

Thursday 28th January ~ Barcelona Zoo

18:00 REGISTRATION & ICEBREAKER (until 20:00)

Friday 29th January ~

08.00 Registration

08.45 Welcome & Opening Remarks

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J.M. Starck, (INVITED SPEAKER)
KEYWORDS: fasting, diet switch, phenotypic flexibility
- 09.45 [Nutrient digestibility and digestive efficiency in Livingstone's fruit bats \(*Pteropus livingstonii*\)](#) 2
C. Schwitzer, J. Bilstra, S. Chikunya, J. B. Carroll
KEYWORDS: energy digestibility, Ejecta pellets, Megachiroptera
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KEYWORDS: dry matter intake, mean retention time, larger herbivores
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KEYWORDS: wild ruminants, rumen, claw, feeding
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KEYWORDS: browser, ruminant, forage
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B.O. Roken
KEYWORDS: moose, giraffe, food composition
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KEYWORDS: browse, nutrients, digestibility

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A. Rodríguez, H. Marquès
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Phenotypic flexibility of the gastrointestinal tract of vertebrates

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This presentation reviews patterns and mechanisms of how animals adjust their gastrointestinal system to fluctuations in food quantity and food quality, and how they cope with variations in internal demand for energy (=food). I begin by briefly summarizing the main external ecological factors that may affect food availability and food composition. While circannual seasonality provides a simple trigger for anticipation of diet switches changes in organ size and function may be coupled to the endogenous hormonal control system. A variety of strategies has evolved to cope with such predictable fluctuations in food supply. Empirical evidence for such internally coupled seasonality in organ size changes is discussed. Avian long distance migration is a key example in which vertebrates are exposed to predictable fluctuations in food quality and quantity in concert with the extreme physiological demands of the long distance flight. I will review patterns of adjustments of the gastrointestinal system to those challenges, discuss possible mechanisms and evolutionary consequences. Unpredictable changes in food supply and food quality cannot be linked to internal regulation systems and require immediate environment-organism interactions. The second part of the presentation discusses such unpredictable changes and the immediate responses of organisms to unpredictable diet switches, in particular feeding and fasting. The overall focus of the presentation is on the pattern of changes in organ size and function in reptilian sauropsids and mammals and how tissues and cells drive the sometime considerable phenotypic changes. Stochastic feeding events of intermittent feeding sauropsids present an extreme but natural example of how animals adjust between periods of feast and famine. Also, because of the relatively high energetic costs of maintaining a functional gut I discuss the question what happens to the gut when fasting animals do not it. Because feeding affects more organ systems than only the gastrointestinal tract, I will include a short discussion of cardiovascular responses to feeding. Recent studies in crocodiles and squamates have demonstrated the importance of the integration of different organ systems, showing that the structure and the functioning of the gastrointestinal cannot be understand without knowing who the cardiovascular system works. With respect to such integration of organ systems, mammals and birds are simple, but crocodilians and snakes present an astonishing complexity and unanticipated level of functional integration. I will finish with a comparative analysis of patterns and processes underlying gastrointestinal flexibility and a possible reconstruction of its evolutionary history.

KEYWORDS: *fasting, diet switch, phenotypic flexibility*

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Nutrient digestibility and digestive efficiency in Livingstone's fruit bats (*Pteropus livingstonii*)

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We measured the digestibility of dry matter (DM), gross energy (GE), crude protein (CP), neutral detergent fibre (NDF), sucrose, and calcium in four male and three female adult captive Livingstone's fruit bats (*Pteropus livingstonii*) on a diet commonly used for *Pteropus* species in zoos. In addition, we determined the nutrient composition of ejecta pellets from the diet as a whole and from four individual foods, as well as preferences for specific food items, and transit time through the gastrointestinal tract. We found high digestibility of sucrose in all trials ($91.9 \pm 0.3\%$). Ejecta pellets from the entire diet and from individual foods contained significantly lower concentrations of sucrose (3.2 ± 0.01 and 5.6 ± 3.0 g/kg DM) as compared to the ingested food (9.7 ± 0.5 and 13.2 ± 6.4 g/kg DM), indicating that Livingstone's fruit bats are able to extract most sucrose from their captive diet. NDF digestibility was low ($41.0 \pm 21.8\%$), and we found higher concentrations of NDF in ejecta pellets, both from the diet as a whole and from individual foods (461.9 ± 30.6 and 380.5 ± 170.1 g/kg DM), than in the ingested food (174.1 ± 5.1 and 130.2 ± 90.2 g/kg DM). Ejecta pellets from apple, pear, and grape contained considerably higher concentrations of calcium than ingested fruits, suggesting that the species' efficiency of extracting calcium from their diet is low. Our results suggest a high level of post-ingestive nutrient selectivity with varying degrees of extraction efficiency in Livingstone's fruit bats.

KEYWORDS: *energy digestibility, Ejecta pellets, Megachiroptera*
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A comparative view on dry matter intake and mean retention time of large herbivores

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Differences in aspects of digestive physiology between the two large groups of herbivorous ungulates, ruminants and hindgut fermenter, have been discussed in different studies. Hindgut fermenters generally show higher intakes and shorter retention times than ruminants. In the course of a comparative study on herbivores we had the opportunity to re-investigate this classic question of herbivore nutritional ecology, and to further quantify the differences described for ruminants and hindgut fermenters, and between different groups of hindgut fermenters. The study was conducted with 7 ruminant (n per species: 2-6) and 6 hindgut fermenting species (n per species: 3-7). Additional data for white rhinoceroses (5 animals) were used from a previous study. All animals received a ration of 100% grass hay (NDF 62 % DM, crude protein 8.86 % DM) with ad libitum access. Dry matter intake was recorded and mean retention time was measured with two different passage time markers: Cr-mordanted fibre for detecting passage time of small particles and Co-EDTA for the fluid phase of the digesta. All statistic comparisons were conducted with non-parametric tests. Ruminants ingested 49 g DM/kg BM^{0.75}/d, hindgut fermenter on the other hand ingested 83 g DM/kg BM^{0.75}/d, 1.7 times the value of ruminants (p<0.05). The ruminants had MRTs for particles in the range of 43 h (blue wildebeest) to 73 h (cattle) and the hindgut fermenting species between 25 h (Shetland pony) and 45 h (white rhinoceros). On average, ruminants had 1.6 fold longer MRTs for particles than hindgut fermenting species (p<0.05). The MRTs for fluids were not significantly different (p>0.05). When comparing the three subgroups of hindgut fermenters (equids n=13, African elephants n=6 and white rhinoceroses n=7) African elephants had food intakes of 103 ± 24 g DM/kg BM^{0.75} and MRTs for particles of 32 ± 7 h, the equids ingested 82 ± 10 g DM/kg BM^{0.75}/d and had MRTs of 28 ± 2 h and white rhinoceroses had food intakes of 70 ± 10 g DM/kg BM^{0.75}/d and MRTs of 45 ± 4 h. The food intake [g DM/kg BM^{0.75}/d] of rhinoceroses was significantly lower than that of elephants and the MRTs for particles were significantly shorter for the equids and elephants than for the rhinoceroses. For the MRTs for fluids no significant difference was found. It was verified in this study that ruminants generally have lower food intakes and longer MRTs than hindgut fermenter. It was also shown that the group of hindgut fermenters is variable in digestive strategies and that rhinoceroses have MRTs for particles approaching those of ruminants.

KEYWORDS: dry matter intake, mean retention time, larger herbivores

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Browse, grass and legumes – investigations on the digestion of different forage types

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The nutrition of ruminants of different feeding types has been a constant concern in zoo animal nutrition. Besides differences on the side of the animal, differences between the respective plants (forage types) need to be considered to gain a comprehensive view on the nutrition of different feeding types in zoos. In this trial different types of dried forages (grass 1 (1st cut), grass 2 (2nd cut), lucerne and a browse mix (consisting of chestnut, aspen and raspberry) were fed to goats, a species accepting all the different types of forage well (n=4 per treatment). Animals had ad libitum access to the forages, and feed intake and faecal output were quantified. Forages and faeces were analysed for their nutrient composition, and mean retention time for fluid and small particles (markers: Co-EDTA and Cr-mordanted fibre) and faecal particle sizes (wet-sieving) were measured. Average intake was 87±15 g DM/kg BW^{0.75} for lucerne, 69±9 g/kg BW^{0.75} for browse and 58±12 and 62±19 g DM/kg BW^{0.75} for the two grass hays. Organic matter digestibility of the forages in the qualities used was highest in lucerne (68%) and lowest in browse (38%), while that of the grass hays was 49 and 51% (grass hay 1 and 2). This led to a considerably higher intake of digestible organic matter in lucerne compared to the other forages. The values of the mean retention times and the faecal particle size indicated no significant difference between the forages, with a tendency for browse to result in larger faecal particles. Browse resulted in characteristic polyedric faecal particles, while grass produced more longish particles. The fact that the DOMI of browse was on a comparable level with the grass hays, irrespective of its considerably lower digestibility, implies that ruminants with some preference for browse can compensate for low digestibility by increasing food intake. Given the low digestibility of the browse used, this implies a tendency of browse to induce higher feed intakes and different packing of ingesta in the GIT. It remains to be demonstrated to what extent the difference in particle forms may influence this characteristic.

KEYWORDS: herbivore, digestion, feeding type

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Investigations on rumen and claw health of different wild ruminants according to the feeding management

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Feeding of zoo and wild ruminants is of empirical nature, as it is based on ideas of feed intake recorded from domestic livestock. In contrast to livestock, captive wild ruminants do not have high production rates but need to cover their requirements for health, longevity and adequate reproduction. Ruminants are specific high sophisticated herbivores which can not be put on uniform rations. Therefore ruminants are classified into a flexible system of three overlapping morphophysiological feeding types: concentrate selectors (cs), grass and roughage eaters (gr) and intermediate, opportunistic mixed feeders (im). Some of the most common disorders in captive wild ruminants are related with the gastrointestinal tract, due to inadequate feeding regimes. In the present study, the rumen metabolism and the effect on hoof health of four ruminant species from the Nuernberg Zoo were investigated in relation to the feeding regime. Five animals of different ruminant species including blackbuck (*Antilope cervicapra*) barbary sheep (*Ammotragus lervia*), sikka deer (*Cervus nippon dybowskii*) and addax (*Addax nasomaculatus*) from Nuernberg Zoo were used in this study. All animals were killed for reasons concerning ranking problems and overcrowding. During the study, the feedstuffs were listed and also weighed during 5 days. Different samples were collected including ruminal fluid, tissue samples of ruminal atrium and claws immediately after sacrifice and sampling was completed within 30 minutes after death. Histological investigations were performed to evaluate the various epithelial layers in rumen as well as to assess the status of the claws. In the ruminal fluid different parameters were measured like pH, short chain fatty acids (SCFA), lactate and ammonium. In three of the four species (blackbuck, barbary sheep and addax) severe characteristics of ruminitis were present. Furthermore within the group of barbary sheep clear indications for laminitis were assessed by a histological investigation of the claws. The SCFA, lactate and ammonium concentrations were in a physiological range, since at the time of sampling all animals were not fed for several hours. The pH ranged from 6.3 to 6.6 in the different species. Significant negative relationships were evident between SCFA and body weight and pH, respectively. The evaluation of the feeding management and the following nutritional analysis were difficult to standardize, since a huge variability of the amount, particularly of concentrate feedstuffs, was evident between the different animal keepers. The diets were offered mainly once a day. The diets were composed of hay and grass, respectively, and concentrated feedstuff. From these investigation under field conditions, it can be concluded, that the shown effects were probably long term effects on the ruminal mucosa of the blackbucks, barbary sheep and addax and on the claws of the barbary sheep. This suggests that a temporarily altered state of the rumen may lead to a subclinical acidosis caused by a high amount of concentrate feedstuff, although the pH of the rumen was not decreased enormously. Additionally, the concentrates were offered only once daily which might influence the ruminal milieu in a negative way, since synchronicity was not guaranteed with this feeding regime.

KEYWORDS: *wild ruminants, rumen, claw, feeding*
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A survey of Eastern bongo (*Tragelaphus eurycerus isaaci*) feeding practices in UK zoological collections.

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The Eastern bongo (*Tragelaphus eurycerus isaaci*) is a rare antelope restricted to the Afromontane forests of central Kenya. Its wild feeding strategy is unusual, poorly understood and few captive feeding recommendations are currently available to zoos. Adequate nutritional husbandry is vital to the success of captive animal populations. However, most zoo animal diets have been developed through trial and error as data regarding their wild diet selection and nutrient intake is often scarce (Bond, 2001). The captive Eastern bongo is fed predominantly upon a diet of forage (hay) and browse (trees) (Ganslosser & Brunner, 1997) but no published studies have investigated the diet variability between different zoos. Thus the aims of this research were; (1) to investigate the use and nutritional quality of forage and browse as components of bongo diets across a range of UK zoos, (2) to provide useful data on bongo diets for improving captive nutritional husbandry and (3) to highlight areas requiring further research. A diet questionnaire, completed by the personnel responsible for nutritional husbandry, documented the complete bongo diet of 8 UK zoos. Each bongo was then scored for body condition (BCS) using a standard scoring system and herd scores were calculated. Forage and browse samples were collected. Using keeper experience and questionnaire data it was possible to obtain samples representative of bongo feeding selectivity. Samples were then analysed for crude protein, modified acid digest fibre, lignin, organic matter and *in vitro* digestibility. Browse samples were also subjected to total extractable polyphenolic analysis. Student's T-tests, one-way ANOVAs and Tukey tests were utilised for statistical analyses. This research provides data (Wright *et al.*, in prep) which may be useful in establishing bongo feeding guidelines. No direct correlations were made between the dietary components analysed and BCS as a full dietary analysis (including concentrations and produce) was not possible. However, some husbandry recommendations can be suggested. Browse provision and species variety should be increased. Regular forage quality analysis should be undertaken where this is not already commonplace. Lucerne may be more suitable as bongo forage than meadow hay. The results suggest that feeding produce (fruit and vegetables) is unnecessary. There is a strong requirement for further study of wild bongo nutritional ecology and captive husbandry, particularly of rumen fermentation characteristics, digesta retention and passage rate, dietary energy requirements, and wild diet nutrient characteristics to allow a more accurate captive diet formulation.

