

Leipzig Zoo
EAZA Research Group
European Zoo Nutrition Centre (EZNC)

Fourth European Zoo Nutrition Meeting
Thursday 20th January – Sunday 23th January 2005



Leipzig, Germany

ABSTRACT BOOK



**Fourth European Zoo Nutrition Meeting
Thursday 20th January - Sunday 23th January 2005**

Leipzig, Germany

ABSTRACT BOOK

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Abstract Book Editors

Conference place

Leipzig Zoo

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Germany

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Acknowledgments

The organising committee wishes to recognize and thank the following individuals which have contributed to the success of this Fourth European Zoo Nutrition Meeting

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FOREWORD

Dear congress participants

The world faces a conservation crisis that is at once urgent and enormous in scale. Zoos and aquaria can make a powerful contribution through nutrition science and research. Good nutrition saves animals from extinction. Nutrition research is vital in helping characterise and solve the challenge at hand. Since the publication of the World Zoo Conservation Strategy, a little over ten years ago, research in zoos and aquaria has expanded in scope, quality and importance. Despite this surge in research efforts worldwide, zoos and aquaria must do even more over the next ten years.

This conference has been set up as a unique opportunity for those interested in zoo animal nutrition. Besides fundamental aspects of nutrition, this conference will focus particularly on the practical implications of zoo animal nutrition.

When we started organising the Fourth Zoo Animal Nutrition Meeting, we believed in the statements above, but did the zoo world support them? From the numbers of participants from many different countries, and the number of talks and poster presentations at this conference, it is clear that zoo animal nutrition does play an important role within the zoo world.

This conference could not have happened without the full co-operation of EAZA Nutrition Group, European Zoo Nutrition Centre and Leipzig Zoo. Sponsorship by several companies is also very gratefully acknowledged. In addition to the above-mentioned institutes and companies, I would like to acknowledge the assistance of students and all volunteers.

January 2005
Joeke Nijboer

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Abstracts Fourth European Zoo

Nutrition

Conference

January 2005 Leipzig

Thursday, 20 January 2005

- 16.00-19.00 Registration in Hacienda restaurant in Leipzig Zoo
- 17.00-23.00 Hacienda restaurant:
Icebreaker
Self-payment (15 Euro) for meal and extra drinks.

Note:

Conference information:

- Icebreaker will take place at the Hacienda restaurant.
- Dinner on Saturday will take place at the African Lodge.
- Talks, poster, coffee breaks, lunches and registration will take place in the main office building at Leipzig Zoo
- All posters will be presented during the poster session on Saturday from 11.45-12.45. All presenters of posters are invited to explain their poster during that session.

Friday, 21 January 2005

- 08.30-09.00 Opening by Dr. Jörg Junhold (Director Leipzig Zoo)

Session: **Primate Nutrition**

09.00-09.30 INVITED SPEAKER:

Standards for feeding nonhuman primates

[C. Kirk Baer, D. E. Ullrey.](#)

- 09.30-09.45 Food intake, nutrient intake and food selection in captive and semi-free Douc langurs (*Pygathrix nemaeus ssp.*).

[C. Ademmer, W. Kaumanns](#)

- 09.45-10.00 Effect of fruits and vegetables on the diet of Silvered leaf langurs (*Trachepithecus auratus auratus*).

[J. Nijboer, T.R. Huisman, M. Olsthoorn, W. Noordermeer, A.C. Beynen](#)

10.00-10.15 Feeding the gentle giant: aspects of gorilla dietary regimes in Zoos.
[K. A. Dörmath Aguirre Alvarez, K. Eulenberger](#)

10.15-10.45 Coffee break

Food intake and body weight of the blue-eyed black lemur (Eulemur macaco flavifrons) in captivity .

[S.Y. Polowinsky, C. Schwitzer.](#)

poster

Session: Feeding browsers

**10.45-11.15 INVITED SPEAKER:
Poisoning of zoo animals by the gardener!
W. Reitschel, Wilhelma Zoo, Stuttgart, Germany**

11.15-11.30 Nutrient content of Carolina willow (*Salix caroliniana*) browse components fed to exotic herbivores.

[M.L. Schlegel, A. Renjifo, E.V. Valdes](#)

11.30-11.45 Developing adequate diets for browsing ruminants: Investigations on the okapi (*Okapia johnstoni*).

[J. Hummel, K. Johansen, M. Clauss, W. Zimmerman, C. Nørgaard](#)

11.45-12.00 The use of near infrared spectroscopy (NIRS) to evaluate browsing and grazing materials in order to optimise the feeding to zoo animals.

[J.A. Lowe, G. Dodson, Horrell](#)

Digestibility and roughage intake in a group of captive giraffes (Giraffa camelopardalis reticulata).

[S. Schmucker, A. Hörhager, L. Kolter](#)

poster

Browse provision for captive herbivores: design and management of a browse plantation.

[S. Höller, B. Stimm, J. Hummel, M. Clauss](#)

poster

Feeding practise of roe deer in Zoo Goldau- a case report.

[A. Liesegang, M. Wehrle](#)

poster

The formulation of a beet pulp-based pelleted food for captive wild ruminants and preliminary experiences.

[C. Berndt, A. Klarenbeek, T. Heijckman, J. Hummel, M. Clauss](#)

poster

Session: Iron storage

12.00-12.30

INVITED SPEAKER:
Iron overload
C. Smith, University of Manchester, UK

12.30-12.45

Iron intake and digestion in Cercopithecinae – a comparison of methods.
[W. Arnhold, M. Anke, A. Bernhard, K. Eulenberger, G. Krische, S. Goebel](#)

12.45-13.00

Excessive iron storage in captive omnivores? The case of the coati (*Nasua spp.*).
[M. Clauss, T. Hänichen, J. Hummel, U. Ricker, K. Block, P. Grest, J.-M. Hatt](#)

13.00-13.45

lunch

13.45-14.00

Effect of feed supplements on iron status in mynahs.
[W. Arnhold, R. Klieforth, P. Morris, M. Schröter, D. Meissner](#)

14.00-14.15

Iron Status in Ruminants.
[W. Arnhold, M. Anke, M. Seifert, S. Goebel, B. Rideout, M. Edwards, G. Nötzold](#)

14.15-14.30

The next meal is today: feeding recommendations in the absence of scientifically sound results – the question of iron availability.
[M. Clauss, J. Hummel](#)

14.30-14.45

Lemurs pumping iron.
[W. McCormick, V. Melfi, C. Muller](#)

14.45-15.00

Hepatic haemosiderosis in birds: nutritional composition and immune mechanisms may contribute to the development of the disease.
[G. Werquin](#)

Sources of high iron content in manufactured pelleted feeds: a case report.
[M. Clauss, J. Hummel, P. Eloff, R. Willats](#)
poster

Session: Practical feeding: Food Presentation

15.00-15.30

INVITED SPEAKER:
Behavioural enrichment
G. Law, University of Glasglow

15.30-15.45

The Behavioural Effects of Feed Presentation Treatments on Captive Strawberry Poison-Dart Frogs (*Dendrobates pumilio*).
[R. Campbell-Palmer, C. Macdonald, N. Waran](#)

- 15.45-16.00 The effect of food presentation on the mortality rates and reproductive success of a colony of Rodrigues fruit bats (*Pteropus rodricensis*).
[S. Sanderson, A.L. Fidgett, C. Evans, J. Denton](#)
- 16.00-16.15 Coffee break
- 16.15-16.30 Chow, How and Wow! Food and Feed Presentation for Primates at Edinburgh Zoo.
[L. McMonagle, C. Macdonald](#)
- 16.30-16.45 The use of “toy-food” in Emmen Zoo, presented in an entertaining program for zoo visitors.
[C. Berndt](#)

Session: Practical feeding: Nutrition Knowledge/Information

- 16.45-17.00 Zoo animal nutrition and nutritional wisdom of zookeepers. Is more synergy possible?
[A. de Bruin, N. de Haan, M. van der Laan, K. Slotman, J.Nijboer, W.L. Jansen, T.R. Huisman](#)
- 17.00-17.15 Analysis of different fish-handling, storage and thawing techniques in eight Zoos in the Netherlands.
[E. Griffith, J. Spiertz, J.Nijboer, L.J.A.Lipman](#)
- 17.15-17.30 Microbiological analysis of frozen and thawed fish in Rotterdam Zoo.
[J.I.C. Pennings, J.Nijboer, L.J.A.Lipman](#)

Dinner at own account

Saturday , 22 January 2005

**Session: Practical feeding: Nutrition Knowledge/Information
(Continued)**

- 08.30-09.00** Presentation of the Leipzig Zoo, Zoo of the future.
Dr. Jörg Junhold, Director Leipzig Zoo
- 09.00-09.15 The Comparative Nutrition Database: International Zoo Animal Nutrition.
[D. A. McWilliams, M. Delorme](#)
- 09.15-09.30 Foundation and function of EAZA Nutrition Group (ENG), providing specialist support for European conservation breeding programmes.
[A.L. Fidgett, P. Bircher, W. Janssen, J. Nijboer](#)
- 9.30-9.45 Spectral Wildlife Nutrition DataBase for plant and animal materials (using visible and near-infrared spectroscopy).
[C.W. Yang, E.S. Dierenfeld, S.Chen, C.R. Hurburgh](#)
- What you see is what you get? Hay quality in Dutch Zoos.*
[F. van Pagée, P.Viergever, W.L.Jansen, J.Nijboer, D.Kuiper, T.R.Huisman](#)
poster
- Compiling a multimedia database of browse species for herbivorous reptiles*
[L. Stevenson, A.L. Fidgett, K. Buley, D. Sheriff](#)
poster
- Continuing global synergy through nutrition training & outreach activities*
[E. S. Dierenfeld, C.W. Yang](#)
poster

Session: Vitamin and Mineral Supplementation

- 09.45-10.00 Intake and digestion in two iguanid species fed a fiber-supplemented salad mixture: preliminary observations.
[E.S. Dierenfeld](#)
- 10.00-10.15 Different supplementation of minerals in bats and the consequences on bone mineral density.
[A. Liesegang, U. Firzloff, B. Kiefer, W.J. Streich, M. Clauss](#)
- 10.15-10.30 Observations on the antioxidants status of domestic equines as influenced by supplementary dietary antioxidants.
[J. A. Lowe, D. Lucas, G. Paganga, G. Dodson, Horrell](#)
- Increasing calcium content in Jamaican field crickets (Gryllus assimilis).*
[K. Eidhof, D.Venema, D.Kuiper, T.R. Huisman](#)
poster

Vitamin A, D, E and B₁ content in diets of captive piscivorous animals: What sense does (multi)vitamin supplementation make?
[M. de Boer, H. Oorsprong, S.J. de Goede, M. Janse, C. Berndt](#)
poster

Session: Sponsor programme

10.30-10.45 coffee break

10.45-11.45 10 minutes presentation of manufacturers (Versele-Laga, Brogaarden, European Zoo Food Group, Mazuri)

Dreamnight at the Zoo, J. Nijboer.

Session: Posterpresentation

11.45-12.45 *Poster presentation*

12.45-13.30 lunch

13.30 **Guided tours in Leipzig Zoo**

19.00 **Joined dinner in African Lodge, planned with cultural programme**

Sunday, 23 January 2005

Session: Avian nutrition

- 08.30-08.45 Using mortality and reproduction data to evaluate captive penguin nutrition.
[R. Pizzi, M. Gibbons, A. M. Wood, M. C. Garcia-Rueda](#)
- 08.45-09.00 Novel plumage pigments and novel prey species antioxidants and immunomodulators: implications for captive penguin nutrition.
[R. Pizzi, K. McGraw, P. Nolan](#)
- 09.00-09.15 Nutrient composition of the diet of captive and wild kiwi (*Apteryx mantelli*) in New Zealand.
[W.H. Hendriks, M.A. Potter, N. Pindur](#)
- 09.15-09.30 Long-term effect of dilution degree of nectar food and the feeding of pollen on the condition of nectarivorous parrots at Loro Parque Fundacion.
[G.P.J. Janssens, B. Geeroms, M. Burkle, L. Crosta, M. Reinschmidt, G. Werquin](#)
- 09.30-09.45 Investigations of dietary calcium requirements in growing storks
[A. L Fidgett, E.S. Dierenfeld](#)
- 09.45-10.00 Nutritional management and feeding behavior during hand- and parent-rearing of Great grey shrikes (*Lanius excubitor meridionalis*) chicks in captivity and in the wild.
[Helena Marqués, Albert Porté, Anna Vives, Noé Torrent and Damià Sánchez](#)
- 10.30-10.45 Coffee break
- 10.45 11.00 Circulating concentrations of vitamins A and E in avian species; evidence for dietary relationships?
[A.L. Fidgett, E.S. Dierenfeld](#)
- 11.00-11.15 Influence of a seed diet versus a formulated diet on bodyweight and intestinal flora in budgerigars (*Melopsittacus undulatus*) over a six-month observation period.
[J.M. Hatt, P. Keller, I. Fischer](#)

Session: General nutritional subjects

- 11.15-11.30 Gross Energy and nutrient content of reptilian eggs.
[J. Mos, J.Erinkveld, D.Kuiper, T.R.Huisman](#)
- 11.30-11.45 Developing nutrition standards and dietary guidelines for polar bear in captivity.
[B. Lintzenich, A. Ward, M. Edwards](#)

- 11.45-12.00 Survey of major nutrients in Asian Elephant (*Elephas maximus*) milk during different stages of lactation.
[S. Kölbl, M. Flügger, C. Kunz, J. Peter-Katalinić, G. Pohlentz](#)
- 12.00-12.15 Do captive plains zebra's (*E. burchelli*) have a preference for individual grass species?
[S. Armstrong, N. Marples.](#)
- 12.15-12.30 Glucosamine and Chondroitin in the treatment of ungulate's Osteoarthritis.
[C.W. Yang, A.S. Li, J.C. Guo](#)
- Faeces consistency in captive tapirs.*
[S. Lang, E., P. Medici, J. Fritz, J.-M. Hatt, J. Hummel, M. Claus](#)
poster
- The effect of different nutritional regimes on the ratio of essential fatty acids in juvenile lined seahorses, *Hippocampus erectus*, 28 days after birth.
[T. Oudegeest, M. Laterveer, J. Nijboer, R. Hovenier, A.C. Beynen](#)
poster
- Food consumption and weight development in captive Malayan sun bears (*Helarctos malayanus*) – preliminary results.*
[S.T. Hoffman, L. Kolter, J. Pallauf](#)
poster
- 12.30-13.30** **Final conference discussion and simple lunch**

Primate Nutrition

Standards for feeding nonhuman primates

Charlotte Kirk Baer¹ and Duane E. Ullrey²

U.S. National Research Council, The National Academies, Washington, D.C. USA

Current affiliations: ¹Baer and Associates, LLC, Silver Spring, MD, USA and ²Michigan State University

In 2003 the U.S. National Research Council (NRC) published a second revised edition of its report *Nutrient Requirements of Nonhuman Primates* (National Research Council, 2003). This report is one of a series of NRC reports on animal nutrition and is an update and expansion of the first edition, which was published 25 years earlier. The revised report takes into account the large number of nonhuman primate species being fed in conservation organizations and research facilities today. The purpose of the recommendations in this report are twofold: (1) to provide science-based information for developing nonhuman primate diets and feeding programs and (2) to provide specific reference points and ranges for determining when dietary nutrient concentrations are adequate or inadequate. Regulatory agencies, industry, and other sectors rely on the NRC to provide these scientifically supported reference values so that when analyses are conducted, foods are formulated, diets are fed, and regulatory decisions are made, they are based on a frame-of-reference supported by scientific evidence and are not subjective. Unlike many reports in the NRC series, recommendations in this report are provided not only for minimum requirements, but also for estimated adequate dietary nutrient concentrations of diets containing conventional ingredients, which can be used to evaluate the adequacy of diets offered to primates.

For purposes of establishing nutrient requirements, nonhuman primates can be divided into six “model” categories based on gastrointestinal morphology, feeding ecology, taxonomic relationships, and the current state of knowledge (i.e., peer-reviewed research), which suggests that the “Old World” and “New World” designations are no longer appropriate in primate nutrition. Reflecting the new knowledge of the past quarter century, variation in feeding ecology and digestive physiology are new topics covered in great detail in the revised NRC report. In addition, comprehensive discussions of individual nutrients are provided throughout the report, with several new additions. Several novel aspects of the revision are noted below.

