Zoo Nutrition News

September 2003

Photo: Peter van der Groten / Antwerp Zoo

Contents

SPECIAL ISSUE 3

Third European Zoo Nutrition Meeting

From the Organising Committee

Dear member,
The third European Zoo Nutrition Conference has this time been held in Antwerp Zoo from 21 to 25 of August 2002. The European Zoo Nutrition Group (EZNRG) took the initiative of organising this conference in cooperation with other groups focused on animal nutrition. Many thanks are offered to Prof. Geert Janssens, from the Laboratory of Animal Nutrition of the Gent University in Belgium, for the secretarial work of this conference. Also many thanks to Antwerp Zoo and especially to Dr. Kristin Leus, who hosted the conference and made this conference successful.

The following groups participated in the conference (in alphabetical order):

AAVN:	American Academy of Veterinary Nutrition	ECVCN:	European College of Veterinary and Comparative Nutrition
ACVN:	American College of Veterinary Nutrition	ESVCN:	European Society of Veterinary and Comparative Nutrition
CNS:	Comparative Nutrition Society	EZNRG:	European Zoo Nutrition Research Group

As a result, this Joint Nutrition Conference (JNS) has been organised as a unique opportunity for nutrition researchers from very different points of view to meet together. The symposium included joint sessions, enabling discussions on various innovative strategies in veterinary and comparative nutrition, and enhanced links between fundamental aspects of nutrition and their application in practice. The programme of this conference can be found on pages 21-24.
Particularly for European zoo nutrition specialists it was a good opportunity to discuss zoo animal nutrition with American colleagues and nutrition specialists from European veterinary universities. More than 160 conference participants from all over the world pronounced this meeting successful. Many contacts have been made to improve zoo animal nutrition in the future.

By the diversity of groups involved in this conference, the programme showed a wide range of the nutrition subjects.
An overview of the presented talks and posters can be found on page 21-24.

The abstracts of the conference can be found on the website of the European Zoo Nutrition Centre (EZNC): www.EZNC.org.
The proceedings of the CNS part of the conference can be ordered via the CNS website: www.cnsweb.org and also the Journal of Animal Physiology and Animal Nutrition will dedicate a special issue in 2003 on the JNS conference.

EZNRG publishes this EAZA News Special issue on Zoo Nutrition 3 and the Zoo Animal Nutrition Book no.3 to mark this conference. More information on this book, which will be published in the second half of 2003 and can be found on page 15.

In this EAZA News Special issue on Zoo Nutrition 3, 11 articles presented at the conference can be found. In these articles, ideas and opinions are presented which can be useful in optimising zoo diets. This special issue is distributed among all conference participants and all EAZA members. Similar to the EAZA News Special Issues on Zoo Nutrition no.1 and 2, this issue can be downloaded as a PDF file from www.EZNC.org.

The JNS conference showed that sincere interest in European zoo nutrition is increasing. Universities, food manufacturers and nutrition specialists in zoos are cooperating more and more in order to understand the nutrition mechanism in zoo animals that will lead to improved diets. For example, the EAZA Research Committee recognizes this and is therefore supporting the European Zoo Nutrition Research Group actively.
In March 2003, a meeting has been held between the core group members of EZNRG, TAG, EEP and ESB nutrition advisors and other individuals interested in zoo animal nutrition in Safari Beekse Bergen in the Netherlands. As a result of this meeting the EAZA Nutrition Group (ENG) will be set up. Detailed information can be found on page 43.
The positive results of the JNS conference and the initiatives taken in Europe have stimulated the organising committee of the JNS conference to announce the Fourth European Zoo Nutrition Conference, to be held from 21 to 23 January 2005 in Leipzig (for more information see page 17).

Many thanks go to the staff of the EAZA Executive Office for their assistance and to Helena Marquès, Antonio Vidigal, Kristina Johanson, Mauvis Gore and Jenny van Leeuwen for their editorial work of this EAZA News Special issue on Zoo Nutrition 3.
It would not have been possible to produce this newsletter without the assistance of our sponsors. We extend our special thanks to Mazuri, Arie Blok Diervoeding, Filander Verlag, Witte Molen, PetAg, Versele-Laga, Lundi, Salvana and Chevideco.

Joeke Nijboer,
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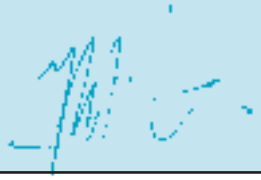
Chair of EZNRG
Staff member EZNC



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COLOPHON

EAZA News is the quarterly magazine of the European Association of Zoos and Aquaria (EAZA)

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Considerations on feed used for zoo ruminants

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M. Hovenjürgen and E. Niess, University of Bonn, Germany;
K. Johansen, Zoo Ebeltoft, Denmark and J. Nijboer, Rotterdam Zoo, The Netherlands; W. Zimmermann, Cologne Zoo, Germany

The provision of the right amount of energy is one of the basic problems when formulating a diet for wild animals. While the negative effect of an inadequate supply of energy is obvious, excessive energy intake may lead to negative consequences such as obesity, reduced or enhanced reproduction and disturbances of normal fermentation in herbivores.
To estimate the energy of feed that is actually available to ruminants is a rather difficult task. The 'standard' metabolizable energy for ruminants in feed composition tables may give a reasonable orientation for many, especially the larger, species. But the more a species differs in the passage rate of digesta through its digestive tract from domestic species, the more the actual ME content for this species is expected to differ from the ME content given in feed composition tables found in agricultural literature. The main time-dependent factors limiting the degree of degradation (the passage and fermentation rates of feeds), modulate the expected energy yield of feed high in carbohydrates.
Information on the degradation of feed over time may also be important from a dietary point of view: Two feeds may offer a comparable amount of energy to the animal after a certain time, but still be different in the rate of energy release during this time. The latter should not be too high, since too fast development of the products of fermentation (short chain fatty acids) may cause a drastic drop in rumen pH.