KEYWORDS: eastern bongo, husbandry guidelines, captive diets

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It seems difficult to feed ruminant browsers adequately; the Japanese Serow (*Capricornis crispus*) as yet another example

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The Japanese serow (*Capricornis crispus*) is a rarely kept species. It is endemic in Japan. Its in situ diet consists mainly of leaves from browse and forbs. The amount of grass in the diet is less than 5%. The species can therefore be classified as a ruminant browser. In 2007 two serows arrived in Zoo Parc Overloon (part of Zodiac Zoos, the Netherlands). From their arrival onwards the animals' faecal consistency was not good and they were regularly suffering from diarrhoea. The male animal died from a clostridium infection. Another male which arrived showed also problems with faecal consistency. These problems were the immediate cause for a project, instigated by Zodiac Zoos, which aimed to get more insight in the nutritional needs of Japanese serows. A literature study was carried out and a questionnaire developed with questions on general husbandry aspects, diet and nutrition related problems. The ISIS database was used to select the zoos with Japanese serows and these zoos received the questionnaire. There are 17 zoos worldwide which keep this species and of them 14 zoos, with altogether 33 animals, responded to the questionnaire. The 14 zoos reported 23 deaths in the period 2003 -2008. Nine deaths were caused by a clostridium infection. In five cases a diet relation was indicated. The nutritional composition of the diets was calculated using several food and feed databases. The results were compared with a standard. Since there are no nutritional guidelines for the serow, the recently adapted guideline for another ruminant browser, the Okapi (*Okapia johnstoni*), was used. The Okapi recommendation is to feed at least 50 % (alfalfa) hay, a minimum of 15 % browse and a maximum of 30 % concentrate. Fruit and vegetables are not recommended in the diet. Only one of the responding zoos offered more than 50% hay in the diet. The majority of zoos offered so much concentrate, fruit and vegetables that the animals did not need to ingest hay to meet their energy requirements. Browse was seldom offered; however the only responding Japanese zoo reported 67% browse in their diet. The calculated energy supply was in eight cases within or slightly below the range for maintenance energy requirement. In six cases the amount offered was above this range. In some cases probably due to the presence of lactating and/or growing animals. The dietary nutritional composition was compared with the average composition of seven browse species eaten by serows. In 9 cases the amount of non fibre carbohydrates (NFC) was higher than in the 'natural' diet while the fibre fractions NDF and ADF were lower. The large amounts of concentrates, fruit and vegetables offered to captive serows are a serious health risk. Even more when these food items are offered in large quantities at once. The rather high incidence of clostridium infections can probably be contributed to the current feeding strategies. There are many examples of sub optimal feeding practices for ruminant browsers. The learning effect of these cases for feeding similar species seems to be not very high given the repeated pattern of similar feeding mistakes. It might therefore be more effective to invest in designing straightforward feeding guidelines for larger groups of comparable species instead of designing a diet for every specific species.

KEYWORDS: *Capricornis crispus*, browsers, zoo diet
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Winter feeding of captive moose (*Alces alces*) with various roughages

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Moose are considered particularly difficult animals in captivity. They are pure browsers in the wild, and are reported to regularly reject grass hay and even not to thrive on lucerne hay offered in human care. In order to test this in a consistent trial, we fed 4 moose their conventional zoo diet (CD), a diet of ad libitum lucerne hay only (LH), a diet of an ad libitum choice between lucerne hay and grass hay (LH/GH), a diet of an ad libitum choice of lucerne hay, grass hay, and dried browse leaves (LH/GH/BR), and an ad libitum diet of dried browse leaves only (BR). Total individual intake and faecal output was recorded so that digestibilities, including energy digestibility, were also measured. Each trial lasted for 14 days, with the first 7 days as adaptation period. Digestible energy (DE) intake on LH/GH/BR was highest, even higher than DE intake on CD. There was a clear trend for an increase in intake from LH to LH/GH although the animals refused the grass hay, which indicates that with increased adaptation time, the acceptance of lucerne hay increased. Intake on BR was higher than LH or LH/GH. Except for one animal, DE intake was within calculated maintenance requirements even on LH. The study adds weight to the observation that moose often completely avoid grass hay. However, we cannot confirm previous observations that lucerne hay is not an adequate food for the species; in contrast, even though the results indicate that browse leaves are the most preferred forage, the animals in this study did not avoid lucerne hay but even ingested amounts that must be considered energetically adequate. We can only speculate that this was due to the very high quality of the lucerne hay offered, not only in chemical terms (at crude protein of 14.7 %DM and ADF of 39.3 %DM, the lucerne hay was not particularly “high nutritional quality”), but in terms of hygienic quality, harvest and conservation technique. Problems often reported in captive browsers with “lucerne hay” may be more due to the quality, hygienic and conservation status of the respective material than its botanical entity.

KEYWORDS: browser, ruminant, forage

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Practical feeding of moose and giraffes in Kolmarden Zoo

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The feeding of concentrate selectors in zoos vary in regard of composition and feeding methods. In Kolmarden the feeding of moose was changed in 1980 as a result of analysis of rumen contents in shot wild moose. Nitrogen analysis revealed a very high (190 g/kg DM) raw protein level in plant material in moose shot in June and July, and a very low level (65 g/kg DM) in moose shot in January and February. A comparison with the composition of the previous diets indicated that we were feeding an excess of protein during the winter period, and too little protein during the vegetation period. The introduced summer diet focused on supplying as much protein as possible, while the winter diet only contained low protein feeds. As a direct effect, the trimming of overgrown hooves could be minimized, and yearlings got pregnant at 15 months of age. The anabolic summer feeding and catabolic winter diet was later introduced to most cervid species as well as most antelopes. The food composition of giraffes had previously been influenced by the results of analysis of natural browse in South Africa, indicating very high protein levels. The "Giraffe pellet" containing 200 g protein/kg was fabricated at the local mill, as well as the "Special pellet" with 150 g protein/kg and the "Standard pellet" with as low as possible protein level, usually 95-100 g/kg. Giraffes are fed the Giraffe pellet all year round, usually ad libitum, together with browse in summer and alfalfa cubes plus grass hay in winter. Moose were fed Giraffe pellets from May to October and Standard pellets from October to April. Despite the fact that moose and giraffes in captivity like concentrates and pellets they are offered the food ad libitum. New animals, used to stressful morning and evening feedings learn within a week to eat in small portions several times a day. As a result of two deaths and another two clinical cases of abomasal constipation due to aggregation of long hay straw, the feeding of long grass, silage or hay has stopped. The present feeding of moose and giraffes consists of pellets mixed with a variable amount of cut and dried alfalfa added with 15% molasses, and a small amount of sugar beet pulp. By increasing the amount of the 2-4 cm long alfalfa straw the intake of pellets can be delayed as neither moose nor giraffes can separate out the more tasty 4 x 10 mm pellets. For occupational enrichment we provide some browse in the summer period and pine branches in the winter period. Moose eat both the needles and the red bark, while the giraffes favourites the bark. When comparing the rumenal mucosa of dead moose with shot wild animals there has been no significant differences except in two old animals with worn premolars and molars who were only ingesting pellets.

KEYWORDS: moose, giraffe, food composition

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Nutritional quality of mid-European browse – a review

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The experience that browsing ruminants represent animals notoriously challenging in captive nutrition has led to comprehensive efforts by the zoo community to understand potential physiological particularities and to optimize their captive diets in general. An obvious measure in the latter respect is the inclusion of significant amounts of local browse in the diets of temperate and tropical browsers. Whereas logistics will often decide which browse type finally can be offered in practice, nutritional quality should also be considered when choosing a particular browse type. The first goal of this contribution is to review published data on nutritional quality of temperate browse taxa, focusing on an old, but comprehensive study done by Nehring and colleagues app. 60 years ago (including 12 browse taxa like maple (*Acer*), beech (*Fagus*), birch (*Betulus*), oak (*Quercus*), lime (*Tilia*), poplar (*Populus*), elm (*Ulmus*), hornbeam (*Carpinus*), alder (*Alnus*), elder (*Sambucus*) and ash (*Fraxinus*)). Browse was investigated for aspects like seasonal changes and acceptance and digestibility when being fed to sheep. The second goal of our contribution is the nutritional evaluation of some commercially available dried browse leaves like horse chestnut (*Aesculus hippocastanum*), European chestnut (*Castanea sativa*), hazel (*Corylus avellana*), aspen (*Populus tremula*), ash (*Fraxinus excelsior*), raspberry (*Rubus idaeus*), blackberry (*Rubus fruticosus*) and vine (*Vitis vinifera*) leaves. These were investigated for their in vitro fermentative behaviour (Hohenheim Gas Test) and proximate composition. From the literature review it is clear that largest seasonal changes occur in birch and beech, which influence their palatability (and other nutritional aspects) negatively at later stages in the year. Acceptance was particularly good in ash, elm, sycamore, lime, aspen and poplar; dry matter digestibility for leaves is only reported for a limited amount of taxa but ranged widely from 22% for beech and 55 and 62% for ash and black poplar. In our own investigations, the eight taxa showed the following values for 24 h gas production (a measure for digestibility) and crude protein content (always in the order gas production [ml/200 mg DM] / CP [g/kg DM]): hazel 18.9/129, horse chestnut 19.1/94.0, European chestnut 20.5/124, blackberry 27.9/159, raspberry 27.9/186, vine 29.6/109, aspen 30.3/134 and ash 34.5/151. Even if the digestibility of browse is often considerably lower than might be estimated from its high crude protein and low fibre content, it should be considered a valuable component in diets of captive browsers for many reasons. If practical factors like availability, logistics and price are disregarded away for once, of the taxa reviewed and investigated here, poplar, aspen, ash, maple and lime represent most desirable diet components even later in the year. Our own lab investigations confirm ash and aspen as promising feeding plants for captive browsing ruminants, a view further supported by their good acceptance in feeding trials with goats.

KEYWORDS: browse, nutrients, digestibility

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Development of a browse identification book for zoo keepers

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The importance of browse as part of the diet of many zoo species and as a helpful tool for environmental enrichment is often described in recent zoo nutrition publications. On the other hand browse remains a relatively unusual feed item compared to more 'traditional' products like hay, produce, fruit and concentrate. There are relatively few people who have knowledge of the feeding suitability of browse. The large majority of the workers in zoos are not aware of the feeding value of browse, the suitability of browse for the various animals and the possible unwanted side effects of feeding browse. Furthermore most people are not able to recognize most browse species. This is quite understandable since it is still a relatively new feed item and in regular courses on nutrition and feeding not much, if any, attention is paid to this type of feed. This lack of knowledge on the properties of browse can lead to under using this important feed item. When having the choice, people responsible for the care of animals will choose well known ingredients. When more people involved in the care of zoo animals get more knowledge on the properties of browse and its possibilities and become also better trained in recognizing browse, the use of this product can increase. To create a broader base of knowledge, a guide for the use of browse was developed in cooperation with the Dutch Zookeepers Union (De Harpij). The booklet consists of approximately 130 pages and is written in Dutch. Besides chapters on general properties of browse, aspects of quality, its use as environmental enrichment and the conservation of browse, the guide will provide information on 60 of the most common used browse species in Dutch zoos. The booklet contains illustrations for determining browse species, information on its nutritional value and possible side effects. The writers of the browse booklet hope that it will help promoting the use of browse in zoo diets.

KEYWORDS: browse, feeding value, keepers education

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Lowering diet costs in two Spanish zoological institutions

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There is the general thought that a nutritionally complete diet for any given species is necessarily expensive. Additionally, the economic cost of animal diets seems to be an important factor for most of the institutions holding wildlife, especially nowadays. Taking these facts into consideration, we tried to determine if it would be possible to assure both, an adequate diet for the animals and a decrease of the diets' costs. In order to do so, we analyzed the diets of two Spanish zoological institutions, A and B. The diets in institution A were reviewed through an intake study. ConZOOlting team went to the centre and determined the total amount of food offered and rejected by, in this case, birds. At institution B, we focused on primate diets. However, in this case, we did not visit the centre and all the communication was done through telephone or e-mail. The technical staff of the centre sent all the information we asked for (diet offered and rejected by each group of primates and specific aspects related to each primate species group), needed to determine the animal's food intake. All the data, collected in both institutions, was processed and analyzed using our own designed diet evaluation spreadsheet. In Centre A, after analyzing diets of 39 different bird species we realized that 1) most of the diets had many ingredients and thus required a long time of preparation, 2) the birds rejected an average of 30% of the total food offered, given the animals the option to chose and 3) the all diets consumed presented a range of two to eight nutritional deficiencies according to the nutrient requirements estimated for each species (based on literature and nutritional strategy). Diets were reformulated using a high quality commercial food (15-30% of the diet), that covered the nutrient requirements of the given species. This allowed us to reduce the total amount of food offered and simplify the diets by reducing the number of ingredients. Therefore, we successfully decreased the costs of each diet an average of 54% compared to the initial costs. Centre B held six different primate species. The initial diets offered were exactly the same for all the animals without considering their nutritional strategy. Additionally, the diets had many ingredients some of which required cooking, thus making preparation time long. Diet analysis revealed that there were at least five nutritional deficiencies compared with the nutritional requirements estimated for each species (based on NRC, 2003). The diets were reformulated based on each species' nutritional strategy and requirements, also using a high quality pellet (15-25 % of the diet), being the rest fresh ingredients. These changes allowed us to reduce the cost of the diets an average of 40% and the diet preparation was simplified, leaving much more time for keepers to dedicate to other important tasks. With this experience in these two centres, we conclude that it is possible to decrease diets costs (at least for primates and birds) without compromising the nutritional status of the animals. However, in order to do so, it is necessary the collaboration of the technical staff and the keepers.

KEYWORDS: *diet costs, adequate captive diets, birds, primates*

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Responsible feed in zoos

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The discussion on social and environmental impacts of large scale soy farming in South America and oil palm production has grasped the attention of the world. Newspapers, internet blogs, radio shows and television networks feature items on the phenomenon and politicians pay attention. Industry, producers and NGOs debate solutions to mitigate social and environmental impacts. What are these impacts? Soy production is associated with, amongst others: large scale deforestation and conversion of natural habitat; soil degradation and erosion; violation of workers rights; land rights conflicts; and loss of livelihoods. The production of palm oil in Indonesia and Malaysia has caused the loss of millions of hectares of pristine tropical rainforest, putting even more pressure on the already nearly extinct orangutan. In South America the biomes of Cerrado, Chaco and to a lesser extend the Amazon, are suffering the same fate as the forest in South East Asia, but now due to soy production. How does this relate to us? To our consumption, and more specifically animal feed in Zoo's? In almost 70% of what we buy in the supermarket soy is used as an ingredient or was used to produce it, varying from cookies to soap and from meat (via animal feed) to milk (again via feed). It takes almost 10KG of soy to produce 1KG of meat. Palm oil is also used in almost any article we buy in the supermarket: in cookies, detergent, etc. By buying products which contain palm oil or soy we put pressure on fragile ecosystems far away. The feed being used in Zoos also contain soy and possibly palm oil. This can be turned around into something positive. If Zoos say no to unsustainable soy and palm oil they can use their market power to promote sustainable palm oil and soy (this is available). The market share of the Zoos in the animal feed sector is low, but the message can be spread to a wide audience of millions of people. This will help put pressure on the industry to stop from sourcing palm oil and soy which comes from deforested land. Optional: IUCN NL and the Dutch Zoos are currently exploring options to source sustainably produced soy for the animal feed used in the Dutch Zoos. This is meant to set an example in the market and to support the conservation of valuable ecosystems on which we all depend. The Netherlands is the second largest importer of soy in the world, hence the importance to target this market. But, most soy is exported again to countries like the UK, Germany, Spain and France. The impact of soy in animal feed is therefore an European issue.