Although energy is not a nutrient in the sense of being a chemically identifiable substance, animals require energy for metabolic functions. Energy requirements of primates vary, as do their size and characteristics. Smaller primates exhibit higher mass-specific energy requirements for growth than larger primates and many species present unique challenges that could be affected by diet. For example, commercial diets for long-term maintenance of marmosets and tamarins formulated to contain 3.5–4.2 kcal of metabolizable energy·g⁻¹ may help to address “marmoset wasting syndrome” among *Callithrix* and *Sanguinus* species (Barnard et al., 1988; Clapp and Tardif, 1985).

Fiber is also not considered a nutrient but based on what we have learned in the past 25 years, certain fiber forms (fractions described by Van Soest et al., 1991) are known to be beneficial to health for certain groups of primates when fed in certain concentrations and proportions. For example, recommended fiber concentrations in total diet dry matter of extruded diets for

callitrichids are 10% neutral detergent fiber and 5% acid detergent fiber; whereas for colobus monkeys (foregut fermenters), 30% NDF and 15% ADF are recommended.

Although quantitative recommendations for amino acid requirements of nonhuman primates cannot be defined, several amino acids are essential. The report discusses evidence for essentiality of methionine, lysine, phenylalanine, tryptophan, and taurine.

Both n-3 and n-6 fatty acids are essential nutrients for nonhuman primates. Fatty acids that could be detrimental include the long-chain, monounsaturated docosaenoic acids. Cholesterol, which is typically not found in manufactured primate diets (with the exception of infants consuming milk or formula), is synthesized in tissues and is likely not required.

For the first time in history, requirements for copper and selenium have been defined. Fat-soluble and water-soluble vitamin requirements have been updated.

In summary, much is known about feeding and nutrient needs of nonhuman primates; however, there are many gaps in our knowledge. The NRC report on primate nutrition, as well as upcoming reports on small ruminants, horses, and mineral tolerance of animals provide the foundation for appropriate nutritional husbandry of exotic animals. For institutions feeding these animals it is essential to utilize respected resources such as the NRC report and expert consultation to interpret current knowledge and to fill in the gaps.

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Food intake, nutrient intake and food selection in captive and semi-free Douc langurs (*Pygathrix nemaeus ssp.*)

C. Ademmer, W. Kaumanns

Cologne Zoo, Germany

Colobines are specialized folivorous primates with a pregastric fermentation system. The endangered Douc langur (*Pygathrix nemaeus ssp.*), a highly folivorous member of this family, inhabits forests of Vietnam, Laos and Cambodia. Morphological, physiological, social and behavioural adaptations allow this species to feed mainly on a diet characterized by low concentrations of easily accessible energy and nutrients. According to the optimal foraging theory (see Hume 1989), animals should optimize their energy and nutrient intake by choosing food items of the best quality. The quality of leaves highly depends on the protein:fibre ratio (Yeager et al. 1997). If Douc langurs select leaves according to the optimal foraging theory, they should select leaves with a high content of protein and a low content of fibre. One aim of the study presented here was to determine the food and nutrient intake of Douc langurs. Moreover, patterns of food selection should be described. In captivity, food selection is possible only within the range of the food plants offered. However, if patterns of food selection exist, they should be similar under different keeping conditions.

In this study, three keeping conditions were included: first, at Cologne Zoo, where the animals are fed a diet consisting of leaves, vegetables, lettuce, pellets and fruits (n=35 days total); second, at the Endangered Primate Rescue Centre (EPRC), situated in the Cuc Phuong National Park (Vietnam), where the animals are kept in outdoor cages and are fed exclusively with leaves of local plants (n=26 days); third, in a semi-free enclosure, consisting of a 4 ha area of primary forest in the Cuc Phuong National Park, which provides natural food trees (n=10 days). The Cologne data represent three different seasons (summer, winter and spring).

The mean individual food intake was estimated by weighing the food offer and leftovers of the captive groups. The individual food intake behaviour was observed by focal animal sampling, and the number of pick-ups was counted for each food plant. Preference indices for certain food plants were calculated. Leaves of a large spectrum of food plants were analyzed for their content of nutrients and fibre.

In Vietnam, an animal was offered about 4000g fresh leaves per day of which 41% were consumed. The Douc langurs were observed to feed on 87 plant species belonging to 36 families (EPRC & semi-free condition). Most of the food plant species consumed in Vietnam belonged to the family Leguminosae.

In Cologne, an animal was offered about 370g fresh leaves per day of which 37% were consumed. Leaves constitute about 12% of the total diet in Cologne. The Douc langurs at Cologne Zoo were observed to feed on 28 species belonging to eleven families. Most of the food plant species consumed in Cologne belonged to the family Salicaceae. In spring, the amount of leaves consumed per animal and day was higher than in summer. During winter, leaf intake reached a minimum with only about 40% of the amount eaten in spring. Regarding the nutrient and fibre content, spring leaves showed a higher protein:fibre ratio than summer and winter leaves.

When young leaves were present, they were consumed first. This was observed under all keeping conditions and for all food plant species.

The results suggest that in fact Douc langurs select leaves with a high protein and a low fibre content, although the presence of other nutrients and of secondary plant compounds would have to be considered as well. The selection of leaves showing a high protein:fibre ratio corresponds to findings of other studies (Bleisch et al. 1998, Yeager et al. 1997) and would be compatible to the expectations of the optimal foraging theory. For the first time, the food and nutrient intake of Douc langurs living under different conditions have been described quantitatively. In spite of the small sample size and the restriction to non-experimental study-conditions, this study provides important information with regard to *in situ* and *ex situ* conservation of Douc langurs and other Colobines, as well as reference values for further studies.

References

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Effect of fruits and vegetables on the diet of Silvered leaf langurs (*Trachepithecus auratus auratus*)

J. Nijboer¹, M. Olsthoorn², W. Noordermeer², T.R. Huisman², A.C. Beynen³

¹Rotterdam Zoo, the Netherlands, ²Van Hall Instituut, the Netherlands, ³University of Utrecht, the Netherlands

The natural diet of silvered leaf monkeys consists of 55-80% leaves. In zoos they are often fed on considerable amounts of fruit and vegetables; However, consuming too much fruit and vegetables will cause soft stools. These soft faeces are probably caused by the higher amount of non-structural carbohydrates (NSC) compared to the more fibrous NDF (Neutral Detergent Fibre) character of the diet in situ.

Comment [ALF1]: Explain abbreviation or don't use it.

This research focuses on the effect of removing fruit and vegetables from the monkey diet and the resulting altered NDF/NSC-ratio on faecal consistency.

Trials were carried out at Apenheul as well as at Rotterdam Zoo, (two zoological collections in the Netherlands).

Ten animals were involved at Apenheul, five animals at Rotterdam Zoo. The trial consisted of three periods (A1, B and A2). During the control periods (A1 and A2) the usual diet, containing fruit, vegetables, langur pellets and browse was fed. During the experimental period (B), vegetables and fruits were removed and the diet consisted of pellets and browse only. During the entire trial the food offered was weighed and the food remains were collected and weighed. The faeces was collected and classified. The faecal classification system ranged from 1 – 5; 5 being loose stool, and 1 being firm stool.

Comment [ALF2]: A1 & A2?

Samples of the diet, food remains and also of the faeces were analysed following the Van Soest and the Proximate Analysis method at the Nutritional Department of the Veterinary Faculty of Utrecht University.

During the B period the intake of both the langur pellets and the browse increased and the faecal consistency improved in both zoos. The faecal consistency score improved from 4 to 2 at Rotterdam and from 3.5 to 2 at Apenheul. For optimum faeces quality (2) is suggested that the optimal ratio between NDF and NSC should be 1.30. More detailed research is necessary to understand the digestion mechanism in langurs.

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Poster:

Food intake and body weight of the blue-eyed black lemur (*Eulemur macaco flavifrons*) in captivity

S.Y. Polowinsky, C. Schwitzer

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The blue-eyed black lemur (*Eulemur macaco flavifrons*) is a highly endangered medium-sized lemur from north-west Madagascar with a mean body weight of 1793 g and a mean body length of about 41 cm. Its habitat consists of mixed forest, dry forest, coffee and citrus plantations. The nutritional ecology of blue-eyed black lemurs in the wild has so far not been studied; generally *Eulemur macaco flavifrons* is classified as frugivorous.

Under captive conditions, lemurs seem to be susceptible to obesity, especially blue-eyed black lemurs (body weight in captivity: 2800 – 3200 g). It is unknown whether the high susceptibility to obesity in this species can be exclusively attributed to a surplus of food and a lack of locomotion in captivity in combination with a comparatively high efficiency of energy utilisation.

This study deals with aspects of the feeding ecology (quality, quantity, seasonal differences and preferences in food consumption, digestibility, activity budgets) of four blue-eyed black lemurs kept at Cologne Zoo. The aim of this study is to reveal possible correlations between food consumption and weight development and name factors, which influence food intake and body weight.

The following methods are used: All food offered to the animals is weighed daily and leftovers are weighed on the following day respectively. Possible food preferences shall be exposed. Additionally the animals are weighed weekly. Samples of feeds are analyzed for gross energy and according to Weende detergent analysis.

Preliminary data on the effect of food and nutrient intake on the body weight of blue-eyed black lemurs in captivity are presented.

This study is part of a comprehensive project, which includes investigations on free-ranging blue-eyed black lemurs in the Sahamalaza region in north-west Madagascar. It aims in collecting systematically data on the quality, quantity and spatio-temporal distribution of food consumed by wild blue-eyed black lemurs.

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Feeding the Gentle Giant: Aspects of Gorilla Dietary Regimes in Zoos

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For the first time, current data on various aspects of gorilla feeding regimes in EEP holdings are being presented. The only similar study, conducted within the SSP, was published by Popovich and Dierenfeld in 1997.

Looking at various zoos, gorillas are being fed very different diets (Hampe, 1999). This is probably due to most institutions basing gorilla feeding and diets on empirical knowledge.

In our study, we were primarily interested in collecting qualitative data regarding different aspects of gorilla feeding regimes in captivity, concentrating on EEP holdings. We firstly aimed at finding out differences and similarities amongst feeding regimes of the various institutions; secondly, we wanted to compare natural feeding strategies of wild ranging gorillas with what the current captive feeding regimes can offer to zoo gorillas; thirdly, we were interested in what diseases and behavioural abnormalities might be linked with captive gorilla feeding.

Gorilla diets in the wild as well as in zoological institutions were reviewed by means of an extensive literature review having used the electronic databases Agricola (1970-2004), Biological Abstracts (1969-2004), Medline (1966-2004) and PrimateLit (1940-2004), as well as having manually reviewed a wealth of publications.

Information on the current feeding regimes in various zoos was obtained using a questionnaire. This was sent out to the 57 gorilla EEP holdings (including Israel) listed in the 2003 Gorilla Studbook (Hilsberg and Bender 2004). In addition, other institutions worldwide volunteered to take part in this study after a request was sent out to the electronic gorilla keeper discussion group. All answers were analysed confidentially and the data will be presented anonymously. At the time of writing, 43 out of 57 (i.e. 75.4 %) EEP institutions participated in this study; 10 zoos outside the EEP contributed data.

Certain aspects were identified of particular importance for the survey, hence the following questions were asked offering multiple-choice answers:

- What is the basis for the gorilla diet in your institution?
- How many meals a day do you offer to the gorillas?
- How many different food items do you offer to the gorillas each day?
- Which food items do you offer throughout the year? (Categories: browse, vegetables, fruits, animal products, commercial diets, liquids other than water, other)
- How often do you offer browse to the gorillas?
- If you offer animal products, which are these and how frequently are they being offered?
- Do you change the diet seasonally?
- Do the gorillas have access to a source of potable water at all times?
- Do you supplement the diet? If yes, how?
- Do you separate the gorillas during feeding? If yes, why?
- Do you hand feed the gorillas? If yes, why?
- Have you experienced cases of diseases related to nutrition in your collection?
- Are the gorillas in your collection generally overweight or obese?
- Do the gorillas in your institution show any regurgitation/ reingestion (R/R)?

In addition to offering an overview and a discussion on the results we received, a list of items being fed to zoo gorillas will be provided including an extensive browse list.

Acknowledgement

This survey was only possible with the support and participation of numerous zoological gardens worldwide. We would like to express our enormous gratitude and appreciation to these institutions for having taken their time and effort to fill in the questionnaire.

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Abbreviations:

- EEP – Europäisches Erhaltungszuchtprogramm (European Endangered species Programme)
- SSP – Species Survival Plan

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Feeding browsers

Nutrient content of Carolina willow (*Salix caroliniana*) browse components fed to exotic herbivores

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Disney's Animal Kingdom Theme Park receives over 150 metric tons of Carolina willow browse (*Salix caroliniana*) yearly from an onsite 25 ha farm which is harvested from April to October. Willow is fed primarily to browsing species such as giraffe (*Giraffa camelopardalis*), lowland nyala (*Tragelaphus angasi*), mountain bongo (*Tragelaphus eurycerus isaaci*), southern black rhinoceros (*Diceros bicornis minor*), as well as to African elephants (*Loxodonta africana africana*). Based on the species that willow is offered, these animals consumed only the leaves; leaves, small stems, and bark; or in the case of black rhinoceros, the entire branch. Although information is available on the nutritive content of leaves and edible stems of willow species, there is little information on other components of the plant such as bark and wood. The objective of this study was to evaluate the nutritive content of the components of Carolina willow. Bundles of willow were harvested in April, August, September, and October 2003; and stored at 4.4 °C until sampled. Each bundle of willow was weighed (average = 6.82 kg, n = 4) and divided into components. These components included: leaves, green stems, stems less than 0.5 cm, stems 0.5 – 1.0 cm, stems 1.0 – 2.0 cm, and stems greater than 2.0 cm. Stems were further separated into bark and wood resulting in 10 components. Each component was weighed to determine bundle component proportion and subsampled for proximate, fibre fraction, and mineral analysis at a commercial laboratory. Bundles averaged 5% green stems, 20% leaves, 21% bark, and 54% wood on a dry matter basis. Wood from stems less than 0.5 cm had the highest DM content. Leaves had the highest and wood had the lowest crude protein content. Acid detergent fibre was the lowest in bark from stems less than 2 cm and the highest in wood. Bark had the highest calcium content with wood having the lowest. Phosphorus was higher in green stems than bark and wood from stems greater than 0.5 cm. Based on the extent to which each species consumes willow browse, the nutritive value will vary. Additionally, the effect of season on nutrient composition of Carolina willow browse is unknown.

Table 1. Selected nutrient composition of Carolina willow (*Salix caroliniana*) browse components.¹

Item	Stems									
	Leaf	Grn	< 0.5 cm		0.5 – 1.0 cm		1.0 – 2.0 cm		> 2.0 cm	
			Bk	Wd	Bk	Wd	Bk	Wd	Bk	Wd
Bundle, % ²	20.1	5.2	7.9	15.2	5.1	12.0	4.4	13.7	3.5	13.0
N	4	4	4	4	4	4	4	4	3	3
DM, %	40.6 ^{ab}	41.5 ^b	50.3 ^b	60.2 ^a	42.5 ^b	50.4 ^{ab}	42.4 ^b	50.4 ^{ab}	40.9 ^b	46.4 ^{ab}
CP, % ²	13.0 ^a	7.0 ^b	7.8 ^b	4.3 ^{bc}	7.8 ^b	3.0 ^c	7.6 ^b	2.7 ^c	7.3 ^b	2.9 ^c
AF, % ²	47.1 ^{bc}	52.3 ^b	40.7 ^c	72.3 ^a	42.6 ^c	76.7 ^a	41.9 ^c	72.4 ^a	45.2 ^{bc}	76.7 ^a
Ca, % ²	1.27 ^b	1.20 ^b	1.82 ^{ab}	0.62 ^c	2.08 ^a	0.24 ^d	2.29 ^a	0.22 ^d	2.59 ^a	0.18 ^d
P, % ²	0.20 ^{ab}	0.26 ^a	0.16 ^{ab}	0.15 ^{ab}	0.14 ^b	0.13 ^b	0.13 ^b	0.12 ^b	0.12 ^b	0.11 ^b

¹Least square means; Grn = green stems, Bk = bark, Wd = wood, DM = dry matter, CP = crude protein, and AF = acid detergent fibre; ²Dry matter basis; ^{abcd}(P < 0.05).

