a natural diet, as a first step in understanding the cheetah's digestive strategy. The three female cheetahs monitored during this study were aged 9 to 14 (body mass 32 ± 3 kg) and housed at the Cheetah Conservation Fund in Namibia. They were fed pieces of a donkey carcass including skin, bones, cartilage with most of the fat removed and supplemented with vitamins and minerals. The pieces averaged at 2 kg per cheetah. They were additionally fed organs including heart, kidney, spleen and liver with an average of 220 g per cheetah almost every day. The animals were adjusted to this diet over a period of 11 days. Three grams of titanium dioxide were added to their food at 10.20 h in the morning of day 12 and the cheetahs were monitored in the subsequent 72 h, during which time faeces were collected on an individual basis. The samples were dried and stored frozen until analysis for marker concentration. The maximum concentrations of the marker in the faeces were between 5 and 20 h after marker ingestion. From 36 h onwards the concentrations were close to basal level. One cheetah had diarrhoea during the period of faeces collection but showed no deviant marker excretion profile. The calculated mean retention times were 22 h, 26 h and 28 h for the three cheetahs. Additionally, it was observed that cheetahs mainly defecated in mornings and evenings. This might fit in their natural behaviour, but it implies that the observed total tract mean retention times might be affected by the time of feeding.

KEYWORDS: *Acinonyx, retention time, carcass*

Nutritional composition of whole brown hare carcasses in relation to in-situ diet situation

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In order to investigate the interaction between predation risk and landscape heterogeneity on hare condition, 74 European hares (*Lepus europaeus*) were collected between October and December 2013 on 14 areas with different soil types spread over The Netherlands. Of these, 30 collected carcasses were used to get insight into the nutritional composition of brown hare for ex-situ diets in zoos. Hare carcasses were homogenized and analysed for nutritional composition (crude protein, crude fat, crude fibre, crude ash, phosphorus, calcium, magnesium content) using standard protocols. Air dried carcass content was dominated by crude protein, ranging between 59.1%-77.7%, on average $66.4\% \pm 3.5\%$ (sd), followed by crude ash (range 13.2%-21.6%, average $16.5\% \pm 2.2\%$) and crude fat (range 3.5%-21.7%, average $11.4\% \pm 4.0\%$). Crude fibre ranged between 1.3%-12.5% (average $5.2\% \pm 3.1\%$). Calcium ranged between 3.2%-5.9% (average $4.4\% \pm 0.7\%$). Phosphorous ranged between 1.0%-2.5% (average $1.8 \pm 0.4\%$) and magnesium ranged between 1.0%-1.7% (average $1.3\% \pm 0.2\%$). Soil type (sand (n=9), river clay (n=4), sea clay (n=17)) was not significantly related to any nutritional variable ($p > 0.27$), except for crude ash ($F=5.8$, $p < 0.01$), where sea clay areas showed significantly higher levels of crude ash than river clay or sandy areas. These patterns do not indicate major influences of soil type on nutritional condition in European hares. Nutritional composition did not differ significantly between sexes (females n=20, males n=10), although a trend towards higher calcium levels in females was observed ($p = 0.09$). This research describes the nutritional composition of brown hare for use in ex-situ diet in zoos. It showed that besides crude ash, the composition of brown hare is not affected by sex or soil type (origin). Levels of crude ash in carcasses can be affected by former uptake via forage, as plant species' crude ash content is influenced by soil type, salinity and fertility. Although animals in captivity should be fed their in-situ diet, this is still not often the case. Ex-situ zoo nutrition can therefore possibly affect the survival, growth and/or reproduction of zoo animals. Analysis of in-situ carcasses regarding their nutritional composition offers the potential for zoos to get a quantitative insight into the differences between the ex-situ diet presented currently to carnivores and their natural prey spectrum.

KEYWORDS: Brown hare carcass, nutritional composition, in-situ diet

Zoo map



Antoon van Hooffplein

Commissary

Organisation and design

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Introduction

In 1975 Royal Burgers' Zoo was the first zoo in the Netherlands to have a commissary and central storage of food supplies. The commissary is part of a broader 'health centre' which also contains a veterinary department for surgeries and X-rays.

Organisation

The commissary was originally build to prepare food at one place and distribute them to the different sections of the zoo. Two keepers per day work in the central kitchen on a daily basis, accompanied by a third keeper when required (depending on work load). Diets are prepared according to diet sheets which are updated regularly. Diets/food items are brought to the different sections in the morning.