KEYWORDS: *soya, palm oil, sustainability, social impact, environment Dutch zoos*
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Diet reviews and adjustments for three species of tortoise, *Geochelone gigantea*, *G. carbonaria* and *Testudo graeca* at Paignton Zoo Environmental Park.

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The family Testudinidae (tortoises) includes 46 species in 12 genera and occurs in the wild in a wide variety of habitats including rainforest, savannah, semi-arid and desert environments in tropical, sub-tropical and temperate climates. Within the family there is a similarly diverse range of natural diets including strictly herbivorous and largely carnivorous species. Some species, particularly in desert environments, may go for days between feeds, whereas others will feed every day and many have large seasonal differences in food intake that may be important in triggering and/or maintaining reproductive activity in the breeding season. Despite this natural variety, in captivity all tortoise species tend to be fed similar diets on similar feeding schedules with little regard to seasonality, with the exception of hibernating species. Captive tortoise diets tend to be of a higher nutritional value than wild diets leading to higher growth rates, carapace malformations, earlier sexual maturity and reduced life expectancy. High sugar and lower fibre levels in captive diets generally lead to faster gut transit times and can cause gastro-intestinal disorders and loose faeces. It has been estimated that 40% of deaths of captive tortoises are due to nutritional ailments. Over the summer of 2009 we measured the dietary intake and apparent digestibility of three species of tortoise on the current diet provided at Paignton Zoo Environmental Park using standard techniques of weighing all food provided, all leftovers and all faeces produced. We also estimated grass intake using the bite count method. The diet as eaten was analysed using Zootrition. Where nutrient values of dietary items were not available in Zootrition the items were sent to a commercial laboratory for analysis, except for minerals which were analysed by the authors at the University of Plymouth. Faecal samples were all analysed in a commercial laboratory. We conducted a literature review of wild tortoise diets and recommended nutrient levels and developed adjusted diets based on this information. The major changes were the provision of a greater range of green leafy material, including browse but reducing the amounts of brassicas, increasing calcium levels and feeding only on alternate days for some species. After a changeover period to the adjusted diets we reanalysed the dietary intake and apparent digestibility. It is too early to identify long term health benefits of the diet change but short time effects which were immediately noticeable were an increase in weight of faeces, improved (more solid) faecal consistency and greatly reduced odour and increased activity particularly in *G. gigantea* while eating browse. The new diet is probably still not ideal and further review and improvements, including introducing seasonality and opportunities for enrichment, will be continued.

KEYWORDS: *chelonina*, diet review, digestibility

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Hand-reared common swifts (*Apus apus*) in a wildlife rehabilitation centre: assessment of growth rates with different diets

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Common swift orphans represent an important number of admissions in rehabilitation centres in Europe. Being an altricial species, chicks require hand-rearing for survival. Swifts are insectivore birds, which represent a real challenge when designing diets in captivity. An insect diet based in crickets is used in some specialized rehabilitation centres in Europe to hand-rear swifts, being optimal in aiding recovery from poor body conditions at admission, reaching optimal fledging weights and feather condition. Many wildlife rehabilitation centres may encounter difficulties in the hand-rearing of large numbers of chicks using commercially available insects as they are expensive food items. These constraints create the necessity of having alternative diets which take into account cost, effort and accessibility. Until 2008, Torreferrussa wildlife rehabilitation centre (CRFST) in Barcelona was using a diet based on rat mince to feed the orphans. In order to assess the performance of this diet, a group was created to compare growth rates during the hand-rearing process and body weight at release to those of wild parent-raised common swifts. Some variables, such as clinical condition at admission, were predicted to have some influence. Weight, feather condition and general behaviour were recorded daily. The results showed significant differences in final weights, being remarkably lower for hand-reared animals on the rat mince diet (Rat mince 32.8g SD \pm 2.7 vs. Wild 42.6 SD \pm 3.9). There was not a significant correlation between final weight and clinical condition. In 2009 CRFST expanded the diet study including three additional diets, a diet based on the FoNS 08 © formula, where the main ingredient is a high protein-low carbohydrate cat food, a diet based on crickets (90% *Acheta domesticus*, 10% *Galleria mellonella*) and another group using exclusively mealworm (*Tenebrio molitor*). Both supplemented with vitamins and minerals. The mealworm diet is quite controversial, as some non peer published sources attribute health problems in long run feeding. However, it is used successfully in hand-rearing Chimney swift (*Chaetura pelagica*) in the US. Three histopatological evaluations of tissues have been requested to observe if there was any damage to internal organs (results still to be confirmed). The final weight results in both insect diets groups were highly satisfactory, with values close to those in the wild (Cricket 40.1g SD \pm 4.2 – Mealworm 40.3g SD \pm 3.1). All birds, even emaciated at admission, were released in perfect conditions. The results for the FoNS 08 © formula were not optimal as expected with the final weights (33.5g SD \pm 4.2) although the birds attained an excellent feather condition and the flying performance at release was remarkable when compared to those observed on the rat mince diet. FoNS 08 © did not work well with very young chicks and birds in poor condition, which were switched to the insect diets. Under the circumstances the pure insect diet can not be provided for economical reasons and still we can not propose a satisfactory non insect base diet, the results of this research encourage and support the necessity to implement changes in the protocols for the upcoming season, and continued research to improve diets.

KEYWORDS: common swift, insectivore, hand-rearing diets

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Efficacy of hoofstock diets at Chester Zoo; assessment by keeper questionnaire and body condition scoring

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For the purpose of this study the term hoofstock refers to the species held by Chester Zoo which are classified in the two taxonomic orders Artiodactyla and Perrisodactyla. The digestive strategies of the herbivores hoofstock species can be divided into hindgut and foregut fermentation. Species from the order Artiodactyla are mainly foregut fermentors and species in the order Perrisodactyla are hindgut fermentors, differences which inform appropriate feeding practices for each group. An evaluation of Chester Zoo's diets for hoofstock species conducted in 2006 revealed that the diets were overcomplicated. The dry feed portion alone comprising varying combinations of 8 'concentrated' pellets, 7 'straight' feed ingredients (e.g. bran, flaked maize) and 2 brands of supplement. Before Chester Zoo appointed a nutritionist, diets fed to the hoofstock species were based on information sent with animals when they arrived from another collection, combined with trial and error use of existing food ingredients available and experience of what worked for similar species. Few health problems were evident; however, there was no consistent rationale for feeding these species within the collection. Since 2007 hoofstock diets take account of the digestive anatomy, feeding ecology and life stage, with an emphasis on forage, and dry feeds rationalised to just three specially formulated concentrates, eliminating the necessity for any additional supplements. Immediate acceptability of the adjusted diets by animals was good, with a month-long transition to ensure minimal disruption to gastro-intestinal function. Assessment over a longer period is necessary to ensure continued efficacy of the hoofstock diets. Are the diets currently being fed to all hoofstock species adequate for optimal health and welfare? Nutritional assessment was based on interviews with the head keepers of the relevant sections and by body condition scoring. Head keepers were asked to confirm current feeding practices, whether there were health problems which may be diet-related and how the current diet is accepted by the animals. The Body Conditions Scoring (BCS) was used to measure the diet efficiency. Nutritional status of an animal can influence the physical dimensions and gross composition of the body. Systematic and objective visual observations of an animal can provide insight into the nutritional status of that animal and the quantity and quality of its food supply. Scoring systems based on body shape and appearance of skeletal features, Body Condition Scoring, has been developed for several species and has been found useful in judging the adequacy of energy supplies. Digital photographs were taken to create body condition profiles for individually identifiable animals, creating an electronic archive that will be used to track changes in condition over time,

KEYWORDS: hoofstock, body condition scores, diet simplification

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Dietary management of an obese kinkajou (*Potos flavus*) with congestive heart failure secondary to hypertrophic cardiomyopathy

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An obese castrated male pet kinkajou (*Potos flavus*) with a history of hind limb osteoarthritis was diagnosed and successfully treated for congestive heart failure secondary to hypertrophic cardiomyopathy. The animal weight was 8.8 kg on presentation; almost 200% of the reported normal upper range for body weight.²The kinkajou's home diet comprised of table scraps, rice porridge baby formula, high calorie sports drinks, candy, and select fruits. Although within the order Carnivora, kinkajous have an almost exclusively frugivorous diet that can occasionally be supplemented with live protein such as insects.⁴ Dietary modification was directed as part of patient management, and owners were given strict guidance on content and proportions of the recommended diet. Dietary changes were implemented over several weeks with some adaptations based on the kinkajou's food preferences. The maintenance diet was calculated to about 250 kcal/day and mainly consisted of an assortment of fruit and sugar-free juice. The kinkajou responded well to its new diet, and over a 3 month period its weight decreased by almost 3.0 kg. Obesity is considered a major risk factor for developing cardiac disease in many mammalian species and may contribute to the high prevalence of cardiomyopathies in this species.^{1,3} Proper diet composition adhering to what is known about diets in the wild, along with controlled calorie intake, can reduce the health risks related to obesity, increase longevity, and offer better care for captive kinkajous.

KEYWORDS: *kinkajou, obesity, diet review*
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Bear weight management: a diet reduction plan for an obese spectacled bear (*Tremarctos ornatus*)

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In December 2006, a fifteen year old male spectacled bear (*Tremarctos ornatus*) was received into quarantine at Smithsonian Institution's National Zoological Park (NZIP). Diet information from the sending institution was analyzed and although diet components / nutrient content were appropriate for the species, the quantity of food was excessive, providing 7570 kcal ME/d. This determination was based on historic diet records for male spectacled bears, as well as the estimated maintenance energy (ME, kcal) requirement of adult inactive dogs: 95 (BW,kg)^{0.75} (NRC, 2006). The equation provides a frame of reference; however, given species and seasonal variability, it is not suggested as a definitive tool for calculating the ME requirement of bears. As part of the quarantine exam, Nutrition staff assessed body condition, recorded physical measurements, and determined total body fat content by bioelectrical impedance analysis. The animal was deemed grossly obese at body weight (BW) = 222.5kg, with a body condition score of 9 on a 1-9 point scale. Total body fat (48.2%) exceeded that of a temperate species bears (*Ursus americanus*) during early winter (31-45% body fat). Note: *Tremarctos ornatus*, a South American species, does not hibernate. A weight reduction plan with a specified timeline was developed and presented to NZIP veterinarians and animal care staff. The overall goal was gradual and continual weight loss over a 6 month period at 1% of initial BW/week, with a maximum of 2.0% and minimum of 0.5% of initial BW/week, to reach an initial summer target BW = 170kg. The base diet was reduced sequentially in conjunction with regular BWs, visual assessment of body condition, and ongoing communication with primary keepers. Food enrichment was initially eliminated and later included in defined quantities to provide 300 kcal ME/d. The animal was monitored for behavioural changes such as aggression, difficulty shifting, and development of stereotypic patterns - none were noted. Seasonal target BW ranges were further refined over the following 12 month period, resulting in a total weight loss of 77kg (35% of initial BW). Upon arrival into the collection this animal reportedly exhibited little interest in daily routines, and even minor movements were laboured. Health and well-being benefits of weight reduction were clear but there were also concerns about his ability to breed. Keepers noted a marked positive increase in physical activity and interaction with enrichment items throughout the weight reduction period and this activity level has been maintained to present. NZIP has since received a female spectacled bear. The pair was successfully introduced and many breeding bouts were observed during June 2009.

KEYWORDS: obesity, body condition scoring, weight reduction plan
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A failed attempt to change the diet of giant anteaters (*Myrmecophaga tridactyla*)

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Because of the perceived advantages of a complete insectivore diet for anteaters – consistency in diet preparation between various keepers, better compatibility of animals between facilities, but most of all, reduction in labour necessary for the preparation of conventional anteater diets – it was aimed to transfer the giant anteaters of Zurich Zoo on a complete, commercial insectivore diet. The product comes in the form of small granules that are particularly easy to handle and could be used in interesting display, e.g. transparent plastic tubing that allows the public to observe tongue movements of anteaters during feeding. In contrast to reports from other zoological gardens, the anteaters refused to eat the diet – irrespective of the form of presentation. Dry granules as packaged, or ground into a meal and mixed with water, were refused. When dry granules were mixed into the traditional diet, animals “licked around” the nests of granules and refused to ingest them. When ground into a powder and mixed into the conventional diet, the animals refused to eat these diets at very low dosages already, making the use of the compound impractical. Up to 5 kg of body weight loss were tolerated in the attempt to force the animals to switch diets before the attempt was considered as failed. We believe this report to be special because everyone involved – keepers, curators and veterinarians – had an exceptionally high motivation to enable the diet change. In particular, the keeping staff was very interested in reducing their own labour time so that more time could be used for other tasks, including observations of the animals. This case raises the question of what to do when the animals do not follow the recommendations, and of when to give up trying.