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Developing adequate diets for browsing ruminants: Investigations on the okapi (*Okapia johnstoni*)

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As many other browsing ruminants, the okapi is regarded as a rather difficult species to be fed in captivity. Efforts have been made to evaluate intake and digestibility of diets fed in different EEP zoos. Typical diets of okapis in European zoos consist of alfalfa hay as roughage source, grain based concentrates and considerable amounts of produce (Crissey et al., 2000). In this study, we wanted to evaluate diets with a higher amount of an alternative concentrate (unmolassed beet pulp) concerning their energy content, and whether additional browse has an influence on overall intake or the roughage proportion of diets.

The study was done at two facilities, including 5 male and 2 female okapis. Intake and faecal output was quantified over a period of at least 8 days. Five sampling periods with variation in diets were done at facility 1 and two test diets were used at facility 2. Proximate and detergent composition was analysed for the samples. Metabolizable energy intake was estimated via a regression equation for domestic ruminants.

The digestibility of the traditional diets was relatively high (65-72 %), supplying the animals with sufficient amounts of metabolizable energy (0.6-0.8 MJ ME/[kg BW^{0.75}*d]). Diets higher in unmolassed beet pulp and diets higher in unmolassed beet pulp and browse also had a high digestibility. Intake of ME in these diets was estimated to be adequate. Digestibility of fibre was high in the diets higher in unmolassed beet pulp (aNDF: 54 – 61 %). Additional browse did not have an unequivocal effect on overall intake and roughage proportion, although it was the most preferred food of the study animals.

Traditional diets for browsing ruminants include a high amount of starch based concentrate and alfalfa hay as the only roughage source. They are regarded to be susceptible to the following problems: Alfalfa hay may not always be palatable to the animals, and a high intake of starch or sugar rich concentrates makes digestive upsets more probable. Diets high in unmolassed beet pulp are regarded to reduce the probability of digestive upsets (Van Soest 1987), and browse is generally the most preferred feedstuff for browsing ruminants. Since the diets including considerable amounts of these feedstuffs apparently provided the animals with sufficient energy they can be considered as valid alternatives to other feedstuffs used for okapis in captivity.

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The use of near infrared spectroscopy (NIRS) to evaluate browsing and grazing materials in order to optimise the feeding to zoo animals

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The use of **near infrared spectroscopy (NIRS)** to predict the chemical composition of feedingstuffs is widely used in the agriculture and the petfood industries. Both of these industries however rely on the development of either specific or general prediction equations based on the mathematical manipulation of the observed spectra of a large sample size in relation to the known chemical analysis of the samples.

Animals in captivity often do not have access to the browse or grazing plants that they would in their natural wild habitat. Finding a suitable material as a substitute depends upon experience of the keepers and zoo nutritionists and in many cases the choice is limited and dependent upon that material which is available locally.

Routine detailed chemical analysis of the available material as well as of the natural browse or grazing is both expensive and not always practicable. The chemical evaluation, particularly of the dietary fibre components and non-starch polysaccharides, of these ingredients is not routinely carried out in many laboratories. Thus establishing which locally available materials most closely match the material available in the wild is difficult. **NIRS** offers a rapid, flexible and cheap method of evaluating browse and grazing materials.

The conventional use of **NIRS** relies upon prior determined calibration equations, which when samples are limited and, or prior chemical analysis is unavailable is not possible. We propose an alternative approach that involves the comparison and manipulation of the spectra itself without relating it to the wet chemical determination of the product.

The individual spectra of a material can be regarded as a “fingerprint” of the chemical structure of a food, thus the subtraction of an identical or closely related spectra from this would result in a spectra which would approximate to a straight line. It is thus possible to use a computer to carry out iterative subtractions of varying proportions of combinations of the spectra of available browse or grazing material from the spectra of a sample of “ideal” material to establish a mix of available material that would match the ideal material. Matching the spectra in such a way would mean that the resulting combination would be nutritionally very close to the ideal material. This technique would permit the development of a more closely related nutritional supply of grazing or browse material without the need for detailed and comprehensive chemical analysis. It could also be used to pinpoint areas where the available combination would fall short of providing key macro-nutritional components.

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Poster :

Digestibility and roughage intake in a group of captive giraffes (*Giraffa camelopardalis reticulata*)

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Adequate feeding and nutrition of giraffes is a constant topic of debate and discussion in zoo community. Giraffes are adapted to browse on digestible leaves by intense lip and tongue movements. While some reports, based on post mortem findings, mention low or missing fat reserves indicating energetic undernutrition, other reports present data on oral disturbances, which are regarded to be caused by insufficient stimuli due to inadequately low intake of forage and high intake of produce and concentrates high in metabolizable energy. The latter are fed in addition to the roughage offered to meet nutritional requirements. Here we present data on composition, intake and digestibility of a diet low in easily digestible carbohydrates offered to the giraffes at Cologne Zoo.

The study group consisted of 3 adult females and 2 subadult females (3 and 1.5 years old). The diet was composed of lucerne hay ad lib., fresh browse (winter: leafless; summer: with leaves), dried chestnut leaves (only winter), fresh lucerne/grass mixture (only summer), different concentrates (pelleted zoo compounds, unmolassed beet pulp, soybean extraction chips) and some produce. Feed intake was quantified over 8-12 days on two occasions (representing summer and winter feeding conditions).

The proportion of roughage in the diet was 65 % in winter and 73 % in summer (on a dry matter base). Dry matter digestibility was 52%. The frequency of oral activities (activity/kg DM) differed considerably between feedstuffs. Intake of the whole group was evaluated to be lower in winter than during summer feeding. All animals were considered to be in a good condition. Compared to published data, the high proportion of forage consumed by the studied giraffes is remarkable. Thus sufficient energy provision could be managed despite a forage intake of 65-73 %. This agrees with recommendations proposing a forage proportion of 60-70 % for giraffe diets (Lintzenich and Ward, 1997). The results will be discussed with respect to nutrition and its potential effect on feeding behaviour.

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Poster :

Browse provision for captive herbivores: design and management of a browse plantation

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Many herbivorous zoo animals are known or are suspected to benefit from provision with serious quantities of browse material. However, for many zoological institutions, the reliable supply of browse is problematic: on the one hand, harvesting browse is a labour-intensive process; on the other hand, browse resources may be limited and subject to conditions that cannot be controlled by the zoological facility – such as urban browse cutting operations, or access to forests in the vicinity.

Therefore, ideally, zoological institutions that keep browsing animals and that do not have reliable access to browse guaranteed by third parties, should maintain or contract their own browse plantation. Although this concept has been pursued by individual facilities for a long time, general interest in such resource management has increased recently.

In this contribution, we explain the different necessary steps of planning, starting and maintaining a browse plantation for the purpose of regular harvesting. We give quantitative information on the size, plant density, expected browse yield etc. that allow the calculation of the necessary resources (in terms of land and logistics) for a targeted amount of browse. Combined with estimates of recommended browse provision to different zoo animal species, this information allows the planning of a browse plantation tailored to any given needs.

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Poster:

Feeding practise of roe deer in Zoo Goldau- a case report

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Roe deer require more energy per unit of body mass for maintenance compared with that required by larger animals, since energy requirement increase proportional to metabolic weight. As the gut capacity can not cope with the high energy requirements, roe deer increase energy and protein intake. To optimise energy and protein intake they select easily digestible forage (highly digestible protein and carbohydrates), with a high proportion of soluble plant cell contents like young leaves and buds of various plants in the forest. These animals belong to the ruminant feeding types called “concentrate selector“. For this reason, the feeding of these animals in captivity is very demanding. Due to the selective feeding behaviour, the digestive system shows several morphological and physiological particularities: relatively small forestomach, a short retention time of ingesta, relatively large salivary glands producing high volumes of saliva, and a highly developed ventricular groove. These animals use both the fore- and hindgut as sites for the fermentation of dietary carbohydrates. In captivity, it is difficult to feed these animals with species-specific rations, especially in wintertime, since it is not easy to compose a diet consisting of natural browse. In addition, roe deer have a reluctance to eat hay in contrast to other ruminants. For this reason the diet often consists of pellets, fruits, and vegetables. In addition roe deer are highly susceptible to endoparasites. There may be a coherence between the feeding problems and this susceptibility to helminths and coccidia.

It was the aim of this study to create a diet for roe deer with different feedstuffs at Goldau Zoo that contained higher portions of browse. This diet is supposed to be more natural than the diet fed before.

The roe deer group in Goldau Zoo included 3 adult animals (1.2, 7, 10 and 2 years old) with 2 juveniles. The enclosure was 1000 m² large with natural meadow in the forest and several trees. The feeding place was roofed. The animals had free access to water. The health status of the animals was monitored with parasitology and from observation.

The diet fed first contained a high amount of roe deer pellets with high crude protein and low crude fiber contents. The proportion of crude fiber derived from structured feeds (hay, silage) was rather low. No hay was consumed by the animals, but a silage containing twigs and leaves was eaten during winter. The animals showed high incidence of endoparasites like helminths and coccidia. The diet was changed thereafter. The change of diet started in August 2003. Some amount of the roe deer pellets was replaced by sugar beet pulp which has a lower crude protein content, but a higher crude fiber content. Instead of a grass-rich hay, a hay rich in herbes (Alpine meadow altitude 1800m , cut only once per year, no fertilizer used) was used. Additionally, molassed hay pellets were introduced. The animals accepted this diet much better and ate more. The palatability of the crude fiber and structure-rich ration was increased. The new silage only contained the leaves without the twigs. In table 1 the crude protein content and crude fiber content is listed. Although the crude fiber content could be increased, the crude protein content remained high. The proportion of crude fiber derived from structured feed was much higher compared to the old diet. Interestingly already in January 2004, the number of treatments against endoparasites could be reduced, since the loading of the faeces with worm eggs was reduced.

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Table 1: Feed consumption before and after feed changes

<u>Before:</u>	amount (g/animal and day)	Crude protein (% TS)	Crude fibre (% TS)	ADF (% TS)	NDF (%TS)
Roe deer pellets*	400	15	3		
Vegetables/fruits	100	2.3	10		
Hay (not accepted)	0	10	27	37	59
Foliage (summer)	600	15	17		
Foliage silage leaves and twigs (winter)	30	16	16		
Chestnut (winter)	200	2.5	3.7		
Gras (in enclosure)	Ad lib.				

<u>After:</u>	amount (g/animal and day)	Crude protein (% TS)	Crude fibre (% TS)	ADF (% TS)	NDF (%TS)
Roe deer pellets*	50	15	3		
Vegetables/fruits	100	6	8	14.1	16.3
Lucerne pellets*	50	18	24		
UFA 256⁺	200	7.5	23	27	35
Sugar beet pulp	100	10	21		
Hay rich in herbs	100	9	26	33	56
Hay pellets ⁺ (molassed)	150	9	27	30	41
Foliage (Sommer)	600	15	17		
Foliage silage only leaves (Winter)	100	15	19	38	49
Chestnut (Winter)	200	2.5	3.7		
Grass (in enclosure)	Ad lib.				

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In conclusion this case report demonstrates a quick change of appetite in a roe deer group after changing the diet to a fiber-rich diet, which is still high in crude protein. Also the excretion of endoparasites in the faeces was decreased, probably due to the fact the animals were healthier, ate more and revealed a better function of their intestinal tract according to a more species-specific diet. It has been stated that the mechanical characteristics of a diet are much more important than the chemical characteristics. So, additionally the structure of the changed diet seems to fit better to the ration the roe deer, as a special browser, can deal with.

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Poster:

The formulation of a beet pulp-based pelleted food for captive wild ruminants and preliminary experiences.

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A major challenge in captive wild ruminant nutrition is the simultaneous provision of an adequate energy supply and the prevention of rumen acidosis. Pectins and other soluble fibre components are a readily available energy source for ruminants, but their fermentation is not, in contrast to starch or sugars, prone to result in an acidotic rumen condition (3).

Therefore, the inclusion of feeds with a high pectin content in the diet of captive wild ruminants has been promoted recently (2,4). The acquisition of a new pair of moose (*Alces alces*) at Emmen Zoo, Netherlands, in March 2003, led to the formulation of a new pelleted food with this concept in mind. Objectives of pellet formulation were a high proportion of pectin-rich ingredients, a low proportion of starches and sugars, a mineral composition with a high copper content considered appropriate for cervids and other wild ruminants except sheep, and the inclusion of sodium bicarbonate as a buffering substance to provide additional protection against rumen acidosis.

An evaluation of the effects of the pellets were noted so far. Compared to earlier years, the skin condition of the impala group was judged to have improved. While beet pulp may cause problems due to swelling in the oesophagus in horses and therefore should be offered soaked, it is commonly fed un-soaked to domestic ruminants. The pellet was offered unsoaked to all 99 animals; only in one case (a giraffe bull) were problems observed in the form of regurgitation/vomiting approximately 15 minutes after food intake, which is believed to be due to an oesophageal stricture.

The formula consists of beet pulp/ citrus pulp (22.5%), soy products (22.5%), lucerne meal (22.5%), sunflower hulls (12.5%), wheat (8%), molasses (2.5%), cellulose powder (2.5%), linseed (2.0), vitamin/mineral premix (2.2%), sodium bicarbonate (1%). The calculated analysis of this product is (on a dry matter basis): crude protein 16.8%, crude fat 5.7%, crude fiber 22.3%, crude ash 8.5%, starches and sugars 16.4%, NDF 40.7%, ADF 26%. Subtracting protein, fat, ash, neutral detergent fiber and starch/sugars from 100% leaves a residual of 12%, which will mostly represent the pectin fraction. Copper is added at 22 mg/kg dry matter.

The pellet has been fed to 3 moose, 13 giraffes (*Giraffa camelopardalis*), 44 impalas (*Aepyceros melampus*), 3 Lesser kudu (*Tragelaphus imbebris*), 4 pudus (*Pudu pudu*) and 32 guanacos (*Lama guanicoe*) for nearly two years. The pellets were accepted readily by all individuals.

Comment [A3]: Numbers do not correspond with how references are presented (alphabetically). I would recommend they are removed for the purpose of this abstract

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Iron storage

Iron intake and digestion in Cercopithecinae – a comparison of methods

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Iron belongs to the essential trace elements for animals and humans. The mean daily intake of heme and nonheme iron varies between 5 and 47 mg in humans. Whereas nonheme iron is absorbed from 2 % to 20 % from the diet, the heme iron absorption is obviously better (5 to 35 %) (Beard and Dawson 1997). Furthermore, the Fe absorption depends on the individual Fe status and the ratio of promoters and inhibitors. Since the knowledge of the Fe intake and digestion has been increased in humans the analysis of the trace element supply of Cercopithecinae and the estimation of the Fe digestion and the Fe status has become necessary.

The trace element intake was determined in 24 clinically healthy individuals of 5 species of Cercopithecinae kept in 8 groups in Leipzig Zoo. The animals were given 4 meals every day. Following the duplicate method, quantitatively and qualitatively identical samples of the offered feed as well as feed residues and faeces were registered (n = 7 per group) on 7 successive days. Thus, it was possible to determine the consumption of the different kinds of feed and the Fe intake of these species. After dry ashing at 450 °C the trace elements were determined with ICP-OES.

The determined Fe intake was compared to the calculated Fe consumption of guenons and lion tailed macaques and with the Fe intake and digestion of people with mixed diets and vegetarians. The iron status was estimated by blood parameters.

The feed dry matter contained an up to three times higher concentration of Fe compared to humans' mixed and vegetarian diets. Although the mean body mass of the animals only amounted to 8 % of the body mass of humans, they had a mean daily dry matter intake of 16 – 42 % and a mean daily Fe intake of 48 – 128 % of that of humans. However, when the daily trace element intake was related to the metabolic body mass an up to 9 times higher concentration of Fe was found in the diet of Cercopithecinae than in humans. Since the animals were clinically healthy and since the reproduction was not disturbed, a mean content of 60 mg Fe kg feed dry matter is regarded as meeting the requirement.

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Excessive iron storage in captive omnivores? The case of the coati (*Nasua spp.*)

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In mammals, reports on excessive iron storage mostly focus on herbivorous animals. Yet, in birds, problems with excessive iron storage are mostly reported in frugivorous and/or insectivorous species. Lowenstine and Munson (1999) mention regular findings of excessive iron deposits in coatis, mammalian omnivores belonging to the carnivora. The natural diet of coatis is well documented, consisting mainly of fruits and insects, with very little vertebrate meat. In contrast, captive coatis are often maintained on dry or canned dog food, or receive mice or day-chicks on a regular basis. This means that they receive diets high in heme iron (from haemoglobin); although free-ranging insects might have high iron levels as well, they do not contain heme iron. As heme iron is absorbed much better than non-heme iron, the diet of captive coatis might therefore be characterized by very high levels of available iron when compared to the natural diet of these animals.