Three sections have their own 'kitchen' to prepare diets: bird section, Burgers' Bush/Desert and Burgers' Ocean (the latter having its own suppliers).

Food safety

- To avoid cross contamination, the kitchen is divided into 4 parts:
 - o Storage of fruits/vegetables and preparation of diets
 - o Silos for storage of dry food/pellets
 - o Fish storage and preparation
 - o Meat storage and preparation
- The use of fixed crates per section and mostly per animal to limit the possibility of contamination.
- Separate coolers (6-7 °C) and freezers (-19 °C) for fruits/vegetables, fish and meat.
- Fish and meat are defrosted by air (in coolers).
- All freezers are accessible through the coolers, so products can be moved from the freezer to the coolers directly.
- The cooler of the fruits/vegetables is also accessible from the outside for suppliers.
- Food is stored according to the 'first in first out' principle.
- No pork is fed with regards to Aujeszki virus.
- The meat freezer can store up to 100 carcasses in case of veterinary restrictions with regards to transport.

Food quality

- Fruit/vegetables, fish and meat mostly come from suppliers for humans with high quality standards.
- Sustainability is an important aspect of food.
- Diets are based on the needs of the animals.
- Nutrient composition of fruits and vegetables are an important tool.
- Whole prey is fed. Besides insects, no prey is fed alive.

Working conditions

- The silos are filled from the attic of the commissary where dry food is stored in bags. The bags are moved to the attic by means of an elevator/tackle.
- Roughages are supplied in combined bales which can be moved by forklift.
- The safari department (with large amounts of hoofstock) have their own silo's (2 silo's of 4 tons and 1 of 6 tons) to minimize the movement of vehicles through the park. Alphalpa hay is also stored there (large amount of giraffes).
- When necessary, food items are cut by means of a mobile cutter.
- Meat is delivered by carcass (average of 350 kg). The carcasses are lifted by means of a tackle and are hung on a rail attached to the ceiling which leads to the freezer.
- The carcasses are divided into smaller pieces by an electric saw.
- Food items are brought to different sections instead of the sections collecting them; this takes about 5 hours per day.

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Commissary**UV lighting in reptile enclosures****A practical exercise for measuring UV B output from different UV lamps and assessing the right UV lamp for various reptile species.**

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In reptile enclosures, UV lamps are used to supply UV B lighting for various reptile species, which they use to produce Vitamin D3. These lamps can be linear fluorescent and mercury vapor lamps produced by different manufacturers (Schmidt, 2010).

Vitamin D3 plays very important roles in reptile calcium metabolism and immune response, amongst others. Without proper access to UV B, a multitude of problems can be expected when keeping reptiles in captivity: in many species, dietary Vitamin D3 does not compensate for Vitamin D3 produced after UV B exposure (Oonincx, 2010). There are indications that some species that traditionally are not considered candidates for UV exposure, do in fact benefit from this. Acierno (2006, 2008) for instance had some very interesting results testing UV B exposure in slider turtles and corn snakes.

'Proper access', as mentioned above, means that the choice and installment of lamps should reflect many factors, such as the circadian rhythm of the reptile and their thermal requirements. According to these authors, it is easier to supply inadequate UV B exposure than to do it correctly. Lamps can be low in effectivity (Lindgren, 2004) due to various factors. UV emitting lamps have also been reported to harm the skin or retina (Antwis, 2004) and cause vascular damage (Shroff, 2010).

The different reptile species differ in habitat, lifestyle, behavior and food composition. Using an excel tool (published by BIAZA), the optimal environment for UV B supply can be established. In this workshop, an experimental design is established to find the right UV lamp for certain reptile species. Some common errors are highlighted. Also, we focus on how to know if the amount of UV B irradiation is sufficient.

Two meters are used: a UV B meter (Solarmeter 6.2) and a UV Index meter (Solarmeter 6.5). The UV B meter measures the UV B irradiation in W/m²/nm in the range of 280-322 nm. The UV index (UVI) meter measures something different: it measures a unitless indicator (range 1 to 10) of the 'photobiological activity' of UV B. The UVI indicates the intensity of UVB radiation in the biologically active range of wavelengths - specifically, those wavelengths that enable skin synthesis of vitamin D3, cause damage to the DNA of living cells, and produce erythema (sunburn) in human skin.