Material and methods

During a study on okapi (*Okapi johnstoni*) nutrition in three zoos (Cologne, Copenhagen, Rotterdam), different feed with regard to their degradability (maximum degradation of each feed item) and their rate of fermentation (percentage of the feedstuff fermented per hour), were characterised. Among them were produce (like the commonly fed apples), high energy feed/ concentrates (grains, beet pulp), zoo pellets (pelleted feeds mainly based on grains and manufactured protein-rich residues of oil manufacture) and alfalfa hay.
The Hohenheim gas production test (HFT or Hohenheimer Futterwerttest) was used as an *in vitro* fermentation system (Menke *et al.* 1979). This method is commonly used for feed energy evaluation in Germany. In this system, the fermentation is quantified by the amount of gas produced during degradation of feed samples after inoculation with rumen liquor from sheep. Gas production is highly correlated with the production of fatty acids in the fermentation chamber. The complete gas production after 24 hours is routinely recorded. Additionally, to estimate the rate of fermentation of a feed, we recorded gas production after 2, 4, 6, 8, 10 and 12 hours. By using standard equations from agricultural literature, it is possible to estimate ME of each feed using the 24 hour gas production and its nutrient composition. We used sheep rumen liquor as a basis and we focused on differences between feed, not between animals. Therefore it was very important to have a standardized inoculum source. Although faeces could be an interesting and easy source of inocula, considerable methodological challenges still need to be solved to achieve valid results based on this source. However, this may be interesting in the future, especially for inter-species comparisons.

Results

Produce (farmed fruits and vegetables) is suggested to be very fast-fermenting due to its high sugar content (Oftedal *et al.*, 1996). Its nutrient composition is completely different from leafy material and even from wild fruits. This holds especially true for commercial fruits like apple or banana. In the study trials, fermentation of fruits and vegetables was generally very fast and yielded high ME contents, even when compared to an average zoo pellet (see Figure 1; Table 1). Gas production for apple during the first time interval was 2-3 times higher than for other feed (see Figure 2). A fast fermentation immediately after a meal might provoke digestive disorders since the animal may not be able to keep rumen pH relatively stable due to fast production of high amounts of short chain fatty acids.

Figure 1: Cumulative gas production of different types of feeds.

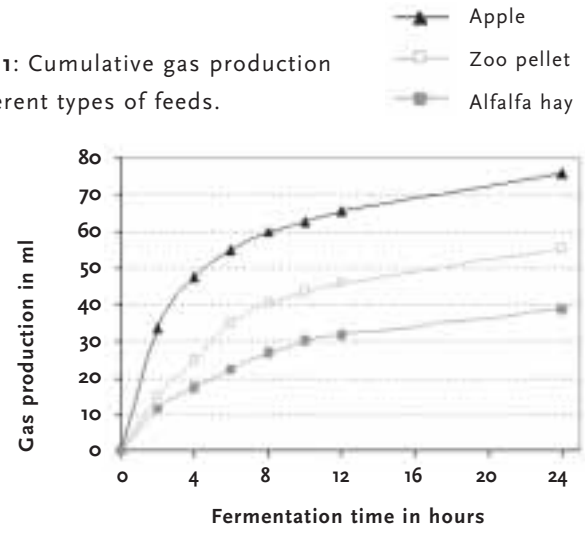


Photo: Rod Doolaard/IZP

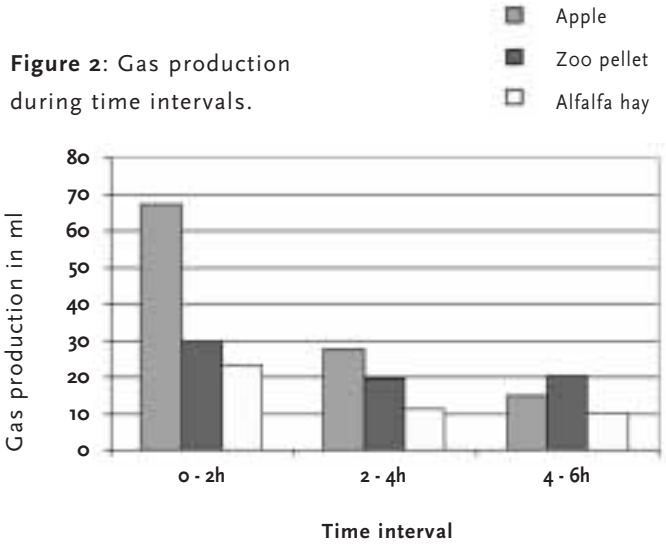
	Apple	Zoo pellet	Alfalfa hay	Onmolassed beet pulp	Rolled oats	Oats
ME, Mj/kg DM	13,2	11,8	9,2	12,5	14,3	12,0

Table 1: Approximate metabolizable energy (ME) contents of some feed calculated according to agricultural standards (DM = dry matter).

One has to keep in mind that the freeze-dried and milled samples we used may behave slightly different from the fresh produce pieces actually fed. However, it is unlikely that this changed the general fermentation pattern of these feeds. Based on our data, the use of large amounts of produce in the diets of ruminants cannot be recommended. This holds especially true for fruits.

As expected, unmolassed beet pulp (sugar content about 7% of DM (Dry Matter)) resulted in high gas production, comparable to that of rolled oats. Due to its lower fat content, its calculated ME was lower than that of rolled oats, but higher than that of oats and of the tested zoo pellets (see Table 1).

Figure 2: Gas production during time intervals.



Beet pulp is known for its high pectin level, which has a stabilising effect on rumen fermentation (Drochner *et al.*, 1988; Van Soest *et al.*, 1991). It has the potential of substituting sugar-or starch-rich concentrates in ruminant diets (Van Soest, 1987). It is recommended to soak dried beet pulp in water for several hours before feeding, in order to prevent risk of obstruction of the oesophagus, which is occasionally reported for horses with uncontrolled access to this feedstuff.

The calculated ME for alfalfa hays ranged widely from 7.3 – 9.9 MJ/kg DM (dry matter), but in each zoo at least one hay with an ME of 8.4 MJ/kg DM was fed.

Discussion

It can still be a challenge to formulate suitable diets that meet the energy demands and simultaneously generate a fermentation pattern in the rumen for some ruminant species in zoos, and that does not overcharge the species capability to keep the pH and the whole rumen environment stable. One way to scientifically increase the knowledge in this field may be to determine the fermentation rate and the absolute degradability of feed as well as the passage rate of digesta for the critical ruminant species. By combining these parameters, one may be able to estimate the energy available for each feedstuff and each species.

Although it may be obvious, we want to state here that this kind of data must not lead to a selection towards fast fermenting/high energy yielding feed by maximising energy density of a diet to unnaturally high levels. In order to feed wild animals properly, physiological as well as ethological adaptations of feeding and foraging have to be taken into account. Consequently planning a proper diet should aim at meeting the energy requirements, and at stimulating natural activity levels. This means that within a hypothetical range of diets, which all allow a species to meet its energy requirements, the one with a rather low energy density should always be chosen.

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Browse silage: the future for browsers in wintertime?