In order to corroborate the report of Lowenstine and Munson (1999), we investigated necropsy reports and liver tissue of 13 coatis from five zoological institutions. Two juvenile animals did not have abnormal iron deposits in the liver. One adult individual had only a few, four adult individuals had moderate, and six adult individuals had massive iron deposits in their liver tissue.

These results suggest that coatis could be considered among the species susceptible for excessive iron storage. Whether this problem represents a medical risk for the animals cannot be proven; however, in five cases the iron deposits were the major pathological finding. The fact that juvenile animals might be not affected agrees with the assumption of a diet-related problem, resulting from a chronic oversupplementation and accumulation. Captive coatis might benefit from diets that do not include substantial amounts of heme iron. Similar findings are to be expected in other omnivorous/insectivorous mammalian species that are kept on meat-based diets.

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Effect of feed supplements on iron status in mynahs

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Mynahs, toucans and birds of paradise which are kept in captivity are sensitive against Fe overload. It is assumed that nutritional factors play an important role for the development of hemosiderose in these species. There is the possibility that the diets contain less feed components that inhibit the Fe absorption compared to the feed in their natural habitat. That's why two tests were carried out to investigate the Fe absorption inhibitory capacity of calcium carbonate and tamarind juice in mynahs.

Four breeding pairs of mynahs, which were kept in the San Diego Zoo Avian Reproduction Centre, were at our disposal. The birds received their normal diet. The diet of four mynahs was supplemented with calcium carbonate on six weeks (test 1) and with tamarind juice on eight weeks (test 2). The remaining four birds were used as control group. Quantitatively and qualitatively identical samples of the offered feed as well as feed residues and excrements were registered. Thus, it was possible to determine the consumption of the different kinds of feed as well as the Fe intake and the Fe digestion.

The Fe status was estimated by blood parameters like ferritin, transferrin, and hemoglobin.

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Iron Status in Ruminants

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The iron content of the various organ tissues in animals depends on nutrition, health status, age, and sex and varies among species. Although hemoglobin, serum ferritin and serum transferrin are influenced by parameters like health status, they are used for the assessment of an iron deficiency or overload in living animals. The iron storage of the body takes place in organ tissues with the highest iron concentrations i.e. liver, spleen, and bone marrow in which iron is bound as ferritin and hemosiderin. Whereas many results exist on the iron concentration in organ tissues of monogastric animals (Morris 1987) only a few datas are available in ruminants (Grün et al. 1980). Due to the species specificity of the iron status, organ tissues (liver, kidney, cerebrum, rib, skeletal muscle, heart, lung, aorta, spleen, and hair) of different wild ruminant species were analysed and compared with domestic ruminants.

The investigated wild ruminants which were kept in captivity came from the Zoological Society of San Diego and the Leipzig zoo. For comparison, organ tissues from wild living deer and domestic ruminants were obtained from different locations of Eastern Germany, and Northern California.

For the presentation of the results the various species of ruminants were classified as morphophysiological ruminant feeding types (Hofmann 2000).

The spleen accumulated the highest iron amounts per kg dry matter among the investigated organ tissues. The iron concentrations of cerebrum and ribs were the lowest.

There was a significant effect of the age on the iron status. In neonatals the liver and aorta contained two to three times more iron per kg dry matter compared to adults whereas the iron concentration of cerebrum was 1.5 times higher in neonatals than in adults. Spleen, lungs, kidney, and skeletal muscle of adult ruminants contain more iron with decreasing extent than neonatals. The iron concentration of heart muscle and rib did not differ between adult and neonatal ruminants.

Depending on organ tissue and age the iron concentration of the tissues differed between the ruminant feeding types, but not between male and female adult and neonatal ruminant feeding types.

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The next meal is today: feeding recommendations in the absence of scientifically sound results – the question of iron availability

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Excessive iron storage is being recognized as a typical pattern found in man zoo animal species. Based on knowledge from human medicine, it is often presumed that the condition will have, in the long run, detrimental effects for the affected animals. Regardless of the cause of excessive iron absorption, it is reasonable – again based on experiences from human therapy – to assume that dietary prevention will help to delay or even alleviate the problem. Zoo nutritionists thus face the dilemma that conclusive results from studies with zoo animals are still largely lacking, but that on the other hand the next meal has to be formulated for today, with the well-being of the animal in mind.

In this contribution, we summarize existing knowledge on the prevention of high levels of (available) dietary iron, while at the same time explaining potential dangers associated with prevention measures. For example, iron content is generally very high in pelleted feeds for herbivores, but the exclusion of pelleted, formulated feeds from diets could result in deficiencies in protein, vitamins and other minerals. It is important not only to stress the negative high iron contents of certain feeds, but also to understand their positive and essential contributions to a diet, in order to choose the right dosage, or choose appropriate replacements.

In short, heme iron (from vertebrate meat) should be used sparingly in susceptible species. Complete pelleted feeds should be used with caution and their important ingredients (protein, other minerals and vitamins) could in certain cases be provided by other feeds, without seriously compromising practicality. Low-iron complete diets (such as for birds) could be tried for other species, and new low-iron products should be tested. Mineral supplements, particularly prone to have high iron contents, must be chosen with care. Vitamin C supplements should only be used in species with a proven requirement. Natural iron chelators, such as tannins from tea or tamarind, can be used with caution, but in the awareness that unknown side-effects might occur; their use should be no excuse for disregarding the iron content of other feed items. Until more is known about the mechanisms of excessive iron storage, monitoring measures (such as serum transferrin saturation testing) should be incorporated in the husbandry management of susceptible species.

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Lemurs pumping iron.

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The provision of diets that meet the nutritional needs of captive primates is an essential part of preventative medicine and the promotion of good animal welfare. In recent years the incidence of iron storage disease (haemosiderosis) in lemurs has become a topical issue. Haemosiderosis occurs when the circulating level of iron in the blood becomes too high and so, it is stored in vital organs (e.g. liver) reducing their ability to function, in some cases with fatal consequences. Currently this condition can not be detected accurately with non-invasive methods.

A variety of explanations have been suggested to explain the incidence of haemosiderosis in zoo housed lemurs. The diet of wild and captive lemurs is thought to be different, in the levels of iron present (higher in captive diets) and the levels and types of tannins present (lower in captive diets). As such, it has been conjectured that captive lemurs will develop haemosiderosis because their intake of iron is too high, or because the level of tannin (which reduces the body's absorption of iron) is too low. Despite the interest shown in this topic, empirical data is scarce (with the exception of a study by Wood *et al.*, 2003).

This study aimed to generate empirical data that could investigate i) the relationship between iron levels in the diet fed and the iron excreted in faeces, ii) whether this relationship varied with different lemur species, and iii) possible relationships between iron and total phenolic intake. Data were collected from several institutions across the UK (ring-tailed N=4, red ruffed N=3, black and white ruffed N=3, red fronted N=3). An intake study was conducted to estimate the total amount of food consumed daily, for 5 days. This was repeated twice (total of 3 x 5 day). The total amount of faeces excreted was calculated for the corresponding days. A representative sample of each food type fed and of the faeces excreted were dried for each treatment (N=3). The iron content of the samples was measured using atomic adsorption spectroscopy, and the total phenolic content of the food was analysed using the Price-Butler method (1977).

Results demonstrated a significant contamination issue with regards to iron making intake-output comparison impossible as the lemurs appeared to be losing more iron than they were receiving in their diet. Soil was suggested as the possible contaminant, and consequently may impact on current husbandry techniques of haemosiderosis-prone species.

We are extremely grateful for the cooperation we have received, from other researchers, university supervisors (Laura Bellingham) and zoo managers (Stewart Muir, Paul Pearce-Kelly, Neil Bemment, Audrey Perkins), throughout this study. Samples analysed in this project were collected by Julie Mathews (Shaldon Wildlife Park, Shaldon, Devon), Clare Reed (Drusillas Park, East Sussex), Paula Walling (Drusillas Park, East Sussex) Jo Cook (London Zoo, London), Catherine Knight (Grangewood Safari Park, Derbyshire), and Shaun Bratchley (Grangewood Safari Park, Derbyshire).

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Hepatic hemosiderosis in birds: nutritional composition and immune mechanisms may contribute to the development of the disease.

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Hemosiderosis is a common finding in frugivorous birds kept in captivity. Until now, most pathologists consider a high iron content in the food as primary cause of this disease. Some researchers did formulate guidelines on maximum allowed iron levels, which are unfortunately not the result of nutritional research under controlled circumstances.

Also, these recommended dietary iron levels disregard the large differences in bio-availability of the iron present in the food. Iron bio-availability is determined by several factors:

1. Sources of dietary iron: Dietary iron is available in two valence states, Fe^{2+} (ferrous) and Fe^{3+} (ferric). The majority of ferrous iron is found in haem iron and the majority of ferric iron is found in non-haem iron.

Haem iron is present in the haemoglobin and myoglobin in animal products. This form of iron is relatively available: about 30% of haem iron is absorbed from the diet. The level of haem iron absorption is relatively unaffected by other dietary factors.

Non-haem iron is found in plant foods such as cereals, vegetables, pulses, dried fruit, etc and compared to haem iron it is relatively poorly absorbed, typically less than 10% and often under 5%. The absorption of non-haem iron is much more influenced by the iron status of the animal and several factors in the diet that can either inhibit or enhance its absorption.

2. Factors influencing the dietary non-haem iron absorption:

The presence of iron chelating agents in the food may reduce the bio-availability of non-haem iron. Tannins reduce the absorption of non-haem iron due to the formation of insoluble iron tannate complexes. Phytate found in the bran of wheat and other cereals strongly inhibits non-haem iron absorption by interacting with it, rendering it less soluble. Oxalates in green leafy vegetables bind iron, preventing absorption. Also calcium and soil clay interfere with iron absorption.

Vitamin C, organic acids or a low dietary pH enhance iron absorption by reducing the ferric iron to the more readily absorbed ferrous form.

The evaluation of the dietary iron load should not be limited to the iron content of the food ration, but should also attempt to take all other important dietary factors into consideration. Due to the wide variation of energy density in bird foods, recommendations on dietary iron levels should be set on energy basis rather than on weight basis.

Besides dietary factors, also other mechanisms may play an important role in the pathogenesis of hemosiderosis. As in mammals, also in birds, withholding iron from potential pathogens has been described as a host defense strategy. In mammals, blood iron is regulated by 2 proteins : lactoferrin and transferrin. Both proteins have a high affinity for iron and are bacteriostatic in vitro for a number of bacteria. In birds, blood iron is regulated by transferrin only. During stress or infections, transferrin is released in birds, which binds the blood iron but also increases intestinal iron absorption and iron flux to the liver. This mechanism may be as important as the dietary iron load in the pathogenesis of hemosiderosis.

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Poster:

Sources of high iron content in manufactured pelleted feeds: a case report

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The analyzed values for iron contents of pelleted feeds are often surprisingly high, exceeding the content calculated on the basis of the assumed iron content of the individual ingredients. A common question asked is how such high iron levels in pelleted feeds can be avoided. In order to investigate potential sources of iron in a pelleted mixed feed, we sampled raw ingredients, processed ingredients, processed mixtures and the final product of Boskos® game pellets. Boskos® game pellets consist of South African browse plants, mainly acacias, harvested during field operations against bush encroachment, of lucerne, various sources of proteins and carbohydrates, and two mineral/vitamin premixes. Representative samples were taken from the production process, and analyzed for iron content.

Two major sources of iron in the final product could be identified. Iron content was low in lucerne and very low in South African bush (app. 40 mg/kg dry matter), but increased after mechanical processing (drying/milling). The iron content of the complete food mixture was reduced after it passed a magnet which is a routine instalment in food manufacturing plants. This indicates that metallic abrasion during mechanical processing can be one cause of increased iron content in manufactured feed. The other organic ingredients had various iron contents. However, iron content was extremely high in the two mineral/vitamin premixes used (5000-7000 mg/kg dry matter), for which the iron content was not specified by their respective providers. These results indicate that, if iron content is an issue of concern, mineral additions must be chosen with particular care in order to avoid unnecessary iron contamination.

The iron content of the final product was within the range analyzed in other pelleted animal feeds (400-500 mg/kg dry matter). Such products are unlikely to be harmful for species not susceptible to iron storage disease, such as ruminants, white rhinos etc. Species susceptible to iron storage disease, in contrast, such as black rhinos, should probably not receive such feeds on a regular basis; if at all, such products can be used in these species for short time periods, such as transport/translocation, where the direct acceptance of the product is more important than potential long-term effects. Wes Enterprises is currently testing different mineral/vitamin supplements for the production of an iron-controlled version of Boskos®.

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Practical feeding : Food presentation

The Behavioural Effects of Feed Presentation Treatments on Captive Strawberry Poison-Dart Frogs, (*Dendrobates pumilio*)

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The majority of environmental enrichment studies have involved captive mammals. Global declines in amphibians have prompted increased attention towards captive breeding and reintroduction programs. Amphibian ethology and psychological requirements in captivity remains a neglected area of research. These animals are often presumed to adapt readily to captivity. However other studies suggest “limited neural complexity” and “innate education system” may render amphibians less able to adapt to captive conditions.

Feed related behaviours are highly affected by captivity, as in the wild foraging constitutes a major activity. Feeding time offers a diversion in the relatively static captive environment, however, the predictable manner in which food is often provided demands few appetitive or consumatory behaviours.

This study determined that feed presentation affected the behaviour of a population of *Dendrobates pumilio*, kept on public display at Edinburgh Zoo. Feeding behaviour and daily group activity was compared when frogs were presented with either a point source or enriched (“leaf”) feed technique. The leaf feed method consisted of a shallow dish covered with dried leaves that enabled the insects to hide amongst them. Food (live pinhead crickets) was retained longer in the leaf feed compared to the standard open dish feeding (66.84, $p < 0.01$).

Overall feed treatment had little effect on the proportional frequencies of behaviours displayed by the group as a whole (including hiding, locomotion, vocalisation, sitting and perching). Social interactions occurred most during leaf feeding ($F_{1,2} = 5.48$, $P = 0.013$). There was no difference in mean number of foraging individuals with feed treatment ($F_{1,2} = 2.35$, $P = 0.124$). Females tended to feed sooner ($F_{1,2} = 9.63$, $P = 0.002$), foraged more often ($t = 123.95$, $P < 0.0001$) and spent longer in feed area than males, regardless of feed treatment. Duration of daily time spent in feed area was significantly increased when leaf feed was presented ($F_{1,2} = 6.98$, $P = 0.001$) and individual focal foraging observations determined frogs exhibited more prey-tracking behaviours. The enriched feed presentation tended to increase time intervals between prey capture events therefore making foraging more challenging, reducing rapid feeding rates and prolonging foraging activity.

Though the use of live insects is an important enrichment technique, routine point source feeding can still become predictable and unchallenging, as evident from the casual observation that many frogs tended to gather in close proximity to feed area prior to food addition. This behaviour constitutes a learnt activity that is indicative of behavioural complexity beyond simple hard-wired behaviour. This type of predictive response could provide evidence that amphibians could respond to appropriate environmental enrichment and “training” for reintroduction. Reintroduced amphibians are still faced with a low success rate. The provision of naturalistic enclosures and appropriate husbandry practices designed to target species-specific requirements could be used to increase behavioural repertoire, improve animal welfare and also raise the profile of a group which could be described as “poor exhibit animals”.

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The effect of food presentation on the mortality rates and reproductive success of a colony of Rodrigues fruit bats (*Pteropus rodricensis*).

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The nutritional content of a diet as fed can vary dramatically from that consumed. This paper describes how a change in diet presentation – the feeding of whole versus chopped fruit thus allowing greater feed selection/discrimination – led to protein, vitamin and mineral deficiencies in a group of 50 Rodrigues fruit bats (*Pteropus rodricensis*). This manifested as a drop in birth rate from 79/100 adult females to 21/100 adult females, 100 % juvenile mortality and a four fold increase in adult female mortality. Adult males appeared to be unaffected. Behavioural and skeletal changes will also be described as will methods of diet evaluation and the use of ZootritionTM.

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Chow, How and Wow!