Solarmeter 6.2 Solarmeter 6.5



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Burgers' Bush: browse and browse quality

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Keeping leaf-eating primates in the Northern hemisphere is always a challenge during the winter season. In the wild, up to 80% of their diet consists of fresh leaves and they are able to select which leaves they eat. Especially the variation between leaves of different tree species and the proportion of young and mature leaves are important. In general they have a preference for young leaves with a high protein-to-fiber ratio.

Because most trees are deciduous, fresh leaves are not available during winter. To provide our primates with 'fresh' leaves in the winter, we harvest leaves in the spring and summer and conserve them. There are different methods to conserve them like drying, ensilage or freezing.

In this demonstration, we show how leaves are conserved by freezing and our experiences with the different conserving methods. We explain the problems and difficulties we encountered and provide opportunities to solve them. Furthermore, examples of how different leaves respond to the thawing process are shown. Finally, the differences between the leaf-eating primates with respect to leaf intake are presented.

Although all primates in this study are primarily folivorous, our results and experiences demonstrate that there are considerable inter- and intraspecific variation. Best intake is achieved by immediately feeding after thawing, as well as providing branches with butts and/ or non-poisonous berries. However, the total "menu" - the other leaves and food items that are provided - also influence the food intake.

A4 ONZE EN MARTINE POSTER TOEVOEGEN!

Nutrition in education at Royal Burgers' Zoo

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Royal Burgers' Zoo is at the moment the one and only Dutch zoo with no feeding presentations or scheduled feeding times that the public can visit. There are numerous reasons for this decision. However, that does not mean that we don't inform our visitors about foraging strategies of animals or about feeding and digestion of different types of animals.

For primary schools, healthy (human) feeding patterns form a more and more important topic in the curriculum. Hence, an special programme on human and animal feeding is in development (but not in a stage that we can present anything yet). But already, feeding of zoo animals is an important topic for information tables for general public, which reach tens of thousands of visitors each year.

During our evening openings each summer, visitors can take a look into the commissary and get explanations there by our zoo volunteers. Also on several occasions the volunteers explain about dentition, digestion and faeces of different animals, showing the connection between foodtype and anatomy. We work a lot with animal artefacts for these information tables, but can also rely on the creativity of our about 100 persons strong team of volunteers in producing different materials themselves. Burgers' Zoo believes in an interactive hands-on approach in education and try to let people think and experience, apart from spreading the information in a one-way talk.

Apart from giving the delegates the opportunity of seeing some of our educational material on nutrition, our volunteers will discuss in which situations we work with real food or real faeces and in which cases we rather use models.

Burgers' Ocean: behind the scene tour feeding the aquaria, light as a nutritional source, fish quality

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Burgers' Ocean consist of 8 million litre water divided over 12 display tanks. Thousands of animals need to be fed on a regular basis. To be sure this is properly done, coordinated diet lists are made to be used in the food preparation in the aquarium. This ensures a stable feeding practice with different keepers feeding the animals. Also from such basis it's easier to discuss necessary changes to the diet. An overview list is made per day of the week (Figure 1).

Monday																				
Time	Mysis	Artemia	planetor	Cyclops	Krill fine	Krill large	Coclea w. schell	Mussel no schell	Shrimp	gamba	Squid	Saith	Mackerel	Herring	Saury	Sandeel	Sprat	Smelt	Pellet fine	Pellet large
Aquarium 1																				
7:30	20																			
12:30						10	10											3000		1000
Aquarium 2																				
9:30		20			40		30						130						20	
12:00					20		30		50										40	
15:30	30																			
Aquarium 3																				
9:30				0	40		50		30								430	70		
12:00																				
15:30	60	60				20	40		40										70	
Aquarium 4																				
10:30					PILLS															
15:00							50						350				1795	150		
					80	50							3345					150		

Figure 1: Part of the Monday feeding chart which is used to feed some of the aquaria at Burgers' Zoo

Constructing such diet is quite a challenge. The different available food items are defined in different size categories: extra small, small, medium and large food items. Depending on the availability the items may change, but currently the following food items are used: Extra small food items are Red Plankton, Cyclops and Lobster eggs; Small items are defined as Krill, Artemia, Mysis; Medium size items are Shrimp, Gamba, Smelt, Sardine and Sprat and Large items are Squid, Mackerel, Herring, Saith (or Haddock) and Saury. Dry food is given as different sizes of pellet food. Greens are provided as leak, lettuce, endive, peas and dried algae. A special gelatine food is made once a week, so extra vitamins can be given to specific animals. When using these food size categories and comparing this with the fish sizes and number in a specific aquarium a better decision can be made what to give and how much. Also within one category a variety of food items can be defined. Where possible one item per category is fed per feeding moment and thus providing variability in the food offered over the day or week.