KEYWORDS: *insectivore diet, diet change, behaviour*

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Carnivore nutrition: bones of contention

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Carnivores only consume meat. This old misconception has already lead to many nutritional imbalances in captive carnivores, of which calcium deficiency has been most documented. Luckily, calcium deficiency is no longer the main problem of carnivores in zoos, because most zoos have become aware of the need for supplements to avoid mineral and vitamin deficiencies with meat feeding. Yet, a number of other threats still cause concerns regarding health, welfare and conservation of several carnivore species. The main threats perceived comprise obesity on the one hand (often with concomitant insulin resistance and inflammatory status) and stereotypies or other unwanted behaviour on the other hand. Although obesity, obesity-related metabolic disturbances and stereotypies are commonly attributed to enclosures lacking space or without species-adapted enrichment, nutrition is often overlooked as another potential factor in the development of these problems. To start with, the actual coverage of energy demands of many carnivores is difficult to estimate, since especially carcass feeding implies uncertainty on how much and which parts are eaten, and also how these specific parts contribute to the animal's energy supply. Obesity control thus has to include a well-considered estimation of body condition to check for underestimation of energy intake. Apart from meat, carnivores also consume variable amounts of bone, fur, skin, connective tissue, tendons, intestinal content of the prey, and even plant material in non-strict carnivores. Although information is available on the digestibility of nutrients among a wide series of carnivore species, the respective digestibility coefficients of non-meat components are insufficiently known. Digestibility largely determines the utilisation of nutrients and energy by the animal, but it also defines the amount and type of digesta proceeding to the distal intestine. The role of this non-enzymatically digested fraction in the large intestine still requires more investigation, but considerable intestinal fermentation has been demonstrated in felidae (e.g. cheetah). Although the large intestine is proportionally short, evolution has still allowed a fair amount of fermentation in the hindgut of carnivores, suggesting that intestinal fermentation might still serve a benefit. Recent studies in domestic cats found evidence for an amino acid sparing effect of fermentation, still to be further evaluated and quantified, but which might play a role in satiation and its concomitant behavioural response. Moreover, recent studies suggest that fermentation substrates are related with the production of potentially noxious components, and might thus be linked with the development of pathologies in carnivores. Seen the likely large differences in fermentation potential among dietary components from animal origin, feeding strategies will modulate intestinal fermentation in carnivores, and might thus indirectly affect the animal's metabolism. In conclusion, captive carnivore nutrition not only requires a balanced supply of nutrients and energy, but also has to be functional in a way that it promotes health, welfare and reproductive success.

KEYWORDS: *carnivores, nutritional disorders, fermentation*

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Impact of diet type on fermentation rate of cheetahs in captivity

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Objectives: As a means of optimizing the health status of captive cheetahs, research on feeding management is required. Yet, to date, data on the influence of the diet type on the intestinal microbiota and fermentation are scarce. A preliminary study on cheetahs showed a high variability in fecal bacterial protein, indicating possible differences in fermentative activity. Therefore, our hypothesis was that fermentation can depend on the provided diet (e.g. chunk meat or small whole carcasses), likely because of differences in indigestible animal tissue such as connective tissue, bones and hair. Since the optimal balance of fermentation products and the microbial composition are indispensable for gut health, but also modulates the immune system, the lack of detailed information on fermentation processes could be an important drawback in optimising feeding management and as a result general health of cheetahs. Therefore this study focused on the impact of diet type on fermentation in captive cheetahs.

Materials and methods: A cross-over study with 14 cheetahs was performed at Ree Park. Each group was given one of two diets: whole rabbit (R) or beef supplemented (B) with 10 g Carnizoo®, at intervals of four weeks. During week four of each testing period individual fresh faecal samples were collected within 15 min of defecation. A score for consistency (1= hard pellets, 5= watery diarrhoea) was immediately noted and pH was determined. In addition faeces per enclosure were collected and scored on a daily basis for 5 days. Fresh faecal samples were analysed for bacterial protein content, short chain fatty acids (SCFA), branched chain fatty acids (BCFA), indol, phenol and p-cresol. In addition, blood samples were obtained from 10 cheetahs on an opportunistic basis. Acylcarnitine profile was measured in serum samples as an indicator of fermentation rate.

Results and discussion: Cheetahs fed whole rabbit showed a significantly decreased faecal score (mean score=2.07) opposed to cheetahs fed chunk beef (mean score=3.13). Faecal pH was not significantly different between the given diets. Concentrations of the SCFA, BCFA, indole, phenol, and p-cresol were significantly lower for cheetahs fed R compared to B. In accordance with these results, serum acylcarnitine profile followed numerically the same trend. Moreover B induced a higher isovaleryl carnitine level and a trend for higher propionyl carnitine level compared to R. Faecal phenol and indole levels showed a positive correlation with faecal propionate and butyrate levels in both diets. These results provide evidence that feeding cheetahs B results in a higher fermentation rate. Moreover, the significantly lower ratio of acetate to propionate and acetate to butyrate when feeding B, confirms that pure meat diets also ferment faster. Although high concentration of SCFA are often related to fermentation of carbohydrates, this study reveals that in these strict carnivores, fermentation of undigested protein results in comparable concentrations of SCFA. When feeding whole rabbit, the high amount of indigestible and hardly fermentable material in the hindgut (e.g. hair), might decrease the fermentation rate and as a result, the formation of harmful products such as indole and phenol. Faecal bacterial protein proved to be higher when feeding whole rabbit. This could be an indication of changes in the composition of the microbial population in the hindgut when feeding whole rabbit.

Conclusion: Intestinal fermentation clearly differs between cheetahs fed chunk meat or whole rabbit. This finding emphasizes the need for further research on the impact of the provided diet on fermentation processes and possible links to the inflammatory status of cheetahs.

KEYWORDS: cheetah, carcass feeding, fermentation rate

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Nutrient digestibility and energy evaluation in carnivorous mammals

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Estimating the energy content is the first step in diet formulation, as it determines the amount of food eaten and hence the concentration of nutrients required to meet the animal's requirements. Additionally, being able to estimate the energy content of a diet empirically known to maintain body condition in an animal will facilitate an estimation of maintenance energy requirements. We collated data on nutrient composition of diets fed to captive wild canids, felids, hyenids, mustelids, pinnipeds and ursids and the digestibility coefficients from the literature (45 species, 74 publications) to test whether differences in protein and fat digestibility could be detected between species groups, and whether approaches suggested for the estimation of dietary metabolizable energy (ME) content in domestic carnivores (NRC 2006) can be applied to wild carnivores as well. Regressions of digestible protein or fat content versus the crude protein or fat content indicated no relevant differences in the digestive physiology between the carnivore groups. For diets based on raw meat, fish, or whole prey, applying the calculation of ME using 'Atwater factors' (16.7 kJ/g crude protein; 16.7 kJ/g nitrogen-free extracts; 37.7 kJ/g crude fat) provided estimates that compared well to experimental results. This study suggests that ME estimation in such diets is feasible without additional digestion trials. For comparative nutrition research, the study indicates that highly digestible diets typically fed in zoos offer little potential to elucidate differences between species or carnivore groups, but research on diets with higher proportions of difficult-to-digest components (fiber, connective tissues) is lacking.

KEYWORDS: *carnivore, digestion, energy*

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Nutritional management of captive cheetahs; is the domestic cat an appropriate model?

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The nutritional requirements of captive cheetahs are unknown, and dietary regimes employed by zoological institutions are typically based on domestic cat requirements and/or field studies of free-ranging cheetahs. Whilst mimicking the diet of free-ranging cheetahs may be viewed as the “ideal”, exact simulation of a wild-type diet is not always possible in a captive setting due to various environmental, logistical, economic, political or social reasons. As such, supplements, alternative meat sources or even commercially-prepared diets are utilised. Where data is lacking in regards to the specific nutrient requirements for cheetahs, information from studies in the domestic cat is often extrapolated to the cheetah. A review of the nutritional and reproductive anatomy and physiology of cheetahs and domestic cats was undertaken in order to evaluate the use of the domestic cat as a model species for the captive cheetah. Inter-specific comparisons included skeletal adaptations, digestive tract anatomy and function, internal organ size and weight, serum chemistry, reproductive physiology and life history characteristics, growth and development as well as maternal milk composition. Data on nutrient digestibility, utilisation and specific deficiencies or toxicities was collected for both species, as well as ecological data including prey size and diversity, feed intake and frequency. The internal organs of cheetahs and domestic cats are remarkably similar when compared relative to body size. In fact, the cheetah appears to bear closer resemblance to the domestic cat in this regard than it does to other large felid species. The shared carnivory and highly conserved genome of the Felidae has resulted in a number of analogous nutritional metabolic pathways. For example, the cheetah and domestic cat were found to possess equivalent metabolic activity for essential fatty acids, phenols, phytoestrogens and xenobiotics. However important differences were detected between maternal milk composition, vitamin A transport in the serum, as well as growth and developmental features. These findings indicate that care must be taken to utilise only the information from the domestic cat for which equivalence is confirmed in the cheetah. Furthermore, similarities between the cheetah and domestic cat cannot be extended to the rest of the Felidae family. The practical implications for the nutritional management of captive cheetahs generated by this review include the recommendation of the inclusion of whole vertebrate prey items, seasonally varied meat sources and the utilisation of starve days and feeding enrichment opportunities.

KEYWORDS: *cat, cheetah, nutrition*

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Nutritional evaluation of two milk replacers used to hand-rear cheetah cubs (*Acinonyx jubatus*): nutrient composition, apparent faecal digestibility and differences to maternal cheetah milk

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Commercially-prepared milk replacers are frequently used to provide the sole source of nutrition for hand-reared cheetah cubs (*Acinonyx jubatus*). However, these milk replacers are generally manufactured for use in domestic cat or dog nutrition, which are likely to have different requirements for growth compared to the cheetah. The nutrient composition of two milk replacers (one from South Africa, and one from North America) which are used in hand-rearing cheetah cubs was determined. Crude protein, dry matter, crude fat, crude fibre, nitrogen-free extract, lactose, ash and gross energy were determined for both formulas. Additionally, 18 amino acids, 10 fatty acids, 10 minerals and vitamin D₃ were determined. Faeces from cubs consuming one of these diets (n=4 on formula 1, and n=2 on formula 2) was collected on the last day of a 14-day feeding trial (7-day adaptation phase, followed by a 7-day feeding period). An indigestible marker (titanium dioxide) was added to the diet (0.3% DM) for the 7-day feeding period and a single faecal sample from each cub. Faeces were then analysed for crude protein, fat, amino acids and dry matter in order to calculate the digestibility of each nutrient. Mean apparent faecal digestibility for both formulas was > 90% for all nutrients analysed. However, the total crude fat content of both formulas was lower than reported for maternal cheetah milk and both formulas were deficient in at least one of the essential fatty acids α -linolenic, linolenic and/or arachidonic acid. Both formulas were low in the majority of essential amino acids and one formula contained an excessive carbohydrate fraction, at the expense of its protein content. Where data was lacking for cheetah maternal milk, comparison with domestic cat milk revealed excess concentrations of a number of minerals (K, Fe, Zn and Cu), while vitamin D₃ was not detected in one formula and only present in concentrations below the minimum requirement for domestic cats in the second formula. Therefore, despite their apparently high digestibility, neither formula was complete or balanced relative to maternal cheetah milk, and/or the requirements established for domestic cats. Although all cubs in the present study were healthy and maintained good body conditions for the duration of the trial, the results of dietary analyses indicate that these milk replacers may not provide optimal nutrition for growth in cheetah cubs when used for extended periods. Of particular concern is the finding that these formulas were deficient in one or more essential nutrient, such as vitamin D₃ and arachidonic acid. In cases where hand-rearing of cheetah cubs is required, only milk replacers which closely resemble the nutrient composition of cheetah maternal milk are recommended. Supplementation of commercially-prepared products is likely to be necessary.

KEYWORDS: cheetah, milk, nutrition.

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Feeding behaviour: meeting nutritional requirements and behavioural needs

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There is growing evidence showing that impossibility to perform normal foraging behaviour may result in abnormal behaviour - mainly stereotypies - and stress. Stereotypies (such as pacing, for example) are defined as invariant, repetitive behaviours that result from disease or from repeated attempts to cope with the environment. Predisposition to develop stereotypies varies between species and between individuals of the same species. Although the mechanisms underlying the development of stereotypies are still debated, it is widely accepted that housing and husbandry systems that result in a high proportion of animals showing stereotypies are not satisfactory from an animal welfare standpoint. Additionally, stereotypies may reduce the educational value of animals kept in zoos and are negatively perceived by the general public. Stress –particularly chronic stress- is also indicative of poor welfare and may have negative effects on reproductive performance and health. Environmental enrichment is frequently used to improve the welfare of captive wild animals, often by encouraging the expression of their normal foraging behaviour. This so-called nutritional enrichment is usually designed to increase the time animals spend foraging and to stimulate specific behavioural patterns that are displayed in the wild as part of foraging. Therefore, nutritional enrichment must be based on a sound knowledge of the natural history of the species. It is also important that nutritional enrichment programs are developed by multidisciplinary teams involving ethologists and nutritionists. When properly implemented, enrichment programs that result in the expression of “natural” foraging behaviour have been shown to reduce aggression and abnormal behaviour, as well as physiological indicators of chronic stress. It is therefore concluded that feeding management of wild animals in captivity must satisfy not only their nutritional requirements but also their behavioural needs.

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Identifying feeding behaviour of corals through stable isotope analysis

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Objectives: Coral reefs are among the most diverse ecosystems in the world, but are experiencing constant threats that are either natural or anthropogenic of origin. To detect when food resources become limiting, it is necessary to know the preferred food items. Since visual observations are difficult, time-consuming and likely inaccurate, other methods have to be developed for identification of prey preference in coral species. Stable isotope abundance has been used to estimate food preference in the wild, but has never been validated in a controlled experiment. The basic idea is that stable isotope abundance in corals can be affected by the natural abundance of C and N isotopes of the ingested food items. It has for instance been described that ¹⁵N increases with trophic level.

Materials and methods: Three dietary treatments were applied to two coral species at the Oceanium of Rotterdam Zoo, i.e. the gorgonian coral *Pinnigorgia sp.* (P) and the stone coral *Stylophora pistillata* (S). Diet A contained the highest concentration of two zooplankton species, *Artemia salina* nauplii and the rotifer *Bracchionus plicatilis*, and one species of phytoplankton, the algae *Nanochloropsis sp.* Diet B treatment contained half the concentration of the zooplankton and 10× less algae than in diet A and diet C (control diet) was the absence of live feed input. The corals were either housed as single species or together with the other species, in order to test potential interactions. Three containers were used per combination of species (S, P and S+P) and per diet (A, B, C), with in each several transplants. After 3 weeks, the transplants were freeze-dried and homogenised for analysis of ¹³C:¹²C and ¹⁵N:¹⁴N stable isotope ratios by isotope ratio mass spectrometry (IRMS). A 3-way ANOVA was used to look for effects of species (S, P), diet (A, B, C), mixing (sole or together) and interactions.

Results and Discussion: The ¹⁵N:¹⁴N ratio was higher in P versus S, irrespective of the diet. Diet A resulted in a lower ¹⁵N:¹⁴N ratio in both species in comparison to diet B, reflecting the higher proportion of algae in diet A. The absence of live food (diet C) exerted a high ¹⁵N:¹⁴N ratio in P versus a low ¹⁵N:¹⁴N ratio in S, which indicates that the two species differ in their catabolic metabolism. When housing both species in the same container, it is remarkable that their ¹⁵N:¹⁴N ratio became more similar to each other, possibly a consequence of the fact that they also started consuming each other's tissues. Although significant diet effects could be demonstrated for ¹³C:¹²C ratio, the species effect was much more apparent, which makes its use for determining food preference less suitable than the ¹⁵N:¹⁴N ratio. Yet, the combination of both stable isotope ratios will allow a better differentiation between species and diet effects in the wild.