Food and Feed Presentation for Primates at Edinburgh Zoo

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Primates display a wide range of feeding methods and feeding specialties. In order to successfully keep a range of primate species in captivity their dietary needs must be met, not only through the nutrient composition of foods but also through the opportunity to display natural feeding behaviours. This poster outlines some of the practical ways in which keepers at Edinburgh Zoo use a wide number of food-based environmental enrichment devices/techniques in order to encourage the primates to display natural feeding behaviours. Many of these methods are presented to a range of species with equal success. Other species, however, are known to have unique feeding behaviours, or needs, which require specific presentation methods to allow each individual to display these behaviours naturally. Primate staff at Edinburgh Zoo have developed many ways of feeding those species with specific requirements so that as well as using food-based enrichment designed to encourage more general behaviours, methods designed solely to target a particular behaviour such as foraging, problem solving, tool-use, investigation, locomotion and co-ordination are employed.

Ring-tailed lemurs, Red-ruffed lemurs and Sclater's Black lemurs

All of these species are known to adopt an inverted posture whilst feeding in the wild- suspended upside-down under the branches of their chosen feeding-site enabling them to exploit food sources above and below them. At Edinburgh we provide all of these species with, amongst other things, rope "walkways" as part of their enclosure furnishings. By suspending fruit such as grapes or bananas on a long, thin piece of rope from these walkways, the lemurs have to adopt the inverted posture in order to reach the food that is otherwise out of reach.

Alaotran Gentle Lemurs

Found solely in the papyrus and reed beds surrounding Lake Alaotra on Madagascar, these lemurs prefer to eat only the stems and soft pith of giant bamboo plants. They move vertically using leaping and clinging movements. The outside enclosure also has a metal grid, suspended from floor to ceiling by parallel ropes. Bamboo is then intertwined through the grid so that the animals have to maneuver down the ropes using hands and feet simultaneously, in a vertical position, as they would when feeding in the wild. The inside house is also furnished with vertical larch poles and rope. The feeding sites can be changed daily to encourage foraging and activity and the position of the ropes requires balance and agility to reach food sites in a vertical position.

Chimpanzees

One of the feeding enrichments used with the chimpanzees is the artificial termite mound. This is a concrete structure with open tubes at various positions within the mound into which items such as honey, natural yoghurt, mustard and fresh orange juice are placed. Browse such as willow branches is scattered around the enclosure. This method not only presents the chimps with a cognitive challenge to produce suitable tools but also offers them a wide range of tastes and flavours which they do not receive on a regular basis.

Allen's Swamp Monkey

As their name suggests, these guenons live in wet, marshy habitats and have webbing between their fingers and toes. Although not deep enough for them to swim into, by floating scatter items such as sunflower seed and peanuts etc. in the water of their pool they will wade into the water to retrieve the food. Shellfish are also presented to them in this manner providing them not only with the opportunity to actively "fish" for food but also to retrieve an important nutrient component of their diet.

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The use of “Toy-food” in Emmen Zoo, presented in an entertaining program for zoo visitors

C.Berndt

Zoo Emmen, the Netherlands

Zoo Emmen wishes to increase its visitors involvement in wildlife and nature in an entertaining manner. It intends to do so by providing information about nature and the environment in the widest sense of the word, hopefully stimulating visitors' interest. Central to Zoo Emmen's activities are its presentations of animals and plants, reflecting their natural environment as closely as possible. Visitors should learn in an entertaining manner, which will only be possible if information is presented in an attractive way.

Visitors have to be aware of the fact that animals, just like humans, need good, healthy food. The animals get their meals on a regularly basis, which is not a contribution to the reduction of unnatural behaviour in the animals. 'Toy-food' is therefore offered to animals in Zoo Emmen, and this phenomenon can be interesting for visitors as well.

'Toy-food' is given besides, or in addition to, the existing diets of the animals. The enrichment food-items have to meet following demands: (1) the animal has to work harder and longer to get the food, (2) curiosity of the animal has to be tickled, (3) behaviour like play/flight/fright/hunt/competition must be stimulated/provoked by the food offered, (4) the 'toy-food' may not lead to habituation, not even on a long term, (5) the offered food may not lead to scared, angry or shocked visitors. Toy-food examples are: herbs and coconuts. But also the way of presenting food items: hang food high or hide food. Use food dispensers that open irregularly at different places on different times on the outside enclosure.

An 'infotaining' program was developed in 2002: a powerpoint presentation about enrichment/ 'toy-food' (what is toy food, why do we feed toy food, toy food in relation with normal diets, safety and health), followed by guided tours where keepers show the 'toy-food'-act.

The development of the program had four messages: (a) wake interest of visitors, (b) increase knowledge of visitors, (c) change attitude of visitors, (d) change behaviour of visitors. The program will provide visitors clarity about the idea 'enrichment'. The powerpoint presentation is shown to adults and children, therefore it has a lot of photo's and a short video.

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**Practical feeding:
Nutrition knowledge /
information**

Zoo animal nutrition and nutritional wisdom of zookeepers Is more synergy possible?

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During the last decades many developments took place in zoo animal nutrition. Knowledge has increased significantly. Both in Europe and the USA conferences on this subject are organised almost on a yearly basis which have resulted in many, often useful, publications.

In most of the publications and also in oral presentations during nutrition conferences the (potential) role of zoo keepers in zoo animal nutrition did not get much attention. This is a rather strange phenomenon; zoo keepers are the persons in a zoo closest to the animals. Through daily observation they probably know best how animals react on their diet and should therefore play a key role in the evaluation of all operations related to nutrition. Another important aspect is that they are the persons responsible for implementation of new diets resulting from new insights.

Based on observations in the Dutch zoo community there is a surmise that the potential important role of zoo keepers in implementation and evaluation of zoo nutrition is not everywhere recognised or appreciated.

A research project was started to get more insight in the present and potential activities of zoo keepers in relation with nutrition, information flows in zoos and obstacles for the implementation of new insights. This project was carried out in 2003.

With a standardised questionnaire keepers and other zoo employees in seven Dutch EAZA zoos were questioned extensively. Questions were asked about nutritional knowledge, time spend on nutrition related activities, importance of nutrition related activities for job satisfaction, organisation of communication about nutrition topics and obstacles for carrying out activities related to nutrition.

In total 82 keepers and 17 other employees (veterinarians, curators, and nutritionists) responded. About 70% of the zoo keepers followed secondary agricultural education. Slightly more than 50% of the zoo keepers stated that during formal education zoo animal nutrition was not a subject in the curriculum. But only 17% followed an application course on this subject afterwards.

Over 80% of the zoo keepers stated that they got a lot or most job satisfaction from activities related to feeding. Especially the actual feeding and applying food items as environmental enrichment were considered most satisfactorily. On the other hand, weighing food or weighing food left overs were considered least satisfactorily. Although 75 % of the keepers answered that it was necessary to keep records of amount of food offered and food intake, only 15% actually weighed the food before offering.

Slightly less than 50% considers the present diet as the best possible for the animals. Only 15 % thinks that nothing can be improved in the diets. More than 80% of the keepers indicated that they followed occasionally their own insights when feeding the animals.

Results also show that there is hardly any formal communication between keepers and other staff about nutrition of the animals. It seems that better use of keepers experience and knowledge in zoo nutrition is possible.

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Analysis of different fish-handling, storage and thawing techniques in eight Zoos in the Netherlands

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Many fish-eating animals living in zoos are fed thawed fish. For a constant daily supply it is necessary to purchase commercially prepared, large blocks of whole frozen sea fish. These fish blocks remain frozen and stored until time of use. Fish has a perishable nature. Therefore it is very important that the fish received in bulk is appropriately handled from the time of receiving, until the actual time of feeding the fish. This way the zoo-animals are guaranteed to be fed good quality fish and receive all the necessary nutrients for their normal growth, health and reproduction.

The contributing zoos all have their own thoughts and theories about thawing frozen fish and correct hygienic practices. This may lead to a difference in the quality of the product. To compare the zoos in their methods of storage, thawing and feeding the fish a questionnaire was made, which contained 75 questions about the subject. During the visits to the zoos, persons working with fish (ordering, thawing, and/or feeding the fish) were questioned about their routines.

After questioning, tours through the parks were made and the different areas were visited. The methods used for working with the fish in each unit of the participating zoos were noted and pictures of each specific situation were taken.

The methods of fish handling differ significant amongst the various zoos. Even within the same zoo different methods were used. Each zoo had several points that could be improved. This could be different steps in the whole fish handling process: ordering, receiving, storing, handling, thawing, feeding, hygiene and sanitation.

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Microbiological analysis of frozen and thawed fish in Rotterdam Zoo

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The fish-eating animals in the Rotterdam Zoo are fed slightly frozen or thawed fish that is taken from the freezer in the morning and put in a fridge where it is slowly thawed for 48 hours. The fish-eating animals eat from this set of fish in the morning, in the afternoon and when there is still some left the next morning. Spoilage of fresh fish and lightly preserved fish is caused by microbiological action. This article will describe the degree of microbiological contamination on the skin or in the fish in whole of three different fish species in four different stages, from frozen fish (stage A) till a fish thawed for 72 hours (stage D). Stage C and D are compared to stage A, because the biggest increase in bacteria is suspected in those stages (the longer the fish is kept). It seems that stage D (especially the mackerel) has an increase of more than log 2 microorganisms in a lot of cases. This is a substantial increase and it would be a good idea not to keep the fish until stage D. Mackerel left after stage C should be discarded.

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The Comparative Nutrition Database: International Zoo Animal Nutrition

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Every aspect of captive animal stewardship depends on the appropriate formulation and presentation of nutrition to ensure the health and welfare of zoo animals. Providing the appropriate nutrition to animals held in zoological institutions is an international concern requiring the cooperation of zoological communities around the world. To facilitate this cooperation, an electronic database of zoo animal diets has been created by the Canadian Association of Zoos and Aquariums Nutrition Advisory and Research Group (CAZA-NARG). The Comparative Nutrition Database© (CND©) is a free, web-based resource of diets proven to maintain the health and reproductive success of animals held in zoological institutions around the world. For each diet, the CND© provides information on the submitting institution, diet ingredients and amounts, commercial suppliers, a nutritional analysis and, specific notes on the presentation of the diets. The CND© is available on the CAZA-NARG website (www.caza-narg.org) and it is hosted by the Biodome de Montreal. Diet submission is a continual process as is diet revision. Participation in the CND© requires submission of diets to CAZA-NARG and, if the submitting institution cannot provide a nutrient analysis, CAZA-NARG will try to provide that analysis. Each participating zoological institution will receive a unique password to access the CND© that will allow them to edit previous submissions. In addition, each institution will receive a password that allows “read-only” access to all their employees. Academic institutions affiliated with participating zoological institutions will receive their own, unique “read-only” password. The compilation and provision of the CND© will help all zoological professionals maintain and increase the welfare of captive animals by providing diets historically successful in maintaining the health and reproductive abilities of those animals within our stewardship. Such a database will also address those animal nutrition issues that result from limited manpower within advisory organizations and will aid zoological professionals in their growth and learning of animal nutrition. Using the CND© as a teaching tool within zoological and academic institutions will also increase the welfare of animals within our stewardship. Present plans include incorporation of the CND© in the ZIMS project with formatting to link animals to ZIMS by ISIS numbers. The presentation of this paper will include a demonstration of the CND©.

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Foundation and function of EAZA Nutrition Group (ENG), providing specialist support for European conservation breeding programmes

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Specialist subject advisors (e.g. veterinary, scientific) are increasingly being added to steering committees for zoo-based conservation breeding programmes worldwide; several advisors in nutrition have already been informally appointed within European programmes. Following the lead of AZA Nutrition Advisory Group, the newly inaugurated EAZA Nutrition Group (ENG) seeks to facilitate improved communication and coordination among nutritionists and those requiring nutrition information, chiefly within zoological institutions. A principal responsibility of the ENG and all its' members will be providing nutrition advice to zoo-based conservation breeding programmes, and developing guidelines and protocols for general use. ENG will support existing nutrition advisors and recruit, screen, appoint and support additional advisors as requested by individual conservation breeding programmes. To achieve this, ENG must define who can act as an advisor and what the position entails. AZA's Nutrition Advisory Group have already established guidelines for nutrition advisors, clearly outlining their responsibilities and their material has been used as a template, adapted to best suit European requirements. A unique relationship has been forged with the European Zoo Nutrition Centre (EZNC) based in EAZA's executive offices, through their assistance in administration duties relating to nutrition advisors.

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Spectral Wildlife Nutrition DataBase for plant and animal materials (using visible and near-infrared spectroscopy)

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The spectral wildlife nutrition databases (SWNDB) were initially developed using a library of stored samples from the Saint Louis, Taipei and Beijing zoos that had been collected and analyzed through conventional methods over the past 17 years. These samples were used for calibrating and developing VIS-NIR (NIRSystems 6500, Perten and ASD) analysis for known chemical constituents (proximate as well as mineral and vitamin data) at the Grain Quality Laboratory, Iowa State University, Ames, Iowa, USA. The samples included: Plants (Brownses, Leaves, Lichens, Bark, Stems, Fruit, Grass, Roots and Pellets), Soils, Feces, Fish, Meat, and a Miscellaneous category. Currently, the database contains over 1500 samples of foods eaten by a variety of species including pandas, gorillas, tigers, snow leopards, hornbills, and lizards, collected from both the wild and as well as captive diets. These data will contribute to an Internet-based, searchable database envisioned both for identification and quantitative proposes. Two primary databases have been developed for calibration that contained 229 plant materials and 103 animal materials. Results comparing three methods of analysis (PLS, ANN and SVM) for crude protein have $r^2 = 0.994, 0.87$ and 0.855 , respectively, for plant materials, and $r^2 = 0.988, 0.917$ and 0.846 for animal materials. VIS-NIR analysis is rapid, not destructive of sample, and can provide accurate results for efficient analysis of a variety of foods, both in the lab and in the field.

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Poster:

What you see is what you get?

Hay quality in Dutch Zoos

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Since hay is the main component in most diets for captive herbivores it is important to know its nutritional quality. Zoos do not produce their own hay and have therefore probably less insight in its quality than for instance livestock farmers who produce themselves.

In October 2003 ten Dutch zoos were visited. In each zoo the person responsible for nutrition was interviewed with the aid of an extensive questionnaire. Questions were asked about the origin of supplied hay, quality control procedures and use of hay in zoo diets.

In each zoo samples (19 in all zoos together) were taken for 'visual' assessment and chemical analysis. From each sample a photo was taken.

Hay chemical composition was not known. The participating zoos only practised visual judging on the supplied hay. The 'sensual' indicators used by all zoos to grade hay are colour, odour and presence of mould. Stage of maturity was seldom considered and leafiness never. Main quality problems mentioned were mould, dust and palatability but these problems did not occur often.

The 'visual' assessment of the samples was done with the help of a standardized form.

Assessment of the samples showed that the majority (12) was in a full bloom stage or beyond. The leaf proportion of most samples was below average. Only three samples were graded as good hay, six were graded as poor hay.

The same samples were chemically tested on dry matter, ash, ADL, ADF, NDF, crude protein, magnesium, calcium and phosphorus.

Crude protein content was in average lower than values given in the Dutch feeding table and by NRC. Fibre content was higher than average, especially ADL and ADF content. Also mineral contents were low. These results are an indicator for a late maturity stage. Quite often hay from land where little or no fertilisers were applied was used by zoos. These samples showed very low calcium and phosphorus values.

There was a direct relation between 'visual' assessment and chemical composition. Samples which scored below average in the 'visual' test had also below standard chemical values. Samples which were graded as good hay had a good nutritional value.

Based on this it can be recommended to put some effort in training zoo employees in 'visual' assessment of hay. This can help in more accurately estimating feeding values.

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Poster:

Compiling a multimedia database of browse species for herbivorous reptiles

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Most zoos recognise that fresh browse is a beneficial, if not essential, component of successful husbandry of herbivorous mammals, although supply is usually limited by the cost and effort involved obtaining it. The term 'browse' can include shrubs, trees, woody vines and stems and also refers to various plant parts - leaves, twigs, shoots, flowers, flower buds and fruits -, and use within zoos is not just limited to mammalian herbivores. However the majority of literature describing browse databases, identifying species and aspects of their suitability for feeding, is limited to these consumers. In 2004 the UK Herp Taxon Advisory Group held a workshop to record and share excellent working practice in reptile nutrition in general, and herbivorous species (mainly terrestrial tortoises and some lizards) in particular. The aim was to describe both the nutritional objectives for optimum diets (e.g. low in fermentable sugars, high in fibre) and also suggest suitable herbaceous ingredients by which this could be achieved. From the list compiled, plants were then classified according to whether they were staple or occasionally used ingredients. To augment the selection of green leafy vegetables that are commercially available, many species of outdoor plants are harvested opportunistically or deliberately propagated. Not only are such species (e.g. dandelion, clover, thistle) nutritionally superior, they add diversity to the diet with potential for physiological and behavioural benefits. However the use of a wider range of plants such as those listed is limited by a lack of knowledge and a means of identifying which species are safe. To counteract this, we describe a database incorporating photographs, scientific and common names of 'native' plant species, together with nutritional analyses of selected material harvested locally.