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Hoffman (1972) made the classic differentiation of ruminants between browser ('concentrate selectors'), intermediate feeders and grazers. The group browsers is a heterogeneous group, consisting of fruit eating animals with a high degree of herbaceous dicotyledones in their diet and tree shrub leaf eating animals. Several diseases in browsing ruminants are linked to an inadequate nutrition (Clauss et al.*, 2003). Examples of browsing ruminants are given in Table 1.*

Bongo	Greater kudu	Tufted deer
Bushbuck	Lesser kudu	White-tailed deer
Chinese water deer	Mule deer	
Dikdik	Moose	
Duikers	Okapi	
Gerenuk	Roe deer	
Giraffe	Suni	

Table 1: Overview of browsing ruminants (adapted from Hofmann 1988, 1991)

Differences between browsers and grazers

The diet and digestion of browsers are different compared to grazers (reviewed with detailed references in Clauss *et al.*, 2003):

- Browse can contain a high amount of secondary plant compounds;
- Average browse has a different nutrient composition to grass, particularly with respect to the fibre composition;
- Grazers have a rumen stratification; browsers do not when properly fed (see Figure 1);
- In browsers, the rumen passage rate is faster than in grazers and they have less selective particle retention in the rumen;
- Browsers have less fibre digestion and more nutrients reach the small intestines unfermented;
- Particles leaving the rumen of browsers are of a bigger size than those leaving the rumen of a grazer.

Browse feeding in zoos

When browsers are maintained in zoos, it is a huge task to supply them with enough browse. As well as problems with harvesting and logistics, the most important question is whether enough browse can be obtained during the whole year. In tropical areas, there should be enough browse to feed all the year around. But in temperate areas, especially in the late autumn, during wintertime, and the beginning of spring, it is difficult to provide enough fresh browse. Ways should be found to supply an adequate amount of browse.

Browse can be conserved in three ways:

– FREEZING

The leaves and twigs have to be deep-frozen fast. In order to prevent freeze-drying and oxidation of the product, the best way is to pack the browse airtight. The temperature of the freezer should be at least min 15°C centigrade. For many animals, the defrosted browse is not palatable. Also, the freezing and storing process costs a lot of money.

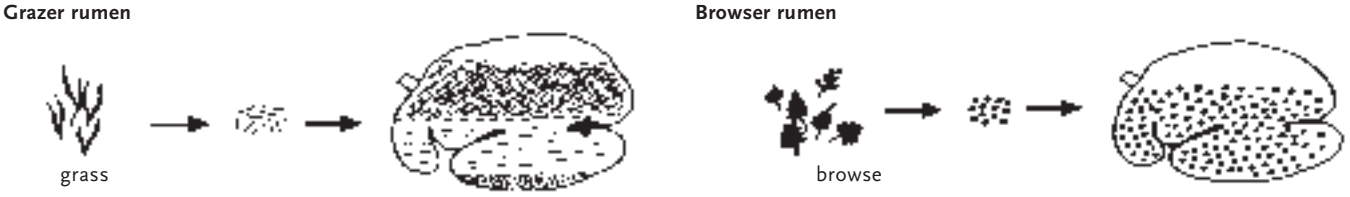
– DRYING

Natural drying of browse depends on the weather. However, drying should be fast, in order to prevent the development of mould and fungi. Artificial drying is preferred; the result is a more palatable product. Dried browse leaves can be bought from several companies, although it is expensive. Dried browse should not be exposed to sunlight. Contamination with pests like rats, mice and birds while storing should be prevented. The palatability of the product will decline after drying.

– SILAGE

Silage is the term used when forage with a high moisture content is preserved by fermentation. The main principle of preservation as silage is the rapid establishment of a low pH by lactic acid fermentation, and the maintenance of anaerobic conditions. After six to eight weeks, the product has reached a pH of about 4.2, after which the process stops. When the pH is higher, butyric acid is produced, which can easily be smelled. When the product is too dry, fungi can develop. The dry matter of the original product should be about 40-45% (Driehuis, 2000).

Figure 1: Simplified comparison between rumen content stratification in grazers and browsers (adapted from Clauss *et al.*, 2003).



Browse silage

The ensiling process can be divided into four phases (Driehuis, 2000):

– AEROBIC PHASE

During this period, the atmospheric oxygen is trapped in the ensiled mass, and readily reduced due to the respiratory activity of plant material and aerobic or facultative aerobic bacteria.

– FERMENTATION OR ACIDIFICATION PHASE

During this phase, different groups of micro-organisms, capable of anaerobic growth, like lactic acid bacteria, enterobacteria, clostridia and yeast compete for available nutrients. In well-preserved silage, lactic acid bacteria will rapidly dominate the fermentation process, and will result in a decrease in pH due to the accumulation of lactic acid, and to a lesser extent of acetic acid formed from sugars, mainly glucose, fructose and sucrose.

– STORAGE PHASE

This phase usually lasts from several weeks to a year, or longer. As long as the pH is sufficiently low and penetration of air into the silage is excluded, relatively little change occurs during this phase. In this phase, bacteria like bacilli and clostridia can survive as spores. Other bacteria, such as *Lactobacillus buchneri*, continue to be active at a low level. During the fermentation and storage periods, a part of the protein fraction is degraded to peptides, amino acids, amines and ammonia by enzymes of plant and microbial origin.

– AEROBIC DETERIORATION

When fed, the silage is exposed to air. Exposure to air also can occur by damaging the silage wrappping. Micro-organism like yeasts and acetic acid bacteria then oxidize the preservative acid present in silage. As this process proceeds, the pH rises and other aerobic micro-organisms start to proliferate. In the majority of silages, lactic acid bacteria grow best between 20 and 40°C, with an optimum at 30°C. In order to prevent growth of unwanted bacteria, the pH should rapidly decrease, and all oxygen should be excluded. Fermentation-controlling additives can be added to improve the fermentation process. If the conditions of the silage are not well, undesirable micro-organism can grow, for example *Listeria*, *Bacilli* and *Clostridium* species as well as several species of yeast, moults and *Enterobactericeae* (*E.coli O157*).

Zurich method

Hatt and Clauss (2001) described in EAZA News Special Issue on Zoo Nutrition II how silage is made at Zurich zoo. Leaves and twigs of willow, hazel and maple are processed in a chaff cutter and then stored under pressure in 200 litter plastic containers, air-tightened and stored at a temperature not above 20°C. After six months, it is fed to their black rhinos. These authors also analysed the browse before and after the silaging process. The analyses did not show a significant alteration in composition before and after silaging.