KEYWORDS: corals, feeding behaviour, stable isotope analysis

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Feeding, breeding and habituation of exotic frogs in the rainforest hall at the Zoo Zurich

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Amphibian species are more under threat than any single animal group, about 1856 species according to the IUCN, which accounts for around 32% of all known amphibians. Habitat loss, pollution and diseases appear to be the major causes. Currently there isn't any possibility to stop the expansion of the deadly chytrid fungus or to medically cure the sick amphibians in the wild. To save them, there is only one possibility: to bring the endangered amphibians to protected stations. Here they will be able to live and reproduce in a secure environment. Zurich Zoo keeps and breeds several amphibian species. Among these, there are for example, frogs endemic in Madagascar, as for example the small poison frog *Mantella laevis*. This Malagasy frog is kept in the Masoala rainforest hall. In addition to intensive investigations in research about husbandry and breeding in this species, there is a gradual plan to release them from the controlled terrarium to the uncontrollable rainforest hall. This plan implies further knowledge of feeding and social behaviour. In the present study, several methods of feeding and handling of free ranging frogs are presented. Almost all frogs are housed in terrariums consisting mainly of metallic fly screen, so they can be integrated into the tropic biotope with the same climatic conditions but can be controlled within terrarium. To ensure sufficient food supply, fruit boxes are placed in the terrarium to attract flies. In this case, flies can circulate freely in the terrarium and hence frogs can catch their prey throughout the day. Contents of the fruit boxes should be changed three times a week. The reproductive success may be increased by hand rearing. Each tadpole should be housed individually in a rearing tank due to cannibalism between tadpoles of this species. Tadpoles should be fed three times a week with a spirulina algae product (e.g. Tetra PlecoMin). When tadpoles already reached final coloration, they are transferred to a small aquarium. This aquarium is positioned so that 75% of the base is filled with water and the other space is covered with rocks and moss; enabling recently metamorphosed frogs to emerge easily. Springtails (*Collembola*) should be offered daily to juvenile frogs.

KEYWORDS: amphibians, feeding, breeding

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To colour or not to colour the role of carotenoids in animal ornamentation and health

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Research on carotenoid as the pigments responsible for the brightest colouration of potentially sexually-selected traits in birds has been intense in the last years. For all animals, carotenoids must have a dietary origin as only photosynthetic organisms are able to synthesize them. The incorporation of carotenoids before final deposition in feathers depends on access to carotenoid-rich foods, foraging ability and specific abilities to absorb them through the gut. Carotenoids, none-the-less, have been assumed to be generally limiting in the environment. As a refinement of this potentially limiting status of the carotenoids, a trade-off between their ornamental properties and their physiological functions, particularly an anti-oxidant role, has also been assumed by most authors. Although this assumption mainly stems from medical literature and there is little actual evidence for this in wild birds, it is replicated in a majority of papers dealing with carotenoids in birds. It has been well established, particularly through experiments in captivity, that birds need to ingest a minimal amount of carotenoids to colour their plumage or other integumentary parts. However, demonstrations that carotenoids are utilized for strictly physiological functions are scant. Current evidence derives from captive-bird trials. As an example, female birds significantly reduce their circulating levels of carotenoids at a time when they form carotenoid-rich egg-yolks. The questions whether carotenoids are mobilized from storing organs or the blood during food shortages or in stressful situations, and how many carotenoids remain available in these situations remain contentious.

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Cricket species vary in gut loading capacity: implications for delivery of carotenoids to amphibians

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There have been anecdotal reports of muted colouration in captive amphibians, particularly with respect to yellow, orange and red pigmentation. Carotenoids are pigments that confer yellow to red colouration in many taxa, however vertebrates are incapable of *de novo* synthesis and must obtain them through their diet. Colour degradation in captive amphibians may therefore be caused by limited carotenoid availability in the diet. Carotenoids are known to function in cell signalling, immunomodulation and antioxidant systems in many taxa, however their importance for amphibians is poorly understood. Furthermore, carotenoid based colouration is often used for sexual or anti-predator signalling. Reduced colouration in captive anurans may therefore indicate poor health, and may have implications for reproductive success in captivity and suitability for reintroduction to the wild. Most amphibians are insectivorous, and will only consume motile prey. In managed breeding programmes, crickets are the main food item for tree frogs (family Hylidae). Nutritional analyses have shown that most commercially available cricket species are a poor source of nutrients, minerals in particular. Furthermore, there is currently very little information on their carotenoid content. We carried out an analysis of carotenoid composition of crickets that are typically fed to captive amphibians to assess variation in gut loading capacity. We also sought to determine which diet delivered the highest nutritional value in terms of carotenoids, and to assess carotenoid retention following a period of starvation. House (*Acheta domestica*), black (*Gryllus bimaculatus*) and banded (*Grylloides sigillatus*) crickets were fed for four days on one of three diets (bran, fresh fruit and vegetable, fish food-based dry diet). The experimental period replicated a typical period of gut loading before feeding to the target species. Following this, half of the crickets from each treatment were starved for two days to assess nutrient retention. Each species was, itself, a very poor source of carotenoids, however nutritional quality in terms of carotenoids was improved by 'gut loading' with a carotenoid rich diet. We found significant differences among species in gut loading capacity, and nutrient retention following a 48 h starvation period was poor across all species. The results of this study have implications for the management of *ex situ* hylid populations since limited carotenoid availability may have negative consequences for health. Furthermore, degradation of carotenoid based colouration in captive hylids may reduce their suitability for reintroduction to the wild.

KEYWORDS: amphibian, crickets, carotenoids

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A preliminary study of Vitamin D₃/UV-B treatments for amphibian bone disease

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The provision of vitamins is important to maintain amphibian health and reproduction in conservation breeding programs (CBPs), zoo and private collections. Vitamin D₃ is synthesised in skin through UV-B radiation, or assimilated through diet. Poor calcium metabolism through a lack of Vitamin D₃ is one causes metabolic bone disease (MBD) and may reduce reproductive potential. Gross symptoms of MBD are malformed skeletons, poor calcification, bent legs, and scoliosis. Vitamin D₃ requirements for most amphibian species are unknown and D₃ requirements between species are likely to vary widely dependent on natural exposure to UV-B and the amount of vitamin D₃ in diet. Amphibian CBPs include many species never before kept/bred in captivity and their survival could depend on the adequate provision of Vitamin D₃ or UV-B. The conventional amphibian diet of feeder insects dusted with vitamin/mineral powder can lead to gross skeletal deformities and low reproductive success, even in some adaptable and commonly kept species. However, there have been few studies of the metabolic requirements of Vitamin D₃ in amphibians. We are conducting a research program with amphibians to develop simple, reliable and benign techniques to study their metabolic requirements for Vitamin D₃, and the most practical methods for its provision. We are developing objective methods to assess both skeletal growth and bone calcification. Using X-rays, growth, health, and plasma calcidiol levels (the metabolically active form of Vitamin D₃), we are testing a number of research models for the Vitamin D₃ requirements of amphibians.

Study 1. Through decalcifying amphibian bones with acid while taking sequential X-rays, we correlated X-ray opacity, bone calcification and bones flexibility. We also developed a simple image analysis technique to quantify bone calcification from X-rays.

Study 2. Proximate veterinary treatments for MBD. Fifteen month old Green and Golden Bell frogs (*Litoria aurea*) in our general collection were found to be moribund, of low weight, with spindly legs and gross skeletal deformities. We provided all frogs with a general diet of mash ed sturgeon pellets fed directly to the stomach using a syringe. We used two frogs per. treatments consisting of: 1) Moderate UV-B light 10 uw/cm² (Reptisun 5.0), 2) Vitamin D₃ orally 2800 IU per kg per week, 3) 1 and 2 combined, and 4) Control: low UV-B light 0.03 uw/cm² (Growlux plant light). Substantial improvements occurred in the skeleton, growth and health of most frogs. Vitamin D₃ orally did not appear to improve skeletal health, and the effects of UV-B alone were weak, however, treatment (3) the UV-B treatment and Vitamin D₃ orally, gave a high degree of skeletal improvement. This study showed 1) there appears to be a synergism between Vitamin D₃ and UV-B in treating MBD, 2) UV-B appears preferable to oral administration of Vitamin D₃ and 3) calcification and skeletal repair is most pronounced in the spine, scapula, and ileum.

KEYWORDS: amphibian, vitamin D₃, UV-B

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Seed diets for psittacine birds: natural food or nutritional calamity?

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Introduction: Parrots are often fed multi-component seed diets. At first sight, this kind of feed seems a natural diet, which enables performance of the birds' normal ethogram, including manipulation of food with feet and beak. However, from a nutritional point of view, provision of seed diets comprises several nutritional drawbacks. First, all seeds are deficient in certain nutrients, such as vitamin A, and are profoundly imbalanced in Ca:P-ratio. Next, different-sized particles tend to segregate when stored. Consequently, replenishing storage containers before being completely emptied, results in a discrepancy between the intended manufacturers' formulation and the actually offered diet. Finally, parrots de-husk seeds, ingesting only the kernel; and have a strong tendency to select oilseeds from the given mixture. Both behaviours as well result in a vastly distinct nutrient profile between offered and ingested diet, which further aggravates nutritional imbalances and deficiencies inherent to seeds. The current study aimed to demonstrate the impact of segregation of seed diets on nutrient supply of offered feed, and to quantify the effect of seed selection and de-husking on nutrient intake. Next, the influence of apple, additional to a seed diet, was assessed.

Methods: A 100 g sub-sample of seed mixture was taken from the top layer of a feed storage container at the Loro parque Fundación, Tenerife. All seed types were separated, weighed, relative proportions calculated and compared to the ingredient and nutrient composition of the formulated mixture. Next, in a 2x2 cross-over design, 8 individually housed yellow-shouldered Amazons (*Amazona barbadensis*) were fed either a seed mixture or the same seed mixture and apple *ad libitum*. Ingredient composition of offered and consumed diet was recorded and nutrient and voluntary energy intake was calculated.

Results & Discussion: The most detrimental nutritional effect of segregation is a steep decline in proportion of oyster shells and vitamin-amino acid-mineral pellets (VAM supplements), which are relatively smallest in size. This lowers Ca:P-ratio from 2.61 in the formulated mixture to 1.36, de-husking of seeds would further lower Ca:P-ratio to 0.82, which is far below the recommended Ca:P ratio of 1.5:1. Seed selection resulted in an increase of fraction of oilseeds from 23% in the offered mixture to 82 ± 7% and 78 ± 5% in the ingested mixture, when feeding only seeds, respectively seeds and apple. Seed selection and de-husking increased energetic density of the diet from 1513 kJ ME/100 g to 2470 ± 158 kJ ME/100 g, respectively 2402 ± 94 kJ ME/100 g and lowered Ca:P-ratio of this seed mixture from 0.43 to 0.24 ± 0.07 respectively 0.19 ± 0.02, when fed only seeds or seeds and apple. Finally, voluntary energy intake was significantly lowered by 13.5% through additional provision of apple (P<0.005).

Conclusion: Notwithstanding efforts of nutritionists to formulate diets in order to approximate estimated, species-specific requirements, nutritional composition of the actually consumed fraction of multi-component seed diets can be vastly deteriorated by both animal and management factors. Voluntary energy intake can be lowered by provision of fruit next to the seed diet.

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Metaplasia caused by vitamin A deficiency in penguins?

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From 2003 to 2007 18 penguins originating from different zoos were necropsied at Department of Pathobiology (Exotic Animals and Wildlife), Faculty of Veterinary Medicine, Utrecht University. Histological examination of the kidneys showed ureteral squamous metaplasia. In a number of the birds metaplastic lesions were also seen in the tongue salivary glands. These lesions are consistent with Vitamin A deficiency in psittacine birds. Vitamin A deficiency in birds leads to squamous metaplasia of the normal pseudo-stratified epithelium of the ureters and collecting ducts. In advanced cases the epithelium can be transformed to a keratinized epithelium, with obstruction of the ureters. Vitamin A also acts as a hormone interacting with the genome to promote certain genes that are necessary in the normal differentiation of cells. In vitamin A deficiency this normal differentiation is hindered, and aberrant cells appear. The metaplastic epithelia are more susceptible to colonization of pathogens, e.g. mycotic pathogens like aspergillus spp. However no information is available on vitamin A deficiency in penguins causing metaplasia. In order to find out whether there is any relation between vitamin A and metaplasia an inventory was made in Dutch zoos of the food and supplements that were fed to Humboldt penguins (*Spheniscus humboldti*) and Black-footed penguins (*Spheniscus demersus*). 54 blood samples were taken from different penguins and examined for the concentrations of retinol. The results were compared with the available literature on the values of retinol. Average calculations on the intake of vitamin A varied from zoo to zoo and were compared with blood analyses and the available literature on the vitamin A status in the blood. It was calculated that the amount of vitamin A in the food should be sufficient. The average values of retinol ($\mu\text{mol/l}$) in the blood varied from 4.13 to 7.13 which is higher than the values given in literature (3.0 $\mu\text{mol/l}$ for Humboldt penguins). In these cases it is not very likely that the birds will develop metaplasia of the ureters or salivary glands. It is however unclear what the retinol values in the necropsied penguins were prior to death. However there are many factors which may have influenced the results. e.g. the actual amount of vitamin A in the fish, the thawing process and the condition of the penguins could have influenced the results.

KEYWORDS: retinol, fish supplements

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Feed intake strategy of breeding pigeons

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Objectives: Feeding pigeon species in zoos should keep the balance between meeting requirements and preventing overfeeding, because this can lead to selection of preferred food items and thus might induce nutritional imbalances. Considerable efforts have been made to bundle all available information on for instance crown pigeon nutrition for zoos, including differences in feeding behaviour between pigeon species. Yet, during breeding, adequate provision of food might become a more challenging issue, since the parents feed their young through crop-milk, and so the “unit” to be fed is the combination of a crop-milk producing couple with their fast growing squabs. Little is known about the way breeding pigeons anticipate on the changing nutritional demands and how efficient food is utilised throughout the breeding cycle depending on the number of squabs.

Materials and methods: Twelve male and twelve female pigeons (*Columba livia domestica*) were allowed to form couples and then housed in spacious group cages with a breeding pen per couple that allowed to measure daily feed and water intake per couple (and squabs). The parent pigeons were weighed at 19 days (oviposition first egg) and 3 days before expected hatching, and day 10 and 22 days after hatching, which is the estimated time that the squabs start feeding autonomously and the time of weaning respectively. The squabs were weighed daily from hatching until weaning at 22 days of age. The diet consisted of a commercial breeding mixture of grains and seeds developed, which was provided ad libitum but close to the estimated voluntary intake, in order to avoid spillage and seed selection.