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Poster:

Continuing global synergy through nutrition training & outreach activities

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The past 5 years have resulted in rewarding recognition and considerable growth of interest in nutrition as a scientific discipline essential for zoo animal management, realized on global scale. In addition to continuing increased membership in the AZA's Nutrition Advisory Group, both the European (EAZA) and Canadian (CAZA) zoo associations have formally initiated nutrition interest groups, and an informal group has been formed within the Colombian zoo association (ACOPAZOA). Latin American growth was jump-started by a training grant awarded through the Columbus Zoo, TACA airlines, and other sponsors to support development of 3 Colombian zoo professionals selected through the Zoo Conservation Outreach Group in 2001. As part of their training program, these individuals reviewed and translated jointly-developed training materials into Spanish (available at www.zcog.org). As follow-up and continuation of the outreach activities, they organized nutrition workshops in-country, support joint food composition as well as diet databases locally, and continue to pursue research topics in comparative nutrition. More recently, the Southeast Asian Zoo Association (SEAZA) supported training workshops in Thailand (2002) and Indonesia (2003); individuals were identified as central contact personnel, and databases of local food composition and diets are being compiled for Internet dissemination. The South Asian Zoo Association for Regional Cooperation (SAZARC), with support from a University Federation for Animal Welfare grant and the World Zoo Association, targeted nutrition training as a priority for its participants in 2003 meeting, held in Sri Lanka. Working Groups highlighted topics in Herbivore, Carnivore, Avian/Reptile, and Primate nutrition areas to better describe, identify, and share information on the composition of local feedstuffs, successful diets and hand-rearing protocols. Follow-up of nutrition goals and objectives was the focus of the 2004 SAZARC meeting in Pakistan. Also in 2004, the Chinese Association of Zoological Gardens (CAZG) organized a 3-day training workshop hosted by the Beijing Zoo, attended by almost 70 zoo professionals, and representing more than 35 facilities. One result of that workshop will be the translation of Zootrition software into a Chinese language version. Lastly, following a nutrition workshop at the Johannesburg Zoo in 2004, a wider-ranging workshop is planned for South African zoos in March 2005. Identifying and communicating local needs, wants, and interests provide the foundation; providing basic educational tools and materials with which to develop local resources – both personnel and information – is the key to full expansion.

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Vitamin and Mineral Supplementation

Intake and digestion in two iguanid species fed a fiber-supplemented salad mixture: preliminary

Observations.

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Two (1.1) adult green (*Iguana iguana*) and one (1.0) adult and 3 (2.1) juvenile rhinoceros iguanas (*Cyclura cornuta cornuta*) were fed a diet comprising a mixture of chopped salad greens, vegetables and fruit (recipe: 55% greens, 30% vegetables, 15% fruits) with or without a dried chopped grass hay supplement. The salad without added hay comprised (dry matter [DM] basis): 19.2% crude protein (CP), 26.0% neutral detergent fiber (NDF), 20.6% acid detergent fiber (ADF), 1.2% Ca, and 0.4% P. The same salad with 5% added chopped hay contained 18.2% CP, about 50% more fiber – 37.5% NDF, 29.8% ADF, and 1.0% Ca, 0.4% P. Adult lizards were housed individually, as was the single juvenile female rhinoceros iguana; the two juvenile males were housed together for a total of 5 data sets. Green iguanas were housed at 28.3°C, 44% RH and fed daily, whereas rhinoceros iguanas were housed at 27.7° C and 60 to 70% RH. and fed every 2 days. Feed intake and total fecal output data were collected over 4 (*I. iguana*) or 12 (*C. cornuta*) consecutive days with correction for desiccation in feeding pans for each diet treatment. The juvenile female rhinoceros iguana (body weight 1342 g) was fed 100 g salad every 2 days whereas the juvenile males (average body weight 1786 g) were fed 400 g total. The adult male (weight 6.82 kg) was offered 500 g salad. The adult green iguanas (weights 3820 kg and 3060 g for male and female, respectively) were each offered 225 g salad daily. Adult iguanas consumed 0.6 – 0.8 % of body weight on a DM basis daily when fed salad with no hay, and 0.4 – 0.7% with added hay. Average daily dry matter intake (DMI) for juvenile rhinoceros iguanas ranged from 0.3 – 1.0% of body weight when fed salad with no hay, and increased (0.4 – 1.4% DMI) when fed the hay-supplemented diet. There was a transitory effect of added fiber on palatability when supplemented diets were first presented. With the exception of one animal, intakes increased and stabilized after the initial offering of the altered diet (transition period 1 to 2 weeks). Dry matter digestibility (DMD) averaged 92% on the salad without hay in adult iguanas, but only ~30% in juveniles. DMD decreased to 73% with the added fiber in adults, but increased to 76% in juveniles. Overall protein digestion decreased from 89 to 76% with the diet change; responses by adults compared with juveniles, however, differed (adults decreased, juveniles increased). Fiber digestion decreased from 88% to 63% (NDF) and 87% to 67% (ADF) in iguanas. Surprisingly, juvenile rhinoceros iguanas displayed higher fiber digestion ability compared with the adult in this trial. Transit of food was apparently slowed by the addition of insoluble fiber, as defecation interval increased from daily to every two days in the green iguanas fed the hay-supplemented diet. Additionally, animals displayed higher fecal protein concentration in feces on the hay-supplemented diet, presumably from greater microbial contribution. Passage rates, however, were not measured in this initial study. Analyses of native foods eaten by iguanas suggest these animals are capable of utilizing higher fiber content than provided by most captive diets. Although high fiber diets can slow growth in young animals, maximal fiber digestion ability of adult iguanas has not been challenged in controlled feeding trials. Increased DMI, longer food retention, possible beneficial gut environment and microbial population alterations, and improved utilization of feeds may be realized by the addition of 5% chopped grass hay to produce-based diets fed to iguanas.

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Different supplementation of minerals in bats and the consequences on bone mineral density

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In feeding insectivorous animals with live insects, the mineral supplementation of the insects is an important part of the dietary management. We investigated the consequences of mineral supplementation of mealworms at a facility where mustached bats (*Pteronotus parnellii rubiginosus*) from Trinidad were kept for experimental purposes. For 11 months after capture from the wild, the animals were constantly housed indoors under a constant photoperiod of 12h at 75 % relative humidity and fed a diet of mealworms. The mealworms were kept on a substrate of oat flakes. Death occurred spontaneously in several animals for no obvious reason, but the cranial skeleton was soft at palpation, a mineral deficiency was suspected. Consequently, the mealworms were placed on a mineral supplement one day prior to feeding, which increased their calcium content from app. 1 g/kg dry matter to app. 10 g/kg dry matter, and increased the calcium:phosphorus-ratio from app. 0.15 to app. 1.50.

We investigated bodies from animals that died at different stages of the husbandry process. Six animals were killed at capture from the wild, representing the free-ranging controls (Group A), eight animals died or were killed for experimental purposes while on the preliminary feeding regime (Group B), and six animals died or were killed for experimental purposes while on the final, supplemented feeding regime (Group C). After measuring the length of the radius with a digital caliper, total bone mineral density (BMD) was measured in the left radius with peripheral quantitative computer tomography (Stratec XCT 2000 bone scanner, Stratec Medizinaltechnik GmbH, Pforzheim, Germany). The measurements were taken in the middle of the diaphyses (at 50% of total length). Cortical BMD (Cortical mode 2; threshold for cortical bone >640 mg/cm³) was calculated by automated computation. Bone mineral density was highest in group A. Group B had significantly lower bone mineral density than Group A. Interestingly, Group C, receiving supplementation, showed no significant difference compared to Group A.

The supplementation of minerals to the diet of bats did induce differences between the groups. The animals from the wild had similar densities in the radius as the supplemented bats whereas the animals receiving no supplementation showed significantly lower densities than animals from the wild. This supports the assumption that it is important to feed a mineral supplementation to captive bats to conserve their normal bone structure.

We thank the Wildlife Section of the Ministry of Agriculture, Land and Marine Resources, Trinidad, for the permission to capture and export the bats, and Mr. F. Muradali for the capture.

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Observations on the antioxidant status of domestic equines as influenced by supplementary dietary antioxidants.

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A study was undertaken to examine the effect of a combination of supplemental antioxidants on the antioxidant status (TAS) of modern, domesticated horse which, by way of management, housing and feeding is considered to experience a relatively high level of free radical challenge and often low and variable antioxidant intake. Six adult horses (12-31 years, 400-680 kg) received a diet of conserved forage and grass (3 hr / day) together with a compound feed corrected to an intake of vitamin E equivalent to 1.65mg/kg body mass (BM), so as to maintain condition pertinent to exercise intensity. Each horse received a metabolic body mass equivalent of supplemental antioxidants (vitamins E 0.05 mg/kg, C 0.09 mg/kg, bioflavonoids 15.5 mg/kg) for six months, followed by 3 month withdrawal period and a subsequent 3 month reintroduction. Routine 3 monthly plasma samples taken by the veterinary surgeon were used with informed consent to determine the antioxidant capacity (TEAC), vitamin C, E, cholesterol and triglyceride concentrations and resistance of low-density lipoprotein to oxidation (RLDLO). Each horse acted as its own control with comparisons using paired t-test for differences between periods. Plasma vitamin E, C, TEAC and RLDLO increased above initial values by 3 and at 6 months (mean $4.5 \pm SE 1.63$ mg/ml to 6.1 ± 2.58 mg/ml $P < 0.05$; 0.8 ± 0.22 mg/100ml to 1.2 ± 0.26 mg/100ml $P < 0.01$; 0.7 ± 0.13 to 0.9 ± 0.07 $P < 0.001$; 46 ± 11.9 min to 63 ± 15.7 min $P = 0.002$ respectively). These values declined when the supplement was removed, but increased to at least the 6 month values after the supplement was re-introduced. No changes were observed in cholesterol (2.9 ± 0.52 mg/dl to 2.7 ± 0.17 mg/dl, $P = 0.2$) or triglycerides (19.2 ± 10.57 mg/dl to 13.1 ± 6.82 mg/dl, $P = 0.06$). The plasma vitamin E increase did not appear to be in proportion to the additional dietary supplemental vitamin E. Improvements in the values for TEAC and RLDLO suggest an improved recycling of endogenous vitamin E. Antioxidants are known to be more effective in increasing TAS in combination than in isolation. These observations indicate that the TAS of the horse - as in other animals such as the dog -, may be further improved by the addition of a combination of antioxidants. In this case the increase occurred even though the horses were receiving what is considered in the literature to be adequate vitamin E.

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Poster :

Increasing calcium content in Jamaican field crickets (*Gryllus assimilis*)

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Crickets are a poor calcium source but often used as feed insects for reptiles and other captive animals. A method to enhance the calcium content of crickets is feeding them a diet with a very high calcium content (>8%). This so called 'gut loading' is already well researched in house crickets (*Acheta domesticus*) but never in Jamaican field crickets (*Gryllus assimilis*).

In an experiment we tested the effect of gut loading with one base diet (0.84% Ca) and three experimental calcium fortified diets (8%, 10%, 12% Ca respectively). All feed was finely ground and its dry matter content was 95%.

The calcium content in the dry matter of the crickets fed the base diet increased during 144 hours from 0.20 % to 0.27%. After 48 hours feeding the 8% diet, dry matter calcium content in crickets was 1.3%. Similar levels were reached after 24 hours feeding the 10% and 12% diet. After 72 hours feeding the experimental diets Ca levels in the crickets reached their maximum. After this the levels decreased in the 10% and 12% groups, probably due to reduced intake, but remained constant in the 8% group. A positive calcium phosphorus ratio was reached after 48 hours feeding the 8% diet and 24 hours feeding the 10 % and 12% diets.

Crickets consumed slightly more from the 10% and 12% diets, maybe due to energy dilution in the experimental diets. During the experiment hardly any mortality was observed.

Crickets fed the 10% experimental diet for 24 hours were offered for one week to growing leopard geckos. They accepted the crickets well.

For fast increase of calcium levels in crickets we recommend at least 10% Ca in the diet offered. When the crickets are kept for a longer period before feeding we recommend 8% Ca in the diet.

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Poster:

**Vitamin A, D, E and B₁ content in diets of captive piscivorous animals
What sense does (multi)vitamin supplementation make?**

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Literature indicates that when feeding fish to piscivorous (fish-eating) animals, due to the unsaturated fatty acid content and risk of presence of thiaminase in fish, there is a necessity to supplement vitamin E and B₁. Results of a preliminary survey indicated that there are important differences between zoos pertaining to the dosage of vitamin supplements. Quite often multivitamin supplements are used instead of specially manufactured supplements.

To get more insight in present supplementation practices in Dutch Zoos a more detailed survey was started. Data on the ingredient composition, including supplements, were collected for eleven different species (3 bird species, 2 marine mammal species and 6 shark species). With these data energy and vitamin content of the diets were calculated using various food tables.

Diets (fish and supplements offered) from 26 separate groups of animals from 7 zoos were evaluated. Results indicate that for 24 groups supplementation with vitamin A seems not necessary. In 11 cases animals are offered more vitamin A than the upper safe levels. However, it is not clear whether the existing upper safe levels in literature are also applicable to specialised piscivores.

All animals receive enough vitamin D. For 25 groups there seems no need for supplementation. In 15 cases animals get more than the recommended upper safe level. The comment on Vitamin A upper safe levels also applies to vitamin D.

In eight cases the calculated dietary vitamin B₁ levels were lower than recommended in literature.

Vitamin E levels were also in eight cases lower than recommended. In a few cases shortages could be explained because it appeared that totally inadequate supplements (designed for ruminants) were used. Overall, there were dramatic differences in the use of supplements and their dosage.

It is strongly recommended that supplementation practices for piscivorous animals in Dutch zoos are thoroughly re-evaluated.

A major obstacle in this project was the lack of reliable data on the nutrient content of whole fish. A proposal will be made to help solving this important problem.

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Avian Nutrition

Using mortality and reproduction data to evaluate captive penguin nutrition

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While evaluating diets fed to penguins in captivity with that consumed by wild birds would be ideal, there is a paucity of much relevant knowledge. Little nutritional analysis of Notothenioid fish species has been performed. The small amount of lipid and vitamin analysis in Antarctic krill *Euphausia superba*, the predominant prey of numerous penguin species, has shown marked variation in nutritional content, dependant on season, gender, and life stage of krill. It is also known that some penguin species can discriminate and actively consume gravid female krill, further complicating extrapolation to captive diets. Instead a combination of needs extrapolated from domestic poultry, other fish eating vertebrates, and partial knowledge of wild diets has previously been used. Penguins have been kept for over a hundred years in Edinburgh zoo. A large closed population of King penguins *Aptenodytes patagonicus*, Gentoo penguins *Pygoscelis papua*, Macaroni penguins *Eudyptes chrysolophus*, and Rockhopper penguins *Eudyptes chrysomus*, has been maintained for the last 40 years. This appears to be the largest long-term self-sustaining captive penguin population in the world, and offers a unique opportunity for nutritional research. Of the more than 1200 penguin post-mortem examinations performed at Edinburgh zoo, 813 post-mortem examinations have been performed in the last 40 years, 635 of which are of a single species, the Gentoo penguin *Pygoscelis papua*. Analysis of mortality and disease incidence patterns, as well as reproductive success have been correlated with dietary changes, as a different method of trying to determine the impact of captive nutrition. The adult gentoo penguin population has shown a significant rise ($p < 0.01$) in mortality rate between 1964-2003 (95%CI of gradient: 0.12-0.51). The median age at death of adult gentoo penguins has fallen from 8 years (95%CI 7-10, $n=199$) during the period 1980-1990 to 5 years (95%CI 3-8, $n=118$) during the period 1993-2003. Interesting findings, confounding factors, and limitations will be discussed.