A total on the end of the list is provided so it's clear how much should be prepared for the next day. Since most food is pre-frozen the food for the next day is sorted in the afternoon and placed at 5°C. This way the next morning most of this food is defrosted and can be prepared per aquarium and per feeding moment.

The bold and italic figures in the day (Figure 1) list are referring to the week list of the elasmobranchs (Figure 2). Since all elasmobranchs are fed individually a separate list is constructed for the elasmobranchs.

Diet of elasmobranchs										
	Name	Tank	Monday			Tuesday		Wednesday		
			Mackerel	sprot	# pil/animal LARGE	saith	squid	herring	gamba	# pil/animal LARGE
<i>Neotrygon kuhlii</i>	0,1 panjs	Aquarium 2	90						90	1,0
<i>Neotrygon kuhlii</i>	1,0 antw	Aquarium 2	40						40	0,5
<i>Hemiscyllium ocellatum</i>	0,1 D	Aquarium 3		30					30	0,25
<i>Rhinobatus cemiculus</i>	0,1	Aquarium 3		100			100		100	0,50
<i>Rhinobatus cemiculus</i>	1,0	Aquarium 3		100			100		100	0,50
<i>Rhinobatus cemiculus</i>	0,1	Aquarium 3		100			100		100	0,50
<i>Rhinobatus cemiculus</i>	1,0	Aquarium 3		100			100		100	0,50
<i>Carcharinus limbatus</i>	donker	Aquarium 4	500					500		
<i>Sphyrna lewini</i>	man	Aquarium 4	1000					1000		
<i>Rhinobatus typus</i>	0,1	Aquarium 4	525					525		
<i>Stegostoma fasciatum</i>	1,0	Aquarium 4	350			350		350		
<i>Stegostoma fasciatum</i>	0,1	Aquarium 4	500			500		500		
<i>C. melanopterus</i>	1,0 skin	Aquarium 4	200					200		
<i>C. melanopterus</i>	0,1 shar	Aquarium 4	300					300		
<i>C. melanopterus</i>	1,0 manji	Aquarium 4	200					200		

Figure 2 Part of the elasmobranch feeding chart of Burgers' Zoo

Calculations on the feeding ratio of all elasmobranchs is done in a separate sheet. The basic feeding ratio of Janse *et al.* (2004) is used as a starter, however feeding practice might change these figures. Also it's very hard to be 100% sure of the weight of an animal. Since feeding practice in elasmobranchs is calculated as %BW per day (or week) care must be taken not to feed only fatty fish. It would be better to use kcal/kg BW/d as a unit in feeding ration calculations when feeding different types of food.

Monterey Bay has started in 1999 the Seafood Watch (www.seafoodwatch.org). This important initiative helps consumers and businesses to choose the right seafood that's fished or farmed in ways that protect sea life and habitats, now and for future generations. 'Best choice' and 'good alternative' are important handholds for choosing the right seafood for humans, but also for good zoo and aquarium practice. Since the initiative of Monterey Bay Aquarium similar sea food watches are made locally in other countries. Burgers' Zoo uses the Dutch seafood watch to help to choose the right seafood for their aquarium fishes.

The living coral reef display is quiet unique due to the size. There is only one large life coral reef tank in the world, which is in Reef HQ, Townsville, Australia. Coral are very sensitive, so managing a 750.000 L display is quite a challenge. Only little external filtration is used on this aquarium. This so called 'ecological purification' uses natural chemical and biological processes as base for its management. This way a food chain is developed with the aquarium. Corals will be part of the food chain, so part of their heterotrophic feeding is from the life and organic matter within the water. However most corals are living together with microscopic algae (zooxanthellae). These algae will provide 60 to nearly 100% of the nutrition for their host, the coral. Light levels within the tank are provided by artificial lighting and are kept at the surface in the same range as on 10 m depth in a natural reef. When keeping the algae happy, the corals will also thrive, as long as all other conditions are kept close to natural levels.