Results and discussion: Both the male and female parents started to spontaneously gain weight already before hatching, pointing to the start of producing crop-milk. Important weight loss occurred between d-3 and d10 in both male and female parents, whereas between d10 and d22 weight loss decreased. This weight loss despite ad libitum feeding is similar to many mammalian species where negative energy balance is difficult to avoid, seen the high demands for growth of the progeny. Although non-significant differences in weight loss were observed between males and females, the magnitude of weight loss did not reflect the described sexual dimorphism of crop feeding in pigeons. Body weight at weaning was still below the situation at oviposition. This implies that pigeons might have a dietary need for recovering after breeding. Pigeons with one squab lost less weight and the squab showed faster growth than those with two, but the efficiency for food utilisation was lower than for two squabs, meaning that the number of squabs should not be taken as a linear measure for food allowance in breeding pigeons

KEYWORDS: *pigeons, squabs, breeding diets*

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Managing zoo diet information; what do we need from the next generation software?

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There is a gap within the current suite of animal records software provided by International Species Information System (ISIS); the facility to record diet notes is currently available within the Animal Records Keeping System (ARKS) but as a free text box, it can be completed with varying attention to detail. Bespoke software designed for the zoo community could i) ensure diet information is stored in a rigorous, standardised format, ii) be linked with animal stock numbers, allowing comparison with food purchasing/accounts, iii) be used for diet formulation, permitting the exchange of true 'diet' data – the nutrients that are being offered and consumed in specific quantities, not just a list of the food ingredients involved, iv) allow easy collation of diets used for many species at a single collection thereby fulfilling criteria for legal purposes or professional accreditation. Furthermore, diet information for a single species held in many collections could be easily collated, providing a useful research tool for producing zoo husbandry guidelines; it could also be a valuable educational tool. All of this information is essential for advancing our understanding and improvement of captive animal husbandry. Pragmatic reasons for using a customised diet management programme include legislative drivers (e.g. zoo licence and or accreditation requirements to keep diet records), plus economic incentives (e.g. the facility to check the quantity of food that should be fed matches what is being ordered). A number of programmes currently in use offer some of the functionality described, but no single one can do all of the above. Also, with no investment or management evident, all of these programmes are becoming technically obsolete and incompatible with modern technology. This presentation will make a case for why we should work together to design and build the next generation software.

KEYWORDS: zoo diets, information management, software

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Sodium and potassium intake of Cercopithecinae

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Due to changed biotopes or poaching, the existence of many Cercopithecinae kept by humans is seriously endangered in their natural habitats. Apart from the characteristic keeping of the species, the breeding management, and veterinarian prophylaxis, their nutrition is an essential factor for the successes or losses of breeding and keeping. The sufficient supply of nutrients, vitamins and minerals does not only guarantee the survival of the wild animals, it also takes an essential effect on their performance and immune defence. Due to hardly known comparative data, it is difficult to assess the mineral supply in many species. The mineral intake was determined in 5 species of Cercopithecinae (DeBrazza Guenon, Campbell's Guenon, Diana Monkey, Hamlyn's Guenon, Lion tailed Macaque) kept in the Zoo Leipzig. Following the duplicate method, quantitatively and qualitatively identical samples of the offered feed as well as feed residues were registered on 7 successive days. Thus, it was possible to determine the consumption of the different kinds of feed and mineral intake of these species. The mineral analysis was carried out with ICP-OES. The sodium and potassium status was estimated by blood parameters. The daily dry matter intake of monkeys and humans produced a considerable effect on the minerals consumption. Related to the metabolic body mass Cercopithecinae consumed 26 to 85 % less sodium than humans, however 1.5 to 4.8 times more potassium. Furthermore, the sodium and potassium concentration of the feed components varied considerable and had an effect to the daily sodium and potassium intake. The feed dry matter of the monkeys contained only 13 to 38 % of the sodium amount found in humans' mixed and vegetarian diets. Contrary, the potassium concentration was 1.5 times higher in monkey diets than in human diets. The mean sodium concentration of the consumed dry matter of monkeys varied between 1.2 to 2.2 g and was lower than the recommended sodium concentration for non human primates, whereas the feed dry matter contained more potassium than recommended.

KEYWORDS: sodium, potassium, DeBrazza guenon

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Urolithiasis in maned wolves (*Chrysocyon brachyurus*)

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The maned wolf is the biggest predator of South America. Urolithiasis and cystinuria (elevated cystine content in the urine) in maned wolves leads to a high mortality and morbidity among these animals. So far a clear cause for these urinary problems has not been found. There may be a connection between the development of urolithiasis and the diet offered to the maned wolves. After consulting a literature review a questionnaire was drafted to collect data on feeding regimes and the occurrence of urolithiasis in maned wolves in various zoos and institutions. The questionnaire was sent to all zoos and/or institutions in Europe keeping maned wolves. Urolithiasis was found 14 times in the past and at present. This is 4.2% of the entire maned wolves population that was screened. Eight from the eleven zoos where urolithiasis had been found offered a diet containing less than 50% plant material. In three zoos a diet containing more than 50% plant material was offered. In 13 zoos (including the zoos where no urolithiasis had been found) the food offered contained less than 50% plant material. Four zoos are “doing well”, offering food containing more than 50% plant material. This talk presents information from the questionnaire on the stones found in the possible relation to the diet and advises how maned wolves should be fed in captivity.

KEYWORDS: *maned wolf, urolithiasis, cystinuria*

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Evaluation of a nutraceutical joint supplement in camels (*Camelus* spp.)

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Efficacy and safety of Steadfast® Equine Joint Supplement (Novus International, Inc.), a proprietary blend of natural eggshell membrane, organic chelated trace minerals, antioxidant vitamins, and other nutrients that support joint, bone, hoof, and connective tissue health, was tested in a cross-over blinded study with 7.4 camels ranging in age from 4 to 18 yr of age. Two animals were Bactrian (*Camelus bactrianus*); the remainder were dromedaries (*C. dromedarius*). Individuals received dietary supplement doses calculated according to body weight; camels <600 kg received 50 g/head/day whereas those >680 kg were fed 75 g/head/day. Five animals were fed colour-coded supplements in each of two treatment groups (placebo vs. Steadfast) for 6 wk, followed by a washout of 1 wk (no supplement), and switchover to the other treatment for 6 wk. No other management changes to diet were implemented; camels previously on joint supplements (glucosamine, chondroitin sulfate) were taken off supplement a minimum of 21 d prior to the study. One aged, known arthritic animal was treated with a commercial lot of Steadfast (no colour code designation) throughout the study duration. Blood samples were obtained at days 0, 21, 42, 49, 70, and 91, separated, and serum analyzed for clinical chemistry, electrolyte, CBC, and cartilage biomarkers (CTX-II, PIIANP) – the latter utilizing commercial ELISA kits. In addition, videotapes of movement were obtained as another means of assessing supplement efficacy. Two animals were removed from the study due to relocation. Of the remaining camels, serum chemistry and electrolyte values were unremarkable and did not differ from expected normal ranges ($P > 0.05$) throughout the study. While no significant effect of sex or camel type was observed for the serum biomarkers, there was a significant effect of age observed for CTX-II ($P < 0.05$), but not PIIANP. CTX-II decreased with increasing age and tended to plateau between 8 and 11 years of age (quadratic effect $P < 0.05$). There was a significant time effect for PIIANP ($P < 0.05$); PIIANP decreased at d 49 for all camels and significantly increased thereafter at both d 70 and 91, regardless of dietary supplement. No effect of Steadfast was observed for either CTX-II or PIIANP. Concentrations of CTX-II were similar to concentrations measured in horses, whereas PIIANP concentrations were substantially lower in camels relative to those measured in horses fed equivalent doses of Steadfast, and the first reported measures in ruminant species. Validating available ELISA assay kits for the detection of CTX-II and PIIANP as biomarkers in camel sera is an important first step towards further investigation into early detection of joint pathology, as well as measures of therapeutic efficacy in treatment. The lack of efficacy of a sustainably-sourced, non-drug joint nutritional supplement for hoofstock may have been attributable to the fact that only one of the 11 camels had noticeable lameness.

KEYWORDS: hoofstock, nutraceutical, lameness

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A comparison of two different diets for growing moon jellyfish (*Aurelia aurita*) in Rotterdam Zoo

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Since January 2006, Easy DHA Selco enriched *Artemia salina* nauplii (Marine Water Systems, Putten, The Netherlands) are fed to moon jellyfish (*Aurelia aurita*) kept in Rotterdam Zoo Aquarium. Before 2006 the jellyfish were growing successfully, however since the diet changed approximately two thirds of the growing jellyfish developed a disfigured bell. This lowers their survivability in the large aquarium and makes them unsuitable for showing to the visitors. An experiment to investigate the possible effect of nutrition on bell development was initiated. Literature indicates high dietary protein affects bell structure and therefore a product with a higher protein content was tested. This product, 'Cyclop-eeze', was also supplied by Marine Water Systems. Newly strobilated ephyrae from two different groups of polyps were put in 18 large balloon flasks, approximately 250 ephyrae in each flask. In nine flasks the jellyfish were fed the currently used product. In the other flasks the ephyrae received the product 'Cyclop-eeze'. The experimental period was seven weeks. Jellyfish weight was determined weekly. After seven weeks bell disfigurement was scored and after this the animals were caught, terminated in a freezer and freeze dried to prepare them for laboratory analysis. They were analysed for dry matter, crude fat, crude protein and ash. A few samples were analysed on fatty acids. In addition moon jellyfish caught from the North Sea were analyzed to obtain reference values. All jellyfish fed *Artemia* grew well. Approximately 15% of this group showed bell disfigurements after 7 weeks. Within 12 days the group fed 'Cyclop-eeze' grew significantly less than the 'Artemia' group. Of the 'Cyclop-eeze' group only a few animals survived to the end of the period. Dry matter content of the *Artemia* fed jellyfish was 3.98% (± 0.019), while in wild caught jellyfish it was 4.64% (± 0.379). Ash content in the dry matter of the *Artemia* fed jellyfish was 72.05% (± 0.52) while in wild caught jellyfish it was 68.37% (± 3.51). The average crude protein content in the dry matter of the *Artemia* fed jellyfish was 5.48% (± 0.38). For the wild caught jellyfish this percentage was 7.33% (± 0.44). This was a significant difference ($p=0.031$). The average crude fat content in the *Artemia* fed jellyfish was 4.94% (± 0.50), while in wild caught jelly fish it was 8.02% (± 1.96). This difference, however, was not significant ($p=0.195$). The high mortality of the 'Cyclop-eeze' fed jellyfish is probably caused by the nature of this feed. It is non-living and the particles are difficult for small jellyfish to ingest. The feed particles are probably too large and do not stay suspended long enough in the water. The role of nutrition in the development of bell disfigurements remains unclear. The *Artemia* fed jellyfish showed only 15% bell disfigurements after seven weeks. Probably a longer experimental period is needed to get more insight. This project resulted in some additional information on jellyfish composition, but more data is definitely needed.

KEYWORDS: *Aurelia aurita*, nutrition, jellyfish composition

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Species-dependent mineral accumulation in corals

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Objectives: The breeding of corals in captivity is still prone to major lack of know-how on their nutritional requirements. Given the huge diversity in structure among coral species, it is likely that their response to available minerals might differ, and might reflect on species-dependent requirements. The present study looked into the effect of diet and coral species on their mineral composition in order to evaluate the potential of mineral analysis for detecting changes in food and mineral availability in the wild, and to learn about the principles of mineral utilisation by corals.

Materials and methods: Twenty-seven containers contained either transplants of the gorgonian coral *Pinnigorgia* sp. (Pi) (9 containers), or the stone coral *Stylophora pistillata* (St) (9 containers) or the combination of both (9 containers). For each of these three groups, 3 containers received Diet A (*Artemia salina* nauplii + *Bracchionus plicatilis* rotifers + *Nanochloropsis* sp. algae), 3 containers received Diet B (half the concentration Artemia and Bracchionus + 10× less algae of diet A) and 3 containers received no live food (Diet C). The transplants were freeze-dried and homogenised after three weeks, and analysed for mineral composition by induction-coupled plasma spectrometry (ICP). A 3-way ANOVA was used to look for effects of species (St, Pi), diet (A, B, C), mixing (sole or together) and interactions, and Pearson correlations were calculated.

Results and discussion: During the three weeks of the trial, the different diets could not exert effects in mineral composition, whereas the difference between the coral species was prominent. As expected, the Ca content of the stone coral was much higher than in the gorgonian (soft) corals, but remarkably, other minerals like Cu, Zn, Mn, Fe and Mg were significantly higher in the gorgonian corals, even when correcting for the “dilution” effect of the high Ca content in *Stylophora*. This implicates a different need or at least different preference for mineral accumulation between coral species. Although Ca concentrations were highest in St, the variation in Ca concentration was considerably higher within Pi. An explanation for this phenomenon might be the unequal distribution of calcium carbonate containing sclerites in Pi corals. Many of the other minerals were significantly correlated with Ca within the gorgonian samples. This could point to a preferential storage of these minerals in sclerites, but might also mean that sclerite-rich parts are for instance situated at the borders of a colony and therefore might have more access to mineral sources.