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Novel plumage pigments, novel prey species antioxidants and immunostimulants: implications for captive penguin nutrition.

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Gentoo penguins (*Pygoscelis papua*) fed a captive diet deficient in astaxanthin, the carotenoid present in their main prey, Antarctic krill (*Euphausia superba*), appear to develop pale beaks and feet, in contrast to the bright orange coloration seen in wild birds. King, macaroni, and rockhopper penguins kept under the same conditions and fed a similar diet in captivity do not show any change in coloration. Recent work has shown yellow plumage coloration in macaroni penguins (*Eudyptes chrysolophus*), king penguins (*Aptenodytes patagonicus*) and emperor penguins (*Aptenodytes forsteri*) is not due to carotenoids, but possibly to pterins, a novel group of pigments not described before in the plumage of other avian species. These pigments are soluble in mild acids and bases and fluoresce strongly under UV light, characteristics consistent with pterins, only previously isolated from the yellow, orange, and red irises of blackbirds, starlings, owls, pigeons, and the wings of some Lepidoptera. Yellow plumage patches have been shown to affect mate selection in the wild in species such as the king penguin. Zoo visitors may also notice the abnormal appearance of paler birds.

Work on Notothenioid fish species and *Euphausia superba* krill has shown that aside from α -tocopherol (Vitamin E), these penguin prey species contain Marine Derived Tocopherol (MDT), α -tocomononol, postulated to enhance antioxidant activity at low temperatures. Notothenioid fish have higher levels than phytoplankton, showing accumulation in the food chain. The situation is unknown in sub-antarctic seabirds, but potentially may be similar. Piscivorous birds such as penguins probably have higher antioxidant requirements than other avian species due to their high intake of polyunsaturated fatty acids. Freezing, storage and thawing of fish is also likely to deplete antioxidant content, increasing supplementation levels needed. Pacific krill (*Euphausia pacifica*) has not been shown to contain MDT. It is used in calculating wild penguin diets in lieu of antarctic krill as there is more published literature on its nutritional content. This practice may be questionable. Until further research has elucidated the situation regarding carotenoids and MDF in wild penguins, it may be prudent to include or supplement α -tocopherol (Vitamin E) at a higher level in the captive diet than is known to occur naturally in wild penguin prey.

Antarctic krill extracts are currently being researched for a variety of reported beneficial effects. Chickens fed a commercial broiler diet containing 0.5% krill chitin, have shown significant weight gains and increased feed efficiency, compared to controls. These are believed to be due to a change in intestinal microflora. Chitosan, a deacetylated form of chitin polysaccharide polymers found in the exoskeleton of Antarctic krill, has been demonstrated to act as an immunostimulant in salmon and trout. It has also been shown to have beneficial effects in the management of chronic renal disease and hypercholesterolaemia in humans. The ability of the penguin digestive system to deacetylate chitin polysaccharide is not known. Despite the beneficial effects of chitosan, it can also very significantly reduce the absorption of lipid soluble vitamins A, D, E and K, as well as carotenoids, and therefore its use as a supplement does not seem wise. It remains to be seen whether inclusion of fresh-frozen Antarctic krill in captive penguin diets would be beneficial, or justify the associated costs.

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Nutrient composition of the diet of captive and wild kiwi (*Apteryx mantelli*) in New Zealand

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Diets fed to kiwi (*Apteryx mantelli*) held in captivity in New Zealand are based loosely on a recipe recommended in the kiwi husbandry manual that was formulated over 30 years ago (Reid, 1970). Adult kiwi in captivity have been found to suffer higher mortality and lower fertility rates, and produce smaller eggs with lower hatchability and thinner egg shells compared to adults in the wild. Surprisingly, the diet of the North Island brown kiwi held in captivity has never been formulated on nutritional information from the natural diet of wild kiwi, nor has the nutritional composition of the current formulations been determined. The aim of the studies reported here was to compare nutrient composition of diets fed to captive kiwi to that of the diet of kiwi in the wild in order to improve the formulations.

Diets from seven institutions holding kiwi were analysed for dry matter, ash, crude protein, crude fat, amino acid and fatty acids. Data on the composition (dry matter, ash, amino acids and fatty acids) of the diet of kiwi in the wild were obtained from analysis of the gizzard content of wild kiwi carcasses. Large differences were detected in the type and quantity of ingredients used to formulate the kiwi diets by each institution. A total of 19 different ingredients were used with the number of ingredients used in each formulation varying from 3-10. The main ingredients used were oxheart, cat biscuits and roll oats. All of the diets were formulated using meat as the main ingredient with three using a combination of meat and cat biscuits. Chemical analysis of the seven diets showed a large variation in nutrient content with organic matter ranging from 89.6 to 96.9%, crude protein from 23.0 to 42.7% and crude fat from 5.4 to 24.4% of the dry matter. The mean organic matter content of the gizzard content of the wild kiwi was 72.1% with a range of 49.9 to 93.0 %. The protein content varied from 18.4 to 51.0% with a mean of 31.4%. The total fatty acid content was highly variable with a range of 0.4 to 3.9% and a mean value of 1.96%.

Each captive institution in New Zealand appears to have their own recipe for a kiwi diet with overall 19 different ingredients being used with almost all being foreign to kiwi with the exception of an insectivore mixture. Kiwi in the wild have been reported to predominantly consume insects, invertebrates and plants. The nutrient composition of the captive diets varied greatly in crude protein, fat and carbohydrates. Comparison of the nutrient composition of these diets with the gizzard content of kiwi shows that the current diets are high in organic matter and fatty acids. Especially the latter is approximately 5.8 times higher in the captive diets compared to that of the gizzard content. In addition, the carbohydrate content of the captive diets is predominantly starch (derived from cat biscuits, oats, tofu and wheat germ), the intake of which is almost certainly low in wild kiwi.

Reid, B. 1970: Feeding kiwis in captivity. *Wildlife - a review* 2 26-30.

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Long-term effect of dilution degree of nectar food and the feeding of pollen on the condition of nectarivorous parrots at Loro Parque Fundacion.

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Nectarivorous parrots in captivity are commonly fed a commercial nectar food. Nectar foods are sold as a powder that has to be diluted in order to become a nectar-like solution.

A previous study (Janssens et al., 2003) demonstrated that the dilution level had a significant impact on the voluntary energy intake of two rainbow lorikeets subspecies. Due to the short-term character of that trial, only limited changes in body weight and body condition were observed. Besides nectar, pollen are also considered as a main ingredient in the diet of nectarivorous parrots (Cannon, 1984). Only scarce information is available on the feeding value of pollen and its dietary necessity for nectarivorous parrots (Frankel and Avram, 2001).

The present study aimed to clarify whether the dilution degree of nectar food and the feeding of pollen could affect body weight and body condition in a large population of nectarivorous parrots at longer term.

Nectarivorous parrots in the collection at Loro Parque Fundacion were randomly allotted to four dietary treatments: Two groups (D3_0 and D3_P) were fed a commercial nectar food (Nutribird Lori, Versele-Laga, Deinze, Belgium) at a dilution in water of 1/3 (v/w), whereas the other two groups (D4_0 and D4_P) were fed a dilution in water of 1/4 (v/w). Groups D3_P and D4_P also received pollen (mixed flower pollen, Pollenergie, France) in their diet at an inclusion rate of 1/5 (w:w on undiluted nectar food basis). Fresh pollen were nitrogen-packed and frozen.

Pairs without chicks were also given fruit and mealworms in the afternoon.

At day 0 and day 100, all birds were clinically examined and weighed. A body condition score was given, with 1 = underweight, 3 = normal and 5 = obese. This was done by checking the pectoral covering over the sternum and the fat deposits around the cloaca.

The difference in weight change was not significant between groups. Yet, the change in body condition score was significantly affected by the dilution degree of the nectar food ($p=0.005$).

Differences between genders and the feeding of pollen did not reach the level of significance ($p>0.05$). Body condition scores increased with body weight, and were significantly different between species. Whether this can be contributed to biased condition scoring or to the elevated risk of large species to become obese, should be further investigated.

Breeding results were numerically better in the pollen-fed birds, but statistical analysis was not possible.

An appropriate dilution degree of nectar food might be a useful tool to prevent aberrant body condition like obesity in nectarivorous parrots.

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Investigations of dietary calcium requirements in growing storks

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Storks are semi-aquatic carnivorous birds that have historically not bred well in captivity; nutritional factors may well underlie health and successful reproduction in these altricial, rapidly growing species. Although rather catholic in choice of food items in nature much of the year, following hatching, storks have been anecdotally reported to feed frogs almost exclusively to growing chicks. Whole frogs analysed contain up to 5% calcium (DM basis). Field data may thus provide a clue to calcium (and other nutrient) requirements of growing storks. To date, there are few investigations that quantify nutrient needs of altricial avian species. We hypothesize: 1) calcium needs of altricial chicks are higher than those of precocial species, thus poultry do not provide an appropriate physiological model – although a combination of domestic carnivore and poultry data may; 2) growth rates and deposition of calcium are higher in altricial, long-legged bird species compared with poultry species, and 3) prey consumed by storks in nature varies in calcium content on a seasonal basis, corresponding with the nutrient needs of growing chicks. This study attempted to evaluate calcium nutrition of storks by evaluating data both indirectly via the literature and directly within zoos using growth and diet records from captive storks.

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Nutritional management and feeding behavior during hand- and parent- rearing of Great grey shrikes (*Lanius excubitor meridionalis*) chicks in captivity and in the wild.

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The situation of the Lesser grey shrike (*Lanius minor*) in the Iberian Peninsula during the last few years suggests that conservation strategies should be taken. The Departamento de Medio Ambiente (Generalitat de Catalunya), the Trenca Association and the Spanish Ministerio de Medio Ambiente are developing an Experimental Captive Breeding Plan for the Lesser grey shrike. Its aims are to contribute to the future reinforcement of the wild populations through captive propagation, and to develop an education program to sensitize the public. The Experimental Captive Breeding Plan is being developed using a surrogate species, the Great Grey Shrike (*Lanius excubitor meridionalis*). The nutritional program is one of the key factors for a successful captive breeding. Additionally, observations of the feeding behavior during parent chick-rearing both in captivity and in the wild are also important considerations to take into account.

In the spring of 2003 twelve eggs of the Great grey shrike, were taken from the wild to develop working protocols such as the chick hand-rearing feeding protocol. Six growing diets were formulated using a variety of ingredients and proportions that changed according to the age and requirements established for the chicks. The amount of food was offered as a percentage of body weight, starting at 25% and increased progressively until 50%. From day 30 of age onwards, a meat-ball diet was formulated and offered alternatively with live insects during the week. During the first month chicks were weighed daily and the diet consumed by each chick was registered. Eighty three percent of the chicks hand-reared from day 1 reached adulthood without any clinically apparent health problem. The survival rate and average daily weight gain of the chicks were very similar to those observed by the San Diego team working with *L. ludovicianus mearnsi*.

In spring of 2004, 13 chicks of the same species between 5-8 days old were taken from three wild nests. The aim was to test the 2003 protocols and adapt them to the new situation. It has been documented that hand-rearing one-week old chicks is much more successful and less demanding than rearing chick from day 0. Chicks caught from the wild, weighed two times more than the same age chicks hand-reared from day 0. The same diet protocol as in 2003 was used, but a few adaptations were made. Chicks from both experiences reached adult weight (57 g average) in the same number of days (27). In this second experience, all the chicks reached adulthood without any apparent health problem.

At the beginning of March of 2004, the 2003 hand-reared chicks were paired, and two of the pairs bred (one of them twice). The complete development of the parent reared chicks was recorded with a camera allocated on top of the nest. Although chicks were not weighed to avoid interfering too aggressively with the animals, some chick rearing behaviors could be registered, like number of times the chicks were fed by adults and several observations of the type of ingredients the adults provided to the chicks were also recorded. These results could be compared with the results obtained by recorded images taken from wild nests of both *L. excubitor* and *L. minor*.

The feeding protocol used to hand-rear *L. excubitor* may be applicable to hand-rear *L. minor* since both species are biologically very similar.

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Circulating concentrations of vitamins A and E in avian species; evidence for dietary relationships?

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Our understanding of vitamin requirements and interrelationships within the class Aves is based almost entirely on a single species, the chicken *Gallus gallus*. Being granivorous, the chicken has a fairly restricted feeding niche. Thus, vitamin nutrition of birds with diverse nutritional strategies beyond this food group remains poorly understood. Only a small proportion of vitamin requirements can be met by endogenous synthesis in birds; most needs must be met by their diet. Beyond the symptoms of severe deficiencies, little is known about the vitamin requirements of nondomestic species although distribution of vitamins in foods is a major factor determining the probability of deficiencies. Fat-soluble vitamins are usually found in the diet in association with lipids necessary for their absorption and transportation, vitamin A being most prevalent in foods of animal origin and vitamin E more concentrated in plant material. As part of routine testing, blood samples representing 169 species from 19 orders were collected and analysed for α -tocopherol and retinol concentrations; diet diversity was also scored for each species using data collated from natural history literature and published research. We report summary survey values for circulating concentrations of vitamins A and E in these avian species that may be useful guidelines for clinical assessment of nutritional status and also appear to be correlated with feeding niche.

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Influence of a seed diet versus a formulated diet on bodyweight and intestinal flora in budgerigars (*Melopsittacus undulatus*) over a six-month observation period

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Two groups, including 22 randomly selected 2-year-old budgerigars (*Melopsittacus undulatus*) each, were housed under identical conditions for 6 months, with the diet being the only difference. One group was offered a commercial seed mixture ad libitum plus carrots (0.5 g FM/bird/d) and a mineral supplement. The other group received a commercial formulated diet (4g FM/bird/d, manufacturer recommendation) for budgerigars plus carrots (0.5 g FM/bird/d).

Table 1. Analysis of a diets fed to budgerigars (*Melopsittacus undulatus*). Values are expressed on a fresh matter (FM) or dry matter (DM) basis.

	Unit	Pelleted diet	Seed diet (dehulled)
Water	g/kg FM	77.4	100.6
Crude ash	g/kg Dm	36.5	32.6
Crude protein	g/kg Dm	171	171
Crude fibre	g/kg Dm	21.0	29.5
Crude fat	g/kg Dm	96	75
Acid detergent fibre	g/kg Dm	48	-
Neutral detergent fibre	g/kg Dm	88	-
Metabolizable Energy	MJ/kg Dm	19.3	17.0
Calcium	g/kg Dm	4.1	0.4
Phosphorus	g/kg Dm	4.3	5.0
Sodium	g/kg Dm	0.6	0.8

On day 0, 15, 20, 37, 92, and 189 each animal was weighed. The average bodyweight of the pellet-diet group dropped after diet-changing to a minimum average of 41.5g (i.e. a decrease of 16%) on day 15 compared to day 0. One bird died on day 16 due to emaciation. Following an increase of the formulated diet of 50% bodyweights increased by day 37 to 48.1g. At day 92 the average bodyweight (44.9g) dropped again (9.9%) compared to day 0 and subsequently increased again by day 189 (49.7g) without change to the diet.

Average bodyweight of the seed-diet budgerigars remained constant during the trial.

On day 92, and 189 faeces of each animal were analysed microscopically with Gram stain. The evaluation of the faecal samples revealed no significant differences between both groups, with the exception of *Macrorhabdus ornithogaster* which was found in 7.7% of samples of seed diet group versus 36.6% in the formulated diet group. Gram-positive rods dominated (79.1%) over Gram-positive cocci (14.7%). Gram-negative rods were found in 25.6% of the samples. No yeasts were diagnosed.

The present study shows that transition of seed fed budgerigars to a formulated diet is possible, but that bodyweights should be carefully monitored during transition and amounts fed to birds may have to be higher during transition than for subsequent maintenance. A possible explanation for the decrease in bodyweight at day 92 in the formulated diet group could not be found.

The observation that the formulated diet did not have a significant effect on intestinal flora differs from another study in 100 African grey parrots (*Psittacus erithacus*). Possible reasons may be that the durations of both studies were not comparable or that the different number of animals had an influence on the interpretation. Additionally it may be that the diets used in the two studies or the species may be too different to allow comparison.

A possible reason for the increased occurrence of *Macrorhabdus ornithogaster* may be the stress of transition to the formulated diet.