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Burgers' Rimba: Primate Body Condition Scoring and Faecal Scoring

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Body condition scoring (BCS) and faecal scoring (FS) are non-invasive and non-intrusive methods to monitor animal health and can be easily and quickly incorporated into routine husbandry. It is particularly important to undertake health monitoring when diets are changed so that the effectiveness of the new diet can be reliably evaluated. Other variables that can be used to evaluate new diets include food intake, food choice, behavioural comparisons, blood tests for nutrient levels and body weight, but these are generally time consuming, expensive or difficult to measure. BCS and FS are quick and easy but they must be implemented correctly in order to be reliable.

Body condition scoring is based on comparing the body shape of the individual against a standardised chart, usually rating body shape from 1 (very thin, severely underweight) to 5 (obese). The BCS chart should be specific for the species, or at least a closely related species, highlighting particular areas of the body that are the best indicators of fat coverage in that species. One observer's score can be subjective but reliability is greatly improved by calculating an average BCS score of several observers on each occasion. Therefore scoring should be done by several observers over a long period of time, we recommend a minimum of 5 observers scoring at least monthly. It is recommended that a mix of observers, some who are involved in the everyday husbandry of the animals and some who are unfamiliar with the particular individuals are involved in scoring to remove any possible bias. Trends in the average score over time are then a very useful indicator of changes in condition in response to diet changes or other husbandry factors. Ideally BCS should be used in conjunction with actual body weights if it is possible to obtain these regularly. Although body weights may be more accurate than BCS it is still valuable to do both due to individual differences in "build". Some individuals will be heavier than others or above the typical weight for that species because they are big (e.g. tall humans) rather than fat. Differences in life stage may also cause changes or anomalies in expected weight, in which case BCS can be useful to indicate if the individuals are healthy despite gains or losses in body weight.

Faecal scoring uses a similar method, scoring faecal consistency against a prepared chart of scores e.g. from 1-5 (very soft to very hard) or similar. FS should be done as often as possible, preferably daily, and if used to evaluate diets should be linked to the relevant diet. Stress, social altercations, infections or unusual events can cause changes in faeces quality so FS should only be used as a tool when multiple days of scores have been collected (at the very least 10) and the "normal" range for those individuals established.

Both BCS and FS require very little time or knowledge of the species concerned and we recommend conducting incorporating both permanently into husbandry routines regardless of whether there are diet changes. At this station delegates will be able to practice both BCS and FS and discuss how best to implement these techniques in a real setting.

Primate Feecal Score Chart

1. Well-formed, solid faeces with shape



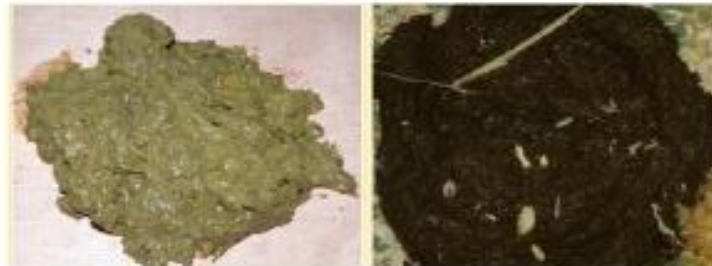
2. Formed faeces but soft



3. Faeces very soft, less defined shape but still some solid texture



4. Mixture of formed and unformed faeces, extremely soft and loose



5. Very loose, no form, mostly liquid; diarrhoea



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Karen Clingerman, Laura Summers (2012). Validation of a body condition scoring system in rhesus macaques (*Macaca mulatta*): inter- and intrarater variability. *Journal of the American Association for Laboratory Animal Science*, 51:31-6.

The scoring chart validated in the above paper is on Page 6 of this document
<http://www.upenn.edu/regulatoryaffairs/Documents/iacuc/guidelines/iacucguideline-foodwaterregualtionnhp.pdf>

AZA Nutrition Advisory Group www.nagonline.net. Use the search box to search for Body Condition Scoring – there are several articles and charts for a range of zoo animals

Kari A Morfeld, John Lehnhardt, Christina Alligood, Jeff Bolling, Janine L Brown, (2014). Development of a body condition scoring index for female African elephants validated by ultrasound measurements of subcutaneous fat. *PLoS ONE*, 9(4):e93802.

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How to Condition Score your Horse

<http://www.bhs.org.uk/~media/BHS/Files/PDF%20Documents/Condition%20Scoring%20Leaflet.ashx>

Body Condition Score Chart for Dogs

<http://www.wsava.org/sites/default/files/Body%20condition%20score%20chart%20dogs.pdf>

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