KEYWORDS: corals, mineral accumulation

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Hand-rearing a crowned sifaka (*Propithecus coronatus*): milk formulation, infant growth, comparison with mother-reared animals and previous protocols used in *Propithecus* sp.
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The crowned Verreaux's sifaka (*Propithecus coronatus*) is a large, diurnal, folivorous lemur species of the Indriids family. The European captive population is composed by 20 individuals, among which only 4 breeding females. The very small size of this population led to the recommendation of hand-rearing the babies, in case of mother failure. Therefore, since 2005, five babies were hand-reared in three French zoos, and are the firsts ever hand-reared from birth. In this paper we will focus on the nutritional aspect of the hand-rearing protocol successfully used on 4 of the 5 animals and in two zoos, on the problems we encountered and how these were overcome. The mean birth weight was 88,8g (ranging 80-96,5g), and the mean gestation length was 169,6 days (ranging 168-172 days). The infants were fed a milk formula, made of a mix of kitten/puppy milk and of human milk. The formula is composed by 17,5% Dry Matter, and the analysis (DM basis) is : 25,4% protein, 26,6% fat, 0,86% Ca, 0,62% P, Ca/P ratio=1,39. From day 20 to day 32, infants were given 10 meals per day, on a 24h-round basis, and then we dropped regularly one meal every 7 to 14 days, depending of the weight gain, until full weaning. The babies were fed *ad libitum* at the beginning, and it stabilized around 18-20g of milk/100g Body Weight (BW)/day. Introduction of solid food was done since day 15, with addition of 1g finely powdered Mazuri leaf-eater primate pellets/100mL milk formula, and/or proposal of acacia and soaked pellets. Progressive introduction of vegetables followed. The animals usually started to readily eat solid food at 1 month-old. The mean weight gain was 3-5g/day for the first 2 months, and then 5-10g/day since the infants ate significant amounts of pellets and vegetables. Around 2 to 3 months-old, all animals encountered a diarrhoea period, which lasted several weeks. This period neither seemed to affect the general health status of the animals, nor the weight gain. Regular diarrhoea medication was not very effective except racecadotril treatment. Support treatment and a vitamins and mineral supplement were given, as well as some mother's stools to enhance the development of gut flora. This problem solved naturally for all animals. 3 on the 4 animals were successfully weaned at the age of 5 to 6 months-old. The 4th animal died at 3 months-old of Tyzzer's disease. Food intakes and growth curves are presented, as well as comparisons with others protocols used in *Propithecus* sp. and mother-reared animals. The presented protocol was designed in order to cope with some identified specificities of rearing a folivorous lemur. However, despite relatively good results, future research is needed to prevent the diarrhoea period.

KEYWORDS: *Propithecus coronatus*, hand-rearing, milk formula
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A novel diet to feed giant anteaters (*Myrmecophaga tridactyla*); research, design, development and trialing of Termant.

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Historically, captive Giant Anteater diets have tended to be very complex, consisting of multiple ingredients mixed with water to form a consistency ranging from soupy to gruel. Reported problems associated with this style of diet are various, not least abnormal faecal consistency and certain nutrient deficiencies. Preliminary research was carried out to establish the style and composition of diets fed to captive Giant Anteaters on an international level. Subsequently Marwell Wildlife's own diet composition was tested by Mazuri's laboratory and compared to estimated nutrient recommendations for the species. Chemical analysis of the current diet revealed certain possible nutrient abnormalities and bacteriology testing revealed a mixed growth of various organisms with possible health implications; all supporting the desire to formulate a new diet. Marwell Wildlife, in conjunction with Mazuri Zoo Foods looked at the prospect of developing and implementing a new diet for captive Giant Anteaters, which would fulfil a number of criteria; not least the provision of a nutritionally balanced diet and one that would ease preparation time. New diet formulation by Mazuri involved a number of steps looking at the digestive physiology of the Giant Anteaters, their natural diet (mainly Ants and Termites) and target (dry matter) voluntary food intake that is seen for normal satiety. A diet form similar to the existing Marwell gruel presentation was designed in order to ease the transition between existing and new foods but, with the ability to reduce the amount of water added to the diet at a later stage. Raw materials were selected based on their nutrient profile and their digestibility. They were then formulated to target the estimated nutrient requirements and improve key areas that were highlighted in the initial research and analysis of the existing diet. The diet project code name 'Termant' produced its first batch in June 2008. A programme of gradual transition onto Termant was established over a couple of months with careful observation and monitoring of the animals throughout the process. Despite a couple of setbacks, this was achieved within the predicted timeframe and almost a year later, both animals are still consuming the diet well. First indications suggest an improvement in the consistency of faecal quality and maintenance of consistent weight patterns has been recorded; although other contributing factors cannot be ruled out. Furthermore, diet preparation time has been greatly reduced. Although long-term efficacy of this diet as an answer to historical diets is still yet to be proven, preliminary observations in providing for the nutritional needs of this species are encouraging.

KEYWORDS: *giant anteater, diet review, novel diet*

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Feeding and body mass development in giant anteaters (*Myrmecophaga tridactyla*)

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The feeding of anteaters is traditionally complicated – not because of particular requirements, but because of a tradition of feeding complex diet mixes that usually need to be prepared manually. Additionally, the energetic requirements of the species are not well-known, but they are reported to have lower metabolic rates than average mammals. We report results from intake and digestion trials in 8 giant anteaters on their conventional diet (in three different amounts to achieve body mass change, both in the summer and the winter season), and on four additional diets (consisting of the conventional diet with three different additions, and of a complete pelleted diet). All animals were weighed continuously throughout the trial to document body mass changes. There were no differences in body mass changes between the summer and the winter period, indicating no fundamentally different metabolic requirements between the seasons. The average maintenance requirement of digestible energy (to maintain body mass) was distinctively lower than that of domestic dogs. Faecal consistency as judged by a scoring system and by faecal water content was positively influenced by the intake of acid insoluble ash (mostly from soil). However, attempts to improve faecal consistency by the addition of soil, shrimp shell meal, or grass meal, were of limited success, mainly because most animals proved very conservative in their acceptance of new diets; even after prolonged periods of trying, there were large differences in the additional amounts of these substances tolerated in the diet by individual animals. For those animals where a change to the complete insectivore feed could be achieved, manual labour of zoo personnel was reduced drastically.

KEYWORDS: *insectivore, complete diet, energy*

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Tropical forages in diets for endemic herbivorous ungulates in Costa Rica

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In Costa Rica many zoos and rescue centres keep herbivorous ungulates as part of their animal collection, including the white tailed deer (*Odocoileus virginianus*), tapir (*Tapirus bairdii*), and collared peccary (*Pecari tajacu*). These species have specialized gastrointestinal tracts; deer is a ruminant, tapir is a hindgut fermenter and peccaries are foregut fermenters (non ruminants); white tailed deer is one of the two ruminant wild endemic species commonly keeping in captivity. The use of tropical trees and shrubs foliages in ruminant diets is common in several countries; some research related to goat production in Central America have identified suitable species, including their nutritional value, biomass capacity production, agronomic traits and use as forage potential. With the deer as a model, a project to determine the palatability and nutritional content of tree species used as forages with domestic species and reported into the wild herbivorous diets: jocote (*Spondias purpureum*), guácimo (*Guazuma ulmifolia*) and mango (*Mangifera indica*), at two different periods (end of summer and rainy season). A portion (25%) of the total diet was substituted by mature leaves with branches and these were each offered over 18 days; nutritional composition was also determined. Nutritional analyses results reported DM as 20.9 - 38.0%, CP as 8.42-10.56 %, NDF as 27.51-56.39%, lignin as 8.85-13.25%, IVDMD as 50.1-73.0% DE as 2209 – 3219 kcal/kg DE and P as 0.13 – 0.30% (ranges of the three species). The high palatability values are from period 1 with jocote, and during period 2 from jocote and mango. The average of dry matter intake was between 860.38 g and 1021.48 g DM/animal/day, and between 1.56 % and 1.86% intake as a percentage of body mass. The forages improved fibre levels of the diets up to 17.14% NDF. The crude protein values were lower than other studies due probably to leaves maturity stages and because the branches had been included as well. Jocote presented the higher intake and palatability perhaps due to low fibre content, high IVDMD percentage and less lignin content and presented the high digestible energy value compared with mango and guácimo; this information is very important for diets balance and to estimate possible animal nutrient requirements, and compare them with template countries individuals. With respect to the other ungulates, tapirs and peccaries diets also include forages, 15 % guacimo/jocote leaves and 15% of bananas peels as fiber sources, although a formal study have not yet been conducted. These diets also include tubers, some legumes, pellets and minerals, balanced according to specific requirements. However, there are some tropical pastures that are consumed for these herbivorous species as well, such as *Cynodom nlemfuensis*, *Panicum maximum* and *Brachiaria* spp., and have adequate nutritional values. The importance of including fibre sources to herbivorous species is known, and their effects in the adequate function of the gastrointestinal tract, providing substrate for microbial protein production, vitamin synthesis, and providing an optimal environment for the development of microbial flora into the fermenters organs. Although there is much research to do, it is very important to consider the potential of tropical forages overall at Latin American zoos in addition to evaluating these forages compared with exotic species from other continents, since the majority of forage studies have been conducted on temperate species.

KEYWORDS: *tropical forages, ungulates, nutrient composition, fiber*
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Implementation of a new weakly allergenic regime for callitrichids and other new world monkeys; preventive and curative effects concerning the Wasting Marmoset Syndrome and digestive sensibility.

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Since August, 2007 a callitrichid diet excluding most common allergens was implemented in Asson zoo, giving evidence that these monkeys were intolerant to their old diet. Since 2004 the thirty callitrichids were fed a gluten-free diet comprising a home-made mix of six ingredients, fruits, protein-snack and feline hypoallergenic soya croquettes. It has been suspected for years that callitrichids develop allergies and food intolerances: gluten has been pointed out, specifically as taking part in the aetiology of the Marmoset Wasting Syndrome (WMS *), but Asson's collection was prone to chronic diarrhoea despite excluding gluten. Therefore the new diet set up in the zoo since 2007 excludes any food potentially containing intolerance factors (lactose, gluten), or allergens (seeds, nuts, soya, casein), and thus a great majority of industrial products and artificial aromas as well as many food complements because of their excipients). At first a home-made pulp was implemented, associated with a complement elaborated for the occasion. A probiotic/prebiotic/enzyme complex was added once a week. We changed the feline croquettes for others containing no soya. In parallel, that pulp (stripped of the callitrichids complement) was integrated into Saimiris diet, these being also, though more rarely, prone to diarrhoeas. After a 20 month follow-up of this new food plan, a second transition allowed to replace the domestic pulp by an industrial one. Indeed use of powder-based foodstuffs is a saving of time for zoo personnel. This complete diet formulated for New World Monkeys is also intended for Marmosets when associated with a food complement produced by the same supplier. Appetence and not needs directs the animal's choice, so it is through balanced tests of increasingly severe restrictions in the choice of raw materials (appetence problems being added to the multitude of foodstuffs forbidden due to intolerances or allergies) that the final diet could be accepted by all those species. Other difficulties occurred, like lack of mash volume compared to ingest capacity, because of a too much concentrated foodstuff with first experiments. The new diet was accompanied from the very start of food transition (which lasted for one month) by the disappearance of digestive disorders, in spite of climatic vagaries (premature temperature drop and increased humidity mid-August 2007). Nevertheless this year an antihelminthic infestation confounded the study. Finally the diet change brought successfully results since it stopped the chronic diarrhoea. Birth rate has been kept and monkeys seems healthy, which has been indeed confirmed by blood samples revealing that unlike two years ago, callitrichids present no more signs of anaemia. Moreover, the recent industrial version, being ready to use only by adding water, is precisely balanced and easy to use, a real improvement compared to the old diet. Last but not least food supply is well known, since animals consume the mash entirely. This new diet highlights that certain callitrichids are sensitive to other allergens than gluten: the next step is to examine which of these allergens is(are) the root cause(s). In the meantime, a ration stripped of the most common allergens, and not only gluten, seems to be the best solution.

KEYWORDS: *callitrichids; new world monkeys; weakly allergenic regime; Marmoset Wasting Syndrome; diarrhoea*

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Nutrient composition tables for fruits and vegetables as a decision tool for zoo animal keepers

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A typical diet item fed in zoos, but of concern for nutritionists, are fruits and vegetables. Commercial fruit and vegetables do not resemble the natural food even of animals that consume fruits in the wild and are hence termed 'frugivores'. A usual recommendation is that if fresh produce should be fed, then fruits and coloured vegetables should be replaced by green leafy vegetables. Unfortunately, in practice, animals often do not tolerate such a change and make the respective diet changes doubtful for all personnel involved. In an attempt to make diet changes part of everyone's routine thinking at Zurich Zoo, we collated literature data on the protein, non-fibre carbohydrate, calcium and phosphorus content of fruits and vegetables, using a colour coding system to indicate adequacy of items. The objective is that each keeper should assess the diets usually fed to the animal in his/her care, and think about, or try out, the acceptance of potentially more adequate items before an official diet change is formulated.

KEYWORDS: *fruit, vegetables, diet change*

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Weight reduction in spectacled bears (*Tremarctos ornatus*)

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Because of adaptations to a seasonal environment, bears appear to be particularly susceptible to obesity in captivity. Due to the impression that Spectacled bears at Zurich Zoo were overweight, due to high body weight measurements as compared to literature data, and due to an evaluation of the traditional diet that exceeded the calculated energy requirement of the species by a magnitude, the diet was changed to exclude bread, reduce the amounts of fruits, and increase the proportions of complete pelleted food and green leafy vegetables. No reduction diet was formulated, but the new diet was formulated to just meet the assumed maintenance requirements at ideal body weight. On the one hand, the weight loss program was successful, with overweight specimens reducing their weight while the non-overweight specimens did not lose weight, and a growing young animal continued to grow. However, the bears were remarkably conservative in their acceptance of new diet items such as vegetables. Even after 6 months of continuous presentation, items such as fennel were not accepted as food by any of the bears. At present, the bears are conceived to be in optimal (slender) body condition and have been considered to be more active than before. The case will highlight the necessity to involve all levels of management in a diet change, emphasize the usefulness of continuous body weight measurements, but also show up limits set to formulating new diets by the preferences of the animals.

KEYWORDS: *omnivore, fruit, vegetables*

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Local food, global nutrient data: how do published values compare for commonly used diet ingredients?

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Animal diets that are known to be successful are often shared by colleagues in zoological collections, within and between countries. However diets are only comparable if the compositions of the ingredients are also equivalent. For manufactured products, such as pelleted feed, this can be confirmed relatively easily by the nutrient information label. Diets for zoo animals also include many perishable ingredients, including whole prey items, forage, fruit and vegetables. Fruit and vegetables (commonly referred to as produce) typically form a large part of the fresh weight and financial cost of zoo diets. Is the produce available in different parts of the world is nutritionally equivalent? Data on food composition is published by many countries and was used to make this comparison. The produce items compared are those most popularly used by Chester Zoo, based on analysis of fruit and vegetable usage over a 12 month period (April 2008-March 2009). The ten most used fruit and vegetables (in kg fresh weight) were identified and data on their composition compared using tables published for 16 countries in Europe, the Americas, Asia and Australasia.