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General nutritional subjects

Gross Energy and nutrient content of reptilian eggs

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Reptilian eggs can be considered as packages loaded with energy and nutrients. Producing these packages requires nutritional support. To give a sound nutritional advice for reproducing reptiles one needs to know the nutritional contents of eggs in the first place. Surprisingly enough there are not many data on this subject.

From January until June 2004, 24 reptile egg clutches or parts thereof were collected from 15 different species in total. From these clutches 158 eggs were analysed for Gross Energy (GE), Dry Matter (DM), Ash, Crude Protein (CP), Calcium (Ca), Phosphorus (P) and Magnesium (Mg). Methods used were Bomb Calorimetry, Proximate Analysis and Atomic Absorption Spectroscopy. Crude Fat contents were calculated by difference. Egg contents and shells were separately analysed.

The average GE values for egg contents varied from 25.1 kJ/g DM to 28.5 kJ/g DM. Soft egg shells contained on average 15.6 kJ/g DM. The energy content of hard egg shells could not be determined.

The Crude Protein percentage of the egg contents varied from 40% to 58%. Crude protein in shells varied from 62% in soft shells to 11.7% in hard shells.

In soft shelled eggs calcium values in the egg contents averaged 13 mg/ g DM. In hard shelled eggs it averaged 4.8 mg/ g DM. Calcium content in soft egg shells averaged 105 mg/ g DM and in hard egg shells 370 mg/ g DM.

Before these results can be translated into a dietary advice more insight is necessary in the reproductive physiology of reptiles. How and in what time the eggs develop in the reptilian body; are energy and nutrients necessary for egg development directly taken from food or from body supplies; and what is the best moment to support egg development nutritionally - these are questions which are worthwhile to answer in future research. But also the relatively small database developed in this project needs further extension.

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Developing nutrition standards and dietary guidelines for polar bears in captivity

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Many factors should be considered when developing nutrition guidelines for captive polar bears. A discussion of nutrition issues took place at the polar bear husbandry conference hosted by Polar Bear International in San Diego, California in February 2004. From that conference a nutrition task force was developed that included SSP/Tag advisors, feed manufacturing nutritionists and husbandry specialists. Polar bear husbandry nutrition guidelines are in development with topics that encompass foraging ecology and general feeding recommendations including, diet proportions, food handling, dental issues, special needs, and proposed nutrient requirements. Additionally, fecal characteristics, seasonal weight fluctuations, and myths/lore will be addressed.

The polar bear (*Ursus martimus*) the most carnivorous of the Ursidae family, prey on primarily on ringed seals (Best, 1985; Briggs, 2002; Derocher, et. al, 2000; Stirling and Archibald, 1977). Other seal species (bearded, harp), some whale species (white, narwhal), walrus, reindeer, sea birds, carrion, and vegetation have been reported as consumed (Derocher, et al. 2000; Knudson, 1978; Russel, 1975). The polar bear, like many other bear species, is subject to seasonal periods of fast due to low food availability and have evolved physiological adaptations for periods of starvation (Cattet, 1990; Derocher, et al. 1990). The stomach of ursids are simple, and the distal segment of their intestine is marked only by an appearance of mucosa with no cecum present (Stevens and Hume, 1995). Most free-ranging adult polar bears typically consume the skin and the blubber of their prey, leaving the muscle and organs in order to optimize efficient use of energy and nutrients in the prey (Best, 1985). In contrast to the seasonal variation of the diet in the free-ranging bears, the captive polar bear in many zoos is fed throughout the year on a constant ration. The basic diet consists of commercial omnivore diet or dog food, in combination with a variety of other foods including frozen, thawed meat and fish, fruits, vegetables, and vitamin & mineral supplements. Food category proportions will be recommended. This will include food used in training and behavioral enrichment as well as browse forage items. Food handling and sanitation guidelines will be summarized. Dental issues were discussed with the Veterinary advisors. Rather than limit food choice, a list ranking foods' effect on dental health is planned. Recommendations for will be outlined for overweight, geriatric, pregnant/lactating, and growing animals. Disease states related to diet will be outlined by the veterinarians. No species specific requirements are known for polar bears so other domestic models (cat and dog) and published research papers were applied to develop a model for use. Fecal characteristics were developed for the bear intake study conducted by the bear TAG nutrition advisors in 1996. These characteristics will be refined and guidelines developed. The nutrition advisors are examining weight data from various institutions for correlations with average temperature, latitude, and photoperiod for those locations across seasons. Finally, a list of myths and lore were outlined by the husbandry advisors from the bear TAG that included low vitamin A in captive diet compared to wild diet related to reproductive rates and coat problems, the questions of whether salt and thiamin/vitamin E supplements are necessary for captive bears, vitamin D and calcium supplementation for pregnant/lactating bears due to fractures in cubs, the addition of fat due to improper hair coat, protein and carbohydrate variation in diets related to seasonal changes in the wild diet, and general feeding carcass in captive diets.

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Survey of major nutrients in Asian Elephant (*Elephas maximus*) milk during different stages of lactation

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Experiences made in different zoos showed considerable difficulties with the artificial rearing of elephant calves born in captivity. Besides loose stools or diarrhea, e.g. skin dryness and umbilical infection seem to be more likely in hand-raised calves. Therefore - and to prevent other nutrition-dependent stressors - it is necessary to provide a milk replacer which closely resembles the nutrient composition of the dam's natural breast milk.

Milk is the sole food for infants during the first six months. It is well known that calves are milk-dependent for the first two years and will often suckle to the age of four or five. After the age of two the volume of the consumed milk begins to decrease gradually.

The makeup of natural milk is extremely complex and in most species the milk composition changes during lactation. In order to achieve a successful hand-rearing it is necessary to optimise the formula over the whole period of lactation. Therefore as much information as possible is required about the milk composition during different stages of lactation.

Since up to date only a few data on milk composition during the whole lactation time of elephants are available we started our project in cooperation with Tierpark Hagenbeck, Hamburg, Germany. Up to now we analysed the mature milk of one Asian elephant taken during early (51-274 days post partum; every four weeks, samples taken on three consecutive days, n=24) and late (4.5 years post partum, previous calves lactation, n=3) lactation for major nutrients. The content of protein was determined according to the method of Lowry, total lipids gravimetrically, and lactose by use of a β -galactosidase/glucoseoxidase test.

Although no dramatic changes could be observed from the 2nd to the 9th month post partum our results suggest a slight increase in protein content (from 2.5 to 3.2%) and a decrease of lactose concentration (from 3.2 to 2.0%). Protein composition (SDS PAGE) and phospholipid pattern (TLC) remained unaltered within this early observation period. However, evident changes of the nutrient composition were observed in the milk of the late lactation. Protein levels in samples taken after 4.5 years were enhanced ($4.98\% \pm 0.18$) and the ratio of caseins and whey proteins was shifted to the latter. In contrast the lactose concentration was significantly lower ($0.24\% \pm 0.09$). The values obtained for the fat content were inconsistent in the samples of early (from 8.9 to 12.9%) and late (from 3.9 to 10.7%) lactation. This might be due to difficulties in milk sampling.

Since our results suggest obvious variations in the contents of at least proteins and lactose in the course of lactation, we are very interested to find out when these changes take place, whether this process is creeping or spontaneous, and whether it is accompanied by a physiological development/event. In addition we intend to get a closer look at the milk of the first two months post partum, including colostrum. Thus, our further analysis may be helpful for adjusting a formula to the requirements at different stages of lactation.

An accurate fatty acid content is regarded to be important to prevent chronic diarrhea. The unusual fatty acid composition - demonstrated for one time of lactation - may be more difficult to standardise for a milk replacer. According to this, one of our objectives is to perform a detailed analysis of the fatty acid pattern and its composition during lactation. To get more sophisticated knowledge on milk constituents we plan to extend our investigations on a larger amount of samples. Therefore we would like to increase the number of collaborating zoos. A long-term aim will be the examination of minor milk components e.g. vitamins, minerals, and hormones.

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Do captive plains zebra (*E. burchelli*) have a preference for individual grass species?

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Most herbivores have been found to be selective in their plant choices whilst grazing. The aim of this project was to give recommendations regarding the 'ideal' grass mix for paddocks used to house captive zebra. In order to do this it was necessary to perform a series of taste tests to determine whether the zebra have a preference for individual species of grass. This study also looked at whether specific nutrients had an influence on the preferences shown for individual grass species or whether other factors such as physical form had an effect.

The research took place at Dublin Zoo, Ireland, where the herd consisted of six zebra; one castrated adult male, 4 adult females and one juvenile female. Seven commercially available agricultural temperate grasses were grown in plots 1m² (Table 1). Once the grass had grown above normal grazing height (4 cm) the plots were cut and fed to the zebra on consecutive days. The reactions of the zebra to the grass was assessed and placed in an order of preference based on this assessment. Four tropical species were also assessed, with cuts taken from ornamental plantings around the zoo grounds (Table 1).

It was found that the zebra did in fact have a preference for individual grass species. The zebra consumed all the grasses offered to them and once the preference had been determined it was tested for correlation with nutrient content using Spearman's Rank correlation tests. It was found that there was a correlation between preference and Acid Detergent Fibre (ADF) ($r_s = -0.755$, $N = 11$, $p < 0.01$) and with total ash ($r_s = -0.636$, $N = 11$, $p < 0.05$).

Since it is unlikely that the tropical grasses would be used for planting in the paddock, the correlation tests were repeat for the seven agricultural species. The only correlation found was between preference and oil content ($r_s = -0.857$, $N = 7$, $p < 0.05$). Further analysis found that preference also appeared to be related to the morphology of the plant with the zebra showing a preference for stalkier varieties compared to finer mat forming species. Comparisons of the nutrient content of the preferred species with that of the common species of the African savannah, this found that the preferred species of grass was also the closest in nutrient content to the savannah grasses. As a result it was possible to make recommendations regarding the 'ideal' grass mix for paddocks housing captive plains zebra.

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Glucosamine and Chondroitin in the treatment of elephant and ungulate's Osteoarthritis

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Because of their heavy weight and the damage of articular cartilage in the older elephants, the animals often suffer from osteoarthritis. The symptom of osteoarthritis is arthrosis tumefaction. Animals become pain ridden, difficult to move, and have leg catatoria. Unusual movements often result in bone fracture and death. Glucosamine and chondroitin sulfate are substances found naturally in the body. Glucosamine is a form of mucopolysaccharide that is believed to play an important role in cartilage formation and repair. Chondroitin sulfate is part of complex protein molecule (proteoglycan) that gives cartilage elasticity.

From 1986 to 2002, Taipei zoo raised three female African elephants and one male African elephant. The animals had many records of difficulty in movements and of leg catatoria. One female was diagnosed with serious osteoarthritis in 2001 and subsequently died from complications related with a broken leg in 2002. Also an old Asian elephant with osteoarthritis died in 2002. Therefore, the elephants were excellent candidates for the medicinal use of glucosamine and chondroitin for cartilage maintenance. In 2002 we initiated the treatment of elephants with the addition of glucosamine (20mg/kg body mass for treatment, 10mg/kg body mass for health maintenance) and chondroitin sulfate in the elephant pellets, and also untied their chains at night and provided hot water to massage their legs. The animals showed no symptoms of osteoarthritis after the treatment. We have also treated other ungulates, such as a dromedary camel and horses, on a similar way.

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Comment [JMH5]: What does "very old" mean

Comment [JMH6]: Which elephant

Comment [JMH7]: Did the animal show symptoms before the treatment? If yes, how was the improvement measured?

Comment [JMH8]: What was the outcome, what was the dosage? How long was the treatment?

Comment [PE9]: I think there are no objective criteria to evaluate the effect of the treatment. Besides the other measures, i.e. unchained keeping and the physical effect of the hot showers, should also have had an important influence enforcing the healing process. Otherwise I agree with Jean-Michel.

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Poster:

Faeces consistency in captive tapirs

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The consistency of the faeces is one of the few medical parameters that is monitored in every zoo as a daily routine. Changes in faecal consistency are an early sign of digestive upset, and are often the first observation reported by animal keepers to the veterinary staff as an indication of a potential medical problem.

In captive tapirs, the assessment of faecal consistency is often prevented by the fact that these animals prefer to defecate in a water basin, which they have at their disposal in many facilities. However, we also experienced that the conception of “normal” tapir faeces differs widely between facilities. Therefore, we photographed tapir faeces from several facilities and from free-ranging lowland tapirs. Additionally, the particle size distribution in tapir faeces from captivity and from the wild was investigated by wet sieving.

With one exception, captive tapirs generally had faeces of a cow pie-consistency, with little indication of formed pieces. In contrast, faeces of free-ranging tapirs consisted of small, compact, formed balls. Only the faeces of one captive tapir, fed a very high proportion of roughage, resembled those of the free-ranging animals. These observations alone indicate that a higher proportion of concentrate (non-roughage) feeds in captive tapirs leads to softer, less formed faeces. Therefore, one would expect smaller faecal particles in captive tapirs as a reflection of the lesser proportion of roughage in their diets. In contrast, faecal particle size was generally higher in captive tapirs.

The results suggest that on the one hand, captive tapirs make little use of offered roughage (grass or lucerne hay), with the result of soft faeces. However, the roughage portion that they do ingest is masticated into larger particles than the forage they ingest in the wild. This could be an indication that the dentition of tapirs, which is different from that of other perissodactyla, is poorly suited for the mastication of hay forages and might therefore be the reason for the low acceptance of these forages observed in captive animals.

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Poster:

The effect of different nutritional regimes on the ratio of essential fatty acids in juvenile lined seahorses, (*Hippocampus erectus*), 28 days after birth.

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Essential fatty acids play an important role in the lives of many different animals. They are crucial in maintaining and improving nerve impulse transmission, appropriate immune responses and cell membrane fluidity. In juvenile fish, fatty acids are necessary in realising a normal development, specifically with regard to the visual system and intestinal system. As the pressure on wild populations of seahorses increases, public aquariums will become more involved with the captive breeding and the long term husbandry of this threatened species. To increase longevity and fecundity of seahorses it is important to improve culturing techniques and therefore increase knowledge on nutritional requirements.

In this study the nutritional value of two different feeding strategies has been assessed by analysing the uptake and ratio of essential fatty acids in juvenile seahorses. One group of juvenile lined seahorses was fed *Artemia nauplii* with nutritional enrichment

(DHA Selco) from birth till 28 days of age and one group was fed non-enriched *Artemia nauplii* (i.e. without nutritional enrichment) from birth till 28 days of age. After 28 days a fatty acid analysis was performed on both groups of seahorses as well as on the enriched and non-enriched *Artemia*. The same experiment was conducted with two groups of juvenile lined seahorses from birth till 14 days of age.

Preliminary results from a pilot study demonstrate a positive correlation between age and unsaturated fatty acids, particularly EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), both required specifically by marine species.

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Poster:

Food consumption and weight development in captive Malayan sun bears (*Helarctos malayanus*) – preliminary results

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The diet of wild Malayan sun bears consists mainly of insects and fruits high in fibre content. Mast periods with high abundance of energy rich easily digestible fruits are brief and unpredictable. It can be assumed that these features shaped the feeding and nutrition strategy of the species towards maximising energy intake at any time. This is consistent with the fact that sun bears in captivity do not display endogenously controlled seasonal cycles of feeding and fasting like other ursid species. Captive sun bears tend to be permanently obese. This is most likely a result of the lower activity performed by captive individuals and the difference in nutritional composition of zoo diets. The main source of energy for wild sun bears are tropical fruits, which contain a much higher amount of fibre and less soluble carbohydrates than the domestic fruits regularly fed in zoos. The body mass of wild bears varies between 27-65 kg, whereas captive animals range from 50 to 123 kg in bodyweight with the majority above 65 kg. The data are in general taken opportunistically without reference to food composition and consumption. This presentation deals with the effect of food and nutrient intake on the body mass of sun bears.

In the course of a study on digestive strategies with respect to fibre content, the food consumption was measured in four adult female sun bears at Cologne Zoo. The intake of main meals was recorded by weighing the offered food and the leftovers individually. The intake of scatter feed items was estimated for each individual. The animals were weighed regularly over a period of ten months, during which the fibre content of the diet was varied systematically. The data include a four weeks “mast period” mimicking the natural situation with respect to sugar and fibre content of the diet.

The weight development varied individually, which indicates different maintenance requirements. In the running study on the effect of crude fibre on digestion parameters, food consumption, and nutrient intake, the results will be discussed with respect to energy intake, individual activity levels and feeding habits. The findings highlight the relevance of individual demands of captive animals, which have to be considered with respect to body mass maintenance and health care.

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