Rotterdam method

In the autumn of 2001, Rotterdam Zoo started harvesting willow browse. The cut willow branches were about 1 meter long, and the diameter of the branches were 1 to 2 cm. The willow branches were bailed through a bailing machine, under similar pressure as hay being bailed. The bales were double wrapped in plastic and the dimensions were 100 x 50 x 35 cm, and weighted between 45 and 50 kg. Due to the pressure of the bailing machine and the plastic wrapping machine, most air was excluded from the willow bales. Every bale had to be checked to ensure no branches pierced the plastic wrap. All holes were repaired using plastic tape. During the first few weeks, the remaining oxygen produced inside the bales caused anaerobic growth. At this time, the bales appeared swollen. When the oxygen level in the bales subsequently declined, anaerobic bacteria started growing and consumed the gas. After six to eight weeks, the process ceased and as so much of the gas had been consumed, the willow in the bales was in a vacuum. Because there is a surplus of willow in the area of Rotterdam, mainly willow (*Salix alba*) was processed, although some poplar (*Populus canadensis*) browse was silaged as well. A total of 70 willow bales and 15 poplar bales were prepared. The silage was fed to the browsers in Rotterdam during winter. Each browser received 0.5 kg a day. The palatability of the fed silage browse was compared to frozen browse. All browsers – okapis, giraffes, kudus, tufted deer and bongos – showed a preference for the browse silage and the palatability (J. Nijboer: pers. obs.) was much better than the frozen browse. Even the branches were eaten! There is a great potential in feeding silage browse to browsers and probably also to intermediate feeders. However, more research is needed. The European Zoo Nutrition Centre and Rotterdam Zoo will perform a detailed study on this subject in the coming years.

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Dietary sugar in okapis

The effect of dietary sugar content on glucosuria in a female okapi

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*Blood glucose values have been described for all domestic animal species and many species of wild mammals. Urinary threshold values, however, are rarely recorded for domestic animals and even less so in wild animals like okapi (*Okapi johnstoni*). With the help of their microbial ruminal flora, ruminants maintain blood glucose levels much lower than monogastric animals and there are very few reports of spontaneous glucosuria in adult ruminants (Bickhardt, 1994; Lutz* et al.*, 1994; Bickhardt* et al.*, 1995; Deinhofer, 1996; Taniyama* et al.*, 1999). Glatston and Smith reported in 1980 that urine of many healthy adult okapis could contain high amounts of glucose. One of the adult males in Antwerp was chronically losing weight in spite of a good appetite but with signs of polydipsia and polyuria and localized skin necrosis. As a result, routine urine analysis was carried out and high amounts of glucose were found. Hereafter, urine analyses of all healthy okapis in Antwerp were carried out on a regular basis, and a preliminary trial was set up to decrease glucosuria in an adult female by lowering the sugar content of the diet.*

Materials and methods

In Antwerp Zoo, 11 okapis of different gender and age were sampled and urinary glucose semi-quantitatively determined with Benedict reagent (copper sulphate reduction test) or Multistix strips (glucose-oxidase-peroxidase reaction). In order to examine the role of the diet on the glucosuria, a diet with reduced sugar content was administered during 170 days to an adult female okapi. The diet at the start and the end of the 170 days is shown in Table 1. During the first 90 days, the initial daily ration consisting of 2.4 kg of bananas, apples and carrots (800 g each) was gradually changed to 0.4 kg carrots and maximum 0.5 kg other vegetables (endives, celery, chicory, tomato, courgette, cucumber and aubergine) and the daily consumption of lucerne hay increased by 0.15 kg on average (see Table 1). Once a month at normal micturition, midstream urine samples were taken and stored at -20°C. The five samples were analysed simultaneously. Urinary glucose (mg/dl) and creatinine (mg/dl) were quantitatively determined using dry biochemistry (Kodak - Johnson & Johnson).

Results and discussion

According to ISIS (International Species Information System – Year 2000), blood glucose values of captive okapis are higher [i.e. in adult males 139 +/- 49 mg/dl (n = 64), in adult females 121 +/- 43 mg/dl (n = 63)] than the values in domestic ruminant (i.e. in cows 57 +/- 7 mg/dl, in sheep 68 +/- 6 mg/dl, in goats 63 +/- 7 mg/dl). The values observed in the okapis in Antwerp Zoo [adult males 141 – 205 mg/dl (n = 4), and adult females 71 – 89 mg/dl (n = 3)] correspond with the ISIS values. Unfortunately, okapis are not sufficiently docile, allowing for determination of glucose tolerance curves and renal thresholds. Concerning urinary glucose, five adults of at least eight years old and one three-year old animal showed glucosuria, whereas five other young animals (between 1.5 and 4 years of age) remained negative. To exclude an institutional reason for this phenomenon, tests (Benedict reagent and/or Multistix strips) were carried out in London Zoo and Marwell where only three out of eight animals were negative.

Photo: Rod Doolaard/IZP

Glucosuria in apparently healthy ruminants remains unexplained yet. A genetic cause is unlikely as inbreeding is very low to absent in okapis with (n = 11) or without (n = 8) glucosuria (inbreeding coefficients ranging from 0.0000 - 0.0469 and from 0.0000 - 0.0704 respectively). Theoretically, a continuous high dietary intake of sugars might be the cause, provided that a ruminal bypass through the reflex of the sulcus ventriculi and/or ruminal escape in a smaller rumen with a lower retention time exists, as suggested for the roe deer (Rowell-Schäfer, 1999). In the wild, okapis browse on more than a hundred species of plants and prefer fast growing heliophilics (Hart *et al.*, 1988). In Epulu station (Central Africa), okapis are given leaves of 35 different

Dietary sugar in okapis

	Start (kg)	End (kg)
Banana	0.8	0
Apple	0.8	0
Carrot	0.8	0.4
Lucerne	4.58	4.72
Endive, celery, chicory, tomato, courgette, cucumber, aubergine	0	0.5
Pellet	0.6	0.6
Total Dry Matter	5.0	4.8
Carbohydrates (proximate analysis)	2.332	2.115

Photo: Rod Doolaard/IZP

Table 1: Changes in diet for an adult female okapi with glucosuria

species *ad libitum* and are not given any fruit, vegetables, grass, hay or pellet. All adult animals (nine older than 8 years and two between 7 and 7.5 years old) are tested without glucosuria (Rosmarie Ruf, *pers. comm.*).

In captivity, okapis are fed various fruits and vegetables (mainly bananas, apples and carrots) containing high amounts of sugars. Table 1 shows the changing diet analysis of the adult female in Antwerp Zoo. The decrease in dietary sugars amounted to approximately 0.2 kg. This was mainly due to a lower (i.e. 3.76%) dry matter intake in the second diet, although the sugar content on a dry matter base of the two diets was almost the same. To compensate for the variations in volume of the excreted urine, the ratios of glucose and creatinine in each sample were calculated (Finco, 1989; Spieker, 1989). These ratios were 13.56, 9.95, 7.21 and 6.32 after 1, 2, 3 and 5.5 months, respectively. Just before the end of the observation period, the animal had to be anaesthetized for hoof trimming and urine was obtained afterwards with a ratio of 8.88. Since hyperglycemia is one of the known side-effects of an a2-agonist (Lees, 1991), this ratio of 8.88 was probably due to the administration of medetomidine. The okapis in Epulu station are fed a natural diet of only leaves and remained without urinary glucose whereas many okapis in European zoos that are fed a sugar rich diet develop glucosuria. It would be very interesting to compare data of urine samples from okapis in American zoos, which are reported to being fed less fruit and vegetables than okapis in Europe (Crissey *et al.*, 2000; Lintzenich *et al.*, 2000; AZA Nutrition Advisory Group, 2001).

Conclusion

These preliminary results seem to indicate an impact of decreasing dietary sugars on glucosuria. However, more data on captive okapis are needed. A survey for glucosuria is currently being carried out in the Okapi SSP in the USA and the results may help us to interpret the high amounts of glucose in the urine of okapis in Europe and the relation with different feeding regimens.

Acknowledgements

The authors thank Kristin Leus and Bruno Van Puijenbroeck (Okapi international studbook, Royal Zoological Society of Antwerp) for calculating the inbreeding coefficients and Rosmarie Ruf for sampling the semi-wild okapis in Epulu station.

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Crib-biting in foals is associated with gastric ulceration and mucosal inflammation

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The functional significance of crib-biting

Crib-biting is a stereotypic behaviour performed by approximately 5% of captive domestic horses. It involves the horse grasping a fixed object with its incisor teeth, contracting the neck muscles and drawing air into the cranial oesophagus. This movement is usually accompanied by an audible grunt. Risk factors for crib-biting, identified in recent epidemiological studies, include feeding high concentrate and/or low forage diets (Waters *et al.*, 2002), but the direct cause(s) of crib-biting has not yet been identified .

Behaviours that involve the mouth, such as crib-biting, seem particularly sensitive to diet and technique of feeding. Such behaviour often arises soon after weaning when youngsters still have the motivation to suckle, but have no means of doing so and may start to redirect oral and ingestive activities towards other youngsters or fixed objects in their environment. Around this time, concentrate rations are also frequently increased and this can cause problems because a foal's digestive tract is adapted to cope with a diet of milk and grass. Foals these days often receive concentrate feeds high in starch and sugar content from early in life or in preparation for weaning, sometimes in considerable amounts. Such rations can cause increased acidity in the gastro-intestinal tract; this may lead to inflammation and ulceration of the gut mucosa in the young horse.

A hypothesis was proposed by Nicol (1998), relating crib-biting to saliva production. Horses need to grasp or bite food (or other objects) in order to produce saliva. Horses with high levels of gastric/hindgut acidity may need to produce extra saliva to act as a buffer and aid normal digestion. The results of a recent study by Waters *et al.* (2002) revealed that foals that received high concentrate rations early in life were at four times greater risk of developing crib-biting than those that did not (Relative risk (RR) = 4.12, p = 0.02). In the same study, the feeding of hay substitutes, such as silage or haylage, instead of grass or hay, also increased the risk of developing oral behaviour problems, particularly wood-chewing (RR = 2.72, p = 0.004).

A young horse crib-biting

Oral stereotypies may, therefore, be a response to a disturbance of the normal digestive process. High concentrate rations early in life can have marked effects on the gastro-intestinal tract which may lead to clinical/behavioural problems in young horses. Dietary and management changes may be effective ways of treating crib-biting (and its underlying causes) in foals.

Aims and key findings of the crib-biting study

The aim of this study was to determine whether there was an association between crib-biting and stomach condition in foals; via investigation of the health of the stomach lining of crib-biting and normal foals using videoendoscopy; investigation of the relationship between stomach condition and frequency/duration of crib-biting; and trialling of diet-based treatments to improve the health of the stomach lining and see if their effects have an impact on crib-biting behaviour.

Crib-biting

Foals that had recently started to crib-bite were recruited into the study and compared with non-stereotypic foals. The stomachs of all foals were endoscoped at the start and end of their time in the trial. Valid endoscopy results were obtained for 24 out of the 35 foals that entered the study (15 crib-biting and nine normal). Frequency and duration of crib-biting by foals were measured at the start of the trial and every four weeks during the trial. Management was standardised and diet controlled throughout the trial for normal and crib-biting foals.

Crib-biting and control foals were randomly allocated to a base or antacid diet (active ingredients: dihydro-aluminium sodium carbonate and aluminium phosphate) for a three month period. Owners were advised how much of each diet to feed their foal and visited every three to four weeks to check if foals were healthy, eating normally and to monitor their behaviour. Behaviour was monitored by direct observation throughout the experimental period, and foals re-endoscoped at the end. Indices of stomach condition were described and scored by a trained observer who examined videotapes 'blind'.

Videoendoscopy revealed that crib-biting foals had significantly more inflamed, dry and ulcerated stomachs than normal foals on first examination (Mann-Whitney: $U = 36$; $N1 = 15$; $N2 = 9$; $p < 0.05$).
Their stomachs also lacked normal folding on first examination, and were significantly smoother when reexamined ($U = 11.5$; $N1 = 12$; $N2 = 7$; $p < 0.01$). Foals that received the antacid diet had fewer ulcers at the end of the trial ($U = 27.5$; $N1 = 13$; $N2 = 9$) and a reduction in crib-biting correlated with reduction in ulceration ($r = 58$; $N = 12$; $p = 0.05$).

These findings suggest that the stomachs of crib-biting foals were exposed to more acid conditions or were more sensitive to normal acidity levels than the stomachs of normal foals. The results of this study, therefore, support the hypothesis that the initiation of oral stereotypy can be a response to disturbance of the normal digestive process; and also demonstrate that dietary and management changes may be effective ways of treating crib-biting (and its underlying causes) in its early stages of development in foals.

Can we prevent crib-biting arising in the first place?
Work on other animal species suggests that if a stereotypic behaviour is identified and treated quickly enough it may be possible to reverse the developmental processes. Our recent research studies have aimed to identify key factors in the management and feeding of young horses that are associated with the very first signs of oral stereotypies, that most frequently emerge within two months of artificial weaning (see Table 1). Traditional weaning methods are usually total and abrupt, involving sudden and permanent separation of the mare and foal, radical changes in diet, and new techniques of management.

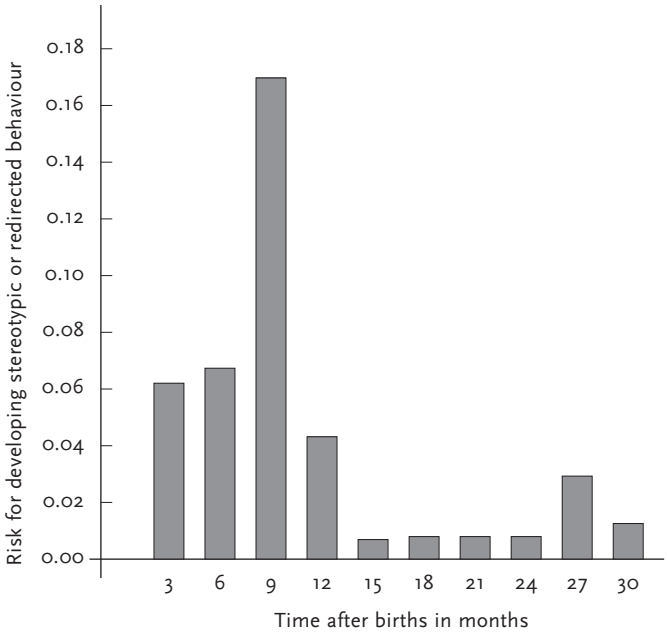

Table 1: The risk of developing stereotypic behaviour in young horses at different ages (Waters *et al.*, 2002).

The results of our studies show that careful management at this early stage in the horse's life is critical to avoid changes in behaviour and digestive physiology. Gradual weaning regimes and high fibre creep diets may help by reducing the severity of change from pre-weaning to post-weaning conditions and lead to a decline in the frequency or severity of crib-biting in foals which have started to develop this problem.

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Nutritional Databank overview

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Currently nutritional challenges remain for captive species and usually no indications of nutritional status exist. Even when nutritional status is assessed, limited information is available with which to compare to determine if an animal or nutrient is within normal ranges. Determinations of circulating levels of lipids (total cholesterol, HDL-cholesterol, measured LDL-cholesterol, and triacylglycerides), vitamin D metabolites, vitamins A and E, carotenoids and minerals can provide a base for examining the nutritional status of animals. As free-ranging populations and resources become more fragmented, assessment of nutritional status in healthy populations will serve as a baseline from which to compare animal populations with unknown or poor health. The purpose of the Brookfield Zoo databank is to examine the above listed nutritional measurements in numerous species to establish normal values for captive exotics.

The databank contains data for 8 canid species (n = 45), 17 felid species (n = 83), 25 primate species (n = 235), 4 ursid species (n = 22) and 22 miscellaneous grouped species (n = 62) which were housed at Brookfield Zoo, Fort Worth Zoo, Lincoln Park Zoological Gardens, and North Carolina Zoological Park. These measurements are unique because they are derived from animals with known diets that were demeaned to be healthy by the veterinary and zoological staff at each representative institution. In addition, the animals represent a comparatively large number of individuals from five different groups of species.

Diet evaluation and blood analyses

– DIET EVALUATION

Diet information was gathered by survey and analyzed for nutrients using the Animal Nutritionist programme (n - Squared Computing). Dietary items were categorized into food groups primarily based on the items consumed by these species in captivity. Computer analyses of dietary nutrients were compared among species and nutrient guidelines were estimated using AAFCO, 2001 and NRC, 1974, 1978, 1985, & 1986. Based on nutrient composition and comparison to estimated requirements, the diets for most species met or exceeded the probable requirements for fat, protein, and vitamins D, A, and E.

– BLOOD COLLECTION

All animals were housed normally and fed their usual diets.

Photo: Rod Doolaard/IZP

Animals were fasted overnight before immobilization, and veterinarians drew blood into tubes without anticoagulants. The protocol was performed in accordance with the Brookfield Zoo Animal Care and Use Committee. Serum was separated by centrifuging, wrapped for UV protection, labeled, and frozen for an average of six months at -80°C until thawed for analysis.

– BLOOD ANALYSES

Cholesterol concentrations were analyzed at the Brookfield Zoo using an Eastman Kodak Clinical Diagnostics Analyzer. Triacylglycerides and HDL-cholesterol concentrations were measured at Loyola University Medical Center (Maywood, USA) using the Synchron Delta CX7 Analyzer. LDL-cholesterol was calculated based on a modification of the Friedewald formula using cholesterol minus HDL-cholesterol and triacylglycerides/6.25 (representing VLDL) (Friedewald, 1972). Samples were assayed for the vitamin D metabolites 25(OH)D and 1,25(OH)2D at the Children's Memorial Hospital (Chicago, IL), following methods outlined by Reed *et al.*, 1993. Aliquots of thawed serum were analyzed for vitamin A (retinol, retinyl stearate, and retinyl palmitate), vitamin E (a- and g-tocopherol) and carotenoids (a- and b-carotene, lutein/zeaxanthin, lycopene, and b-cryptoxanthin) by HPLC at the University of Illinois, Chicago. Statistical analyses were performed using the SPSS for Windows.

Results and discussion

The nutritional databank project is ongoing. Additionally, several publications have resulted from this work and results can be examined (Crissey *et al.*, 1999a, 1999b, 2000a, 2000b, 2001; Slifka, 2000). A detailed presentation of these results is beyond the scope of this paper. However, several species-specific anomalies in the blood parameters

are evident. It is important to examine these data to determine their potential impact on zoo nutrition and ultimately animal conservation.

Some of the irregularities include:

1) Spectacled bears had the greatest total cholesterol (369 mg/dl (n = 7)) and triacylglyceride (1079 mg/dl (n = 7) levels of all species measured.
2) Compared to other canids, the maned wolves and the African wild dogs had the greatest cholesterol (268 mg/dl (n = 9) and 261 (n = 5), respectively) while the maned wolves possessed the greatest HDL-cholesterol (209 mg/dl (n = 5)) levels.
3) Sand cats had substantially greater retinyl palmitate (3149 nmol/L) and retinyl stearate (4882 nmol/L) than all other feline species measured.
4) Cholesterol and LDL-cholesterol were highest in gorillas (247 mg/dl n = 33 & 144 mg/dl n = 32, respectively) and second highest in spider monkeys (195 mg/dl n = 13 & 137 mg/dl n = 12, respectively).
5) Vitamin D deficiencies in certain primate species despite adequate levels in their diets.

Photo: Martin van Wees

Examining the nutritional status of captive animals is important, however there are not always data on their free-ranging counterparts for comparison. Nutritional data obtained from captive howler monkeys (*Alouatta palliata*) and bottle-nosed dolphins (*Tursiops truncatus*) are different compared to those of their free-ranging counterparts and similar species (Crissey, unpublished results, Crissey, 1999c). Thus it is important to note that some inferences made on nutritional status of captive animals may not apply to free-ranging animals. Further, captive diets vary between zoos and may not be appropriate, hence influencing the results of the blood samples.

In summary, the nutritional databank provides a unique collection of information on circulating blood values in a large number of captive animals. These data provide a baseline to understanding the health and nutritional needs of captive animals. With the aid of future cooperative research studies in this area, the conservation of both free-ranging and captive species may advance.

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Global wildlife nutrition database: Howler monkey prototype

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The development of a global wildlife nutrition database has been initiated in response to the absence of information easily and quickly available on the internet. This would allow solutions to the resolution of questions and problems of a nutritional nature relative to populations of wild animals, either in captivity or in nature.

This model represents a first step for the fulfilment of the proposal contained in the CBSG Wildlife Nutrition Database Report (Boardman *et al.*, 2001) where the concept was defined: 'to develop the infrastructure of an internet-accessible database of nutritional information to fill some of these current data gaps, providing a global network for contributors as well as end-users, administered through the Conservation Breeding Specialist Group of the IUCN.'

This specific project was launched as a prototype through a grant awarded from Columbia University's Centre for Environmental Research and Conservation to the Wildlife Conservation Society. A planning meeting involving representative possible users of this envisioned system was hosted at the Wildlife Conservation Society, February 2001, with feedback from staff of Zoo Conservation Outreach Group, Wildlife Information Network, Wildlife Trust, the New York Botanical Garden, and the host institution.

Howler monkeys (*Alouatta pigra*) in Belize were targeted as a likely prototype species for development of a database module for a number of reasons: overlap with human uses of plant resources exists, long and short-term field data on movement patterns, habitat use, and nutrient composition of food plants have been collated. While the conservation issues of howlers may not be as pressing as those of other primates, there is, nonetheless much interest in nutritional management of howler monkeys both in US and Latin American zoological facilities, and the biodiversity index of plant use within Belize itself may have implications for non-primates.

Such a prototype, therefore, could logically and realistically be developed based on datasets that are already published. Phase 1 (Prototype) model development incorporated the field data of Silver (Silver, 1997; Silver *et al.*, 2000,) and Ostro (Ostro, 1998; Ostro *et al.*, 1999). Bibliographic information on howler monkeys in general and specific characteristics of *A. pigra*, along with these field data, defined the primary keys of the model structure. Hence animal species, plant species, or bibliographic data can initiate a search to retrieve more detailed information on any of the other primary keys. Under this integrated model, mechanisms will be investigated to effectively link:

a) detailed information on composition of plants consumed by howlers to the database structure of Zootrition™ software (Zootrition, 2001);
b) botanical uses and toxicological data to extinct plant databases; and
c) published natural history and health information within the WildPro Multimedia electronic encyclopaedia and library of the Wildlife Information Network. Such linkages would magnify the functionality and capacity of a Global Nutrition Database, and accessibility world-wide, while at the same time making most effective use of collaborating partners.

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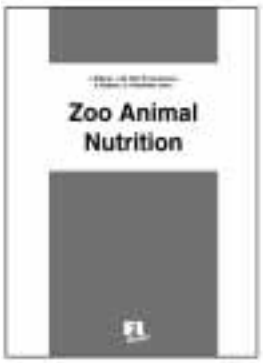

Zoo Animal Nutrition
J. Nijboer, J.M. Hatt, W. Kaumanns, A. Beijnen, U. Ganslosser (eds.)
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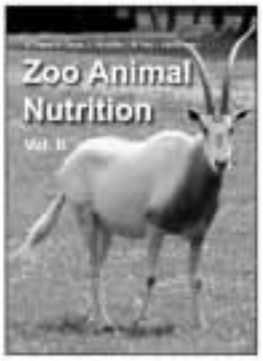

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To be published towards the end of 2003, it will contain articles on immunological aspects of feeding, digestive kinetics, obesity, mineral and bone metabolism, lipids and vitamins, among others.

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Glutenfree diet for callitrichids at Emmen Zoo

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Gluten intolerance, or coeliac disease, is a condition in which the lining of the small intestine is damaged by gluten. Gluten is a protein found in wheat, rye, barley and oats. In creatures who are sensitive to gluten, gluten damages the mucous membrane of the small intestine. The damage considerably impairs the absorption of nutrients, causing problems such as malnutrition. When a glutenfree diet is strictly followed, the intestinal villi can restore and after a few weeks the symptoms decrease. However, it takes one or two years for the mucous membrane to fully recover (Voedingscentrum, 1998).

The symptoms of coeliac disease are intestinal problems such as a swollen abdomen, chronic stinking diarrhoea, but also anaemia, weight loss and osteoporosis (Thomas, 1988; Haalboom and Smit, 1995; Stafleu *et al.*, 1997; Voedingscentrum, 1998).

In Emmen Zoo, callitrichids also showed hunger besides the symptoms described in the literature. They were even observed consuming faeces of other animals in their group to satisfy their hunger (or maybe it also could be an attempt to consume pre-digested nutrients?).

The problem in Emmen Zoo was first detected and described in 1980 (although these symptoms did appear before). Since then all kinds of treatment were tried: medication, injections with multivitamins, antibiotics, diet changes like a lactose limited diet and a lactose free diet, a diet without citrus-fruit (oranges, lemons etc.), but none of these attempts led to a decrease of the symptoms. Every year the symptoms of stinking diarrhoea, hunger and loss of weight appeared again, particularly in the red-bellied tamarins (*Saiguinus labiatus*), frequently leading to death. The symptoms made clear that there was something wrong with the intestines, which caused problems in digestion and resulted in malnutrition.

At the First European Zoo Nutrition Conference held in Rotterdam in 1999, Mauvis Gore presented data from a study conducted at a German primate research facility. It was about the effects of wheat in callitrichid diets (Gore *et al.*, 1999; 2001).

Photo: Rod Doolaard/IZP

The hypothesis about coeliac disease was then considered in Emmen Zoo, and after some discussion with the veterinarian and the keepers it was suggested to try a glutenfree diet (supported by probiotics to help the intestinal flora to recover). The aims were 1) to take care of the lining of the small intestines and recover it and 2) to prevent the appearance of the symptoms in the rest of the animals not yet affected.

The glutenfree diet was introduced in November 1999 and positive effects were observed after two weeks: the callitrichids have not suffered from diarrhoea anymore, in fact their excreta are solid and do not smell badly. This is not an illogical result when one keeps in mind that cereals do not grow in trees, where callitrichids search for their food in the wild (Clapp and Tardiff, 1985; Morin, 1985; Knapka, 1995).
From this experience it was decided to feed more of Emmen Zoo's primates a glutenfree diet (spider monkeys and white-handed gibbons also are known for suffering from diarrhoea easily due to unknown causes). A glutenfree diet is not harmful, neither is the use of probiotics. The probiotic used is 'Yakult', a probiotic dairy product, to which vitamins, minerals and trace elements can be added easily, with no problems of animals refusing their meal, the taste is very sweet due to the high sugar content!
The diet offered to the mentioned primates consists of: Yakult with 15% instant baby milk powder (includes protein,

fat, carbohydrates, vitamins, minerals and trace elements) and one drop of vitamin D_3 per animal, poured over a mixture of fruit and vegetables (amounts depending on the species) in the morning. At lunch they get insects (worms, crickets, grasshoppers, moths etc.), sometimes a boiled egg or other glutenfree but preferably protein rich food items (gibbons and spider monkeys are fed fruit twice a day, instead of insects). In the late afternoon (16:00h) a glutenfree pelleted diet (manufactered by 'Hope Farms', the Netherlands or 'Van Cooten', the Netherlands) or a glutenfree biscuit (manufactered by 'Numico', the Netherlands or 'Danone', France) with a few mealworms is offered.

Allthough it needs to be further researched and scientifically tested whether the callitrichids in Emmen Zoo indeed did suffer from gluten intolerance, the glutenfree diet has proved to be effective so far and the symptoms have disappeared.

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Hornbill diets

An overview of captive *Aceros* and *Buceros* hornbill diets in some Dutch and US facilities

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Hornbills are very popular and spectacular exhibit animals in zoos and avicultural collections. In recent years, these birds have been identified as a group in need of good husbandry guidelines and a priority for captive breeding because of their conservation status. Unfortunately, reproduction success is not very high. Diet could be a key factor in developing successful programmes (Dierenfeld et al.*,1991). It would be useful to determine nutrient requirements in order to compose or evaluate (current) hornbill diets but, as with most zoo species, little is known of hornbill requirements.*
The goal of this study was to obtain insight in the nutrition of captive Aceros *and* Buceros *hornbills and to compare the nutritional composition of the diets with the available literature in order to give practical recommendations towards hornbill keeping organisations.*

Methods

In order to obtain data concerning the hornbill diets, ten zoos (four Dutch and six US facilities) were visited, bird keepers were interviewed and information on the composition of the diets was collected. Two zoos fed more than one diet, which made a total number of 12 diets in this study. The nutritional composition of the diets was analysed, using Zootrition™ software (Wildlife Conservation Society), and compared with the available literature.

Photo: Rod Doolaard/IZP

Results

INGREDIENTS

All facilities fed fruits (such as apple, banana, grapes, and melon) as the main component of the diets (60.6%). Also, all diets contained commercial products like dog food, softbill pellets and other concentrates. One diet contained meat (chicken- and beef heart). Insects used were mealworms and crickets. Supplements included were mainly Avipowder and Carmix. Tofu, rice, gelatine and pig lard were summarized as miscellaneous products (see Table 1).

CAPTIVE DIET COMPOSITION

A considerable difference can be seen in crude protein- (8.4% – 26.9% DM), iron- (19.2 – 108.1 mg/kg DM) and water content (55.3 – 81.6% DM) of the diets (see Table 2). The mean calcium/phosphorous ratio is 1.8:1. This ratio is close to the recommended value as described in Table 2, however some diets contained low levels of calcium and phosphorous. Compared to the nutritional composition of figs, which are the main food component of hornbills *in situ* (Kemp, 2001), the mean calculated value of the zoo-diets are low in fibre, high in fat, protein and soluble carbohydrates.

Discussion and recommendations

Comparatively little is known about the nutrient requirements of frugivorous birds. In this study a variety of publications is used as sources for reference values. Where available data on the species itself was used (Kemp, 2001; Foeken and De Vries, 2001). When these data were not available, for instance on iron, values for other frugivorous birds as published by Worell (1997), Schoemaker *et al.* (1999), Mete *et al.* (2001) and Schoemaker and Beynen (2001) were used.

The study from Wrangham *et al.* (1993) provided data on the nutritional composition of wild fig fruits. These data may give an indication on the composition of the diet in the wild, where fig fruits are a major hornbill diet constituent and are therefore useful as reference values.

Hornbill diets

N of diets containing following Ingredients: *		Range of ingredients	Percentage of diet		Offered amount in diet	
		N	%		g/hornbill/day	
			mean	sd	mean	sd
Fruit	12	2-8	60,6	14,0	363,7	187,5
Vegetables	10	0-8	16,6	7,9	92,9	78,0
Concentrates	12	1-5	18,1	13,8	100,3	86,9
Meat	1	0-2	7,8		55,0	
Eggs	3	0-1	6,7	4,6	28,7	10,1
Insects	2	0-2	1,8	0,5	9,5	3,5
Supplements	9	0-3	3,0	4,7	16,1	24,3
Miscellaneous	5	0-2	6,2	3,8	34,8	20,0
Total					701,0	

Table 1: Description of hornbill-diets, fed bij four Dutch and six US zoos.

* Number of zoos feeding different food-items. Ranges of used ingredients are described as well as the contribution (percentage and weight) of these ingredients to the total diet.

Iron storage disease (hemochromatosis) is often found in frugivorous birds as toucans (Ramphaidae), mynahs (*Gracula* spp), Bali mynah (*Leucopsar rothschildi*), birds of paradise (Paradisaeidae) and hornbills (Bucerotidae) (Schoemaker and Beynen, 