KEYWORDS: food databases, nutrient values, produce

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Use of INFIC nomenclature on the feedstuffs in the National Zoological Gardens of South Africa

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The feeding program in the National Zoological Gardens of South Africa (NZG) has little information available upon which to base necessary decisions. This program is based on common nutrition and feeding principles from the animal kitchen and on the ongoing nutrition program from the management. In this case, most feedstuffs fed to animals are based on the market availability, the human nutrition and livestock principles. The dilemma is that species are fed on the basis of feed items than on nutrients contents of the items. With the objective of formalization and standardization the diet sheet in the NZG, research is initiated on the evaluation of nutrient composition of all the feedings stuff in the NZG. The first objective is to describe correctly and with precision the feedstuffs from the animal kitchen and evaluating the diet sheet of the animal based on the international recommendations and methods, which is the second objective. The data collection of information was done in the animal kitchen of the NZG. This was based on the identification of the feeding stuffs, collections of information procedures of preparation and distribution of food. The determinations of the nutrients composition was done by using the literature checklist from the South African nutrition tables are the results of different tables, the Canada-US tables and UK food composition tables. Among the items some had no information on nutrient composition. A chemical analysis of the items with no nutrients composition will be done based on the variations in terms of season (dry and wet seasons). In the aims of meeting the international requirement of the on feed names, INFIC nomenclatures have been used to describe each one the items to use of the data by others nutritionist in South African zoological gardens. This network assigns internationally acceptable names and numbers to some of the feedstuffs, which could be used for reference by nutritionists and research workers in the zoological gardens. This presentation discusses the possibility of identification, naming and describing the feedstuffs Zoological gardens' of South Africa. The results show the advantages of enhancing communication of information on feed composition and quality in national level and the way of implementation of scientific nutrition program. This information will lead to a coding system compatible with computer software. Nevertheless, some problem points need to be clarified in using the INFIC system which needs attention. This situation is related to the variability of percent figure of some items where a particular nutrient matches but other percent nutrients are different, pose a problem in adopting the INFIC system.

KEYWORDS: *INFIC nomenclatures, feedstuffs, National zoological gardens of Pretoria*
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Growth performance of larvae and postmetamorphic juveniles of the hynobiid salamander *Pachyhynobius shangchengensis*

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Amphibian populations worldwide are in dramatic decline due to several anthropogenic influences and infectious diseases. To safeguard amphibian species from extinction, an increasing number of ex situ breeding programmes are in place. Captive breeding of salamanders and newts, although increasingly successful, still has to cope with several difficulties such as unwillingness to breed, larval mortality and infectious and nutritional disorders. Unfortunately, virtually nothing is known concerning basic feed composition requirements to successfully raise captive bred urodelans. In this study, we determined 1) larval growth rates of *Pachyhynobius shangchengensis* fed a defined diet of bloodworms and 2) feed requirements of postmetamorphic *P. shangchengensis* juveniles by providing two feed types. In 2006, we obtained a first and until now only captive breeding of the Chinese hynobiid stream salamander *Pachyhynobius shangchengensis*. After hatching, larvae were housed individually in approximately 1 l of water. In a first experiment, ten on average 42.5 ± 1.8 mm long larval salamanders were fed aquatic larvae of the non-biting midges of the family Chironomidae ("bloodworms") ad libitum. The average bloodworm weight and composition were determined and the number of bloodworms consumed was counted daily for 8 consecutive days. Salamanders were weighed and measured before and at the end of the experiment. Average total length and bodyweight of the salamanders increased with 7.8 ± 2.7% and 33.2 ± 3.9% respectively on average during the 8 day period. Each salamander consumed on average 462.1 ± 51.1 mg of bloodworms, equalling on average 98.6% of the initial bodyweight, resulting in an average weight gain of 154.2 ± 19.3 mg. In a second experiment, 6 metamorphosed juveniles (119.9 ± 3.4 mm total length) were fed *Tenebrio molitor* larvae and 6 juveniles (113.3 ± 6.4 mm total length) were fed commercial turtle pellets (Natural Aquatic Turtle Food - Growth Formula; ZooMed) ad libitum for 14 days. The average worm and pellet weight and composition were determined and the number of feed items consumed was counted daily for 14 consecutive days. Salamanders were weighed and measured before and at the end of the experiment. The average total length and bodyweight increased with 5.9 ± 1.9 and 25.9 ± 8.7% respectively for the animals fed pellets and with 4.4 ± 1.1 and 31.5 ± 8.7% respectively for the salamanders fed meal worms. The animals consumed on average 1283 ± 244 mg of pellets or 1494 ± 457 mg of meal worms, equalling on average 15.2 and 25.0% of the initial bodyweight respectively and resulting in an average weight gain of 2177 ± 708 and 1917 ± 686 mg respectively. This study provides the first data on growth of larvae and postmetamorphic juveniles of hynobiid salamanders in relation to the feed consumed.

KEYWORDS: *salamander, Pachyhynobius shangchengensis, growth rate, nutrition*
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Diet of captive Kodiak bears (*Ursus arctos middendorffi*) compared; what is a good diet?

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Emmen Zoo has three Kodiak bears (*Ursus arctos middendorffi*) in its collection. To obtain information for further diet improvement a project to collect information on optimum diets was started. For this project a literature study was carried out to collect data on the in situ diet. These data were used to calculate a nutritional profile for this species. Also a questionnaire pertaining feeding practices was sent to institutes keeping Kodiak bears or brown bear subspecies with comparable feeding patterns (*U.a. horribilles* and *U.a. beringianis*). Furthermore the digestibility of the diet offered in Emmen was determined. Twenty institutes (25%) of the 63 keeping Kodiak bears or comparable subspecies responded. A seasonally adapted diet was offered in 16 zoos. In four zoos the diet was the same throughout the year. More than seventy different feed items were offered in the 20 responding institutes. Most fed items were apples, dry dog food, carrots, fish and carcass parts. Based on the data in the returned questionnaires the daily amount of energy offered was calculated. On average this was 0.65 MJ/kg^{0.75}. The daily energy offered varied from 0.21 MJ/kg^{0.75} to 1.18MJ/kg^{0.75}. Compared to the calculated average daily energy intake in situ (hibernation period included) of 0.35 MJ/kg^{0.75} this is rather high. For the diet digestibility determination in Emmen the feed items were weighed and all faeces were collected from the enclosure during a period of seven days. Both proximate analysis and van Soest analyses were used for the feed and faeces samples. Average crude protein digestibility was 82%, for crude fat it was 92%, crude fibre 7%, ADF 3%, NDF 58% and NFC 88%. The results for crude protein and crude fat digestibility were in line with the scarce data on digestibility from other bear species. Results of this study show that especially the daily amount of energy offered and the seasonality of the diet deserve attention for this particular group of bear species.

KEYWORDS: *Ursus arctos middendorffi*, bear diets, digestibility

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Study of the response to levels of difficulty in obtaining food for predatory birds in rehabilitation centers for wild animals

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In order to study the difficulty in obtaining food for predatory wild birds in rehabilitation centres and with the aim of optimizing the recovery process, a methodology was followed based on making the birds overcome each of 5 levels of difficulty, stimulating them to find / capture food, dead or alive. The experiment took place between September 2008 and June 2009. For each animal, each level of difficulty lasted for a week and they only moved to the next level if they did not lost weight, nor were damaged and retained their physical abilities. Whenever they did not meet the above criterion, the animals remained at or regressed to lower levels. The species (and sample numbers) studied were, *Ardea cinerea* (1), *Accipiter gentiles* (1), *Milvus migrans* (6), *Athene noctua* (7), *Strix aluco* (7) and *Bubo bubo* (2) which could be compared with control animals. The mean weights were obtained every 7.44 ± 4.94 days, for the 24 individuals. Between individuals of the species that were subjected to food training, stands out the order Owl and in particular *Athene noctua*, because it was reached the highest level fastest. When comparing animals that did not receive food enrichment with those which did, there no weight was lost, so causing hardship in obtaining food as feeding technique prepared them efficiently to find food in the wild. The time it took to reach the level of difficulty was higher for the nocturnal birds of prey (16.00 ± 9.16 days) compared to the daytime ones (44.50 ± 19.09 days). The duration of food training (time it takes to reach the last level and stay on it) ranged between 10 and 47 days (during the 102-day study, the individuals of the species *Milvus migrans* failed to capture live food; the last level). The time needed for reaching the last level, for all the species, was shorter or very close to the average recovery in the exterior cages. We also found the index weighting (number of weighings / time) appeared greater in all cases for subjects tested. The number of weights ranged from 5 to 10, while the average weight of the control was 5.58 ± 0.91 . It follows, therefore, that this process does not delay recovery, although, in some cases, it increases the manipulations associated with the catch for weight control, which on the one hand may be harmful because of the increased stress imposed by capture but on the other hand it enables greater control of clinical and physical condition of the animals.

KEYWORDS: food training, predatory wild birds, rehabilitation

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A multi-zoo survey of colobus monkey (*Colobus sp.*) feeding practice, diet composition and captive activity patterns

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Primates in the subfamily Colobinae possess a foregut microbial fermentation system similar to that seen in true ruminants. Energy is produced in the form of volatile fatty acids from the breakdown of plant material; as obligate browsers with this specific digestive physiology, zoos may struggle to provide these specialised feeders with an entirely suitable diet. Research on wild colobus has shown these primates to be highly seasonal in their feeding habits and food preferences; hence resulting in wild monkeys to be very selective in the items that they consume. Low activity budgets in zoo-housed animals could be a result of natural life history strategy (due to their use of microbial fermentation to extract energy from feed) or inappropriate feeding regimes that disrupt a consistent gut microbial flora. This research reviews diets provided to colobus monkeys (*Colobus guereza* subspecies) in four zoological collections and assesses differences in the nutritional components. Food preferences of each group (by evaluating first, second and last chosen food items) were compared in order to assess any notable differences. Finally, time budgets were constructed to determine a relationship between time spent active and diet. There was no significant difference between the nutritional components of the different zoo's diets with the exception of Dry Matter ($P < 0.001$). Preferred food types selected by individual colobus were fruit, vegetables and 'other' (bread, egg, browse). There was a significant difference ($P = 0.000$) between time spent inactive and active at the four collections, although other variables aside from diet may influence this. Some aspects of the diets fed agree with NAG recommendations (e.g. of high proportions of 'leafy greens') while others disagree (e.g. the use of soft fruits). It could be deduced that welfare of colobus is compromised by inappropriate feeding practice that is limiting expression of key appetitive behaviours. The need for a review of dietary recommendations for captive Colobinae is emphasised by the variation in feeding regimes adopted by the different collections, the diversity of products eaten by the individual monkeys and a lack of standard 'captive activity pattern' between the population at the four zoos. Continuation of this project over a longer time period could eventually yield results that directly improve the welfare of captive Colobinae species.

KEYWORDS: *colobus, dietary practice, activity*

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Using an on-site browse plantation to ensure forage feeding to browsing herbivores at Woburn Safari Park

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Providing sufficient amounts of browse, specifically leaf material on a year round basis is a challenging task for any zoological collection. This is particularly true if large herds of large browsing herbivores such as giraffe or moose are kept. Without a concerted management plan for browse acquisition, the provision of browse becomes a luxury enrichment rather than a part of a staple diet. In 2002 Woburn decided to implement a management plan to ensure all of its giraffe had access to 'fresh' leaves, 365 days of the year as we consider this species to be an obligate browser; a species that doesn't thrive in the absence of leaves. To achieve this Woburn first invested in additional freezer space and a compactor and started a strategy of browse planting; with every new build project and wherever the park would benefit from screening browse plantations were planted to supply the large demand for browse across the site. This culminated in a browse plantation covering 4.4 hectares and planted with some 5,000 trees for use in a coppice system. Five different tree species have been planted; sweet chestnut, hazel, ash and three species of willow. To date, we estimate we have planted some 8,000 trees for browse provisioning on site. In summer leaves and woody material are fed fresh so the giraffe are able to strip the leaves and bark, and through out the summer, leaves are also manually stripped by staff and stored compacted in air-tight barrels for winter feed as a semi-silage. In 2009, Woburn filled 190 barrels each holding approximately 20-25kg of leaf material; totalling nearly 5 tonnes for winter giraffe feed. Previously Woburn had compacted and frozen bales of leaves, but has found the 'barrelling' process more effective and efficient. Although, the labour required to achieve this is considerable, the benefits are evident in the condition of the giraffe and the breeding success in the herd. The poster will describe the management of the plantation and the storage of the leaves for winter. We hope to encourage other facilities to follow this example to set up a consistent supply of browse to those animals that need a source of dietary fibre but do not respond well to conventionally used fibre sources such as grass hay or lucerne hay.

KEYWORDS: *giraffe, browse, forage*
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Seasonal diets for brown bears (*Ursus arctos*) at Brookfield Zoo—successful implementation led to reduced weight and improved behaviour

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In late 2007, it was directed that the grizzly bears (*Ursus arctos*) at Brookfield Zoo needed to lose a significant amount of weight and should be put on a more seasonally appropriate diet. The previous diet for the bears never changed with regard to composition, only by amounts as dictated by the bears' appetites. By waiting for the bears to change their intake, there was no anticipation their needs and making changes beforehand to manage the bears' weight. The bears did have some seasonally appropriate weight gain and loss, but from 1999 – 2004 the weights increased overall until they hit a maximum of 560 kg in the winter of 2004 – 2005. Additionally, during this time period there were many cases of keepers reporting stereotypic behaviour by both animals and increasingly aggressive interactions. The first step was establishing what "seasonal" entailed? In general, it was agreed that greens (different varieties of lettuce) were going to make up the majority of the diet as a means to maintain physical satiety. This approach was especially relevant the first year of implementation, since the goal was to get the bears to lose weight when they naturally want to gain weight to replace what was lost during hibernation. The new diet regime was started in May 2008. Besides trying to decrease caloric intake during the most active time of year, there were significant cultural issues with the keeper staff that needed to be addressed through the diet adjustments in 2008. These two conditions led to an initial increase in aggressive behaviour between the bears and increased keeper reports of the behaviour. The second step was establishing an appropriate weight range for these bears. After consulting with several institutions, a goal range of 363 kg ± 36 kg was established for Axhi and 400 kg ± 40 kg for Jim. The weight gain in the winter months of 2008 – 2009, although still reaching weights of 450 kg, was achieved in half the time. Due to the improved weight loss over the winter months, the diets for 2009 contained even fewer calories than the diets in 2008 and as a result the bears reached their lowest weight in 8 years, looked much healthier, and were more active. Using varied small food items, stereotypic and aggressive behaviour were reduced from the previous years. Logistically, the implementation of the diet change was challenging. The number of food items offered doubled, and did not follow a set schedule. Previously, treat items (peanuts, blueberries, grapes, raisins) were sent in bulk and were supposed to be offered once a week. There was no oversight by the Zoo Nutrition department for how much was actually being fed out. A new system of controlling the treats was implemented with full management by the Zoo Nutrition staff. A random arrangement of the different fruit, vegetables, cereals, prey, and meat products meant the animals received a completely different set of food items day-to-day that repeated on a weekly basis.

KEYWORDS: *grizzly bear, seasonal diet, weight management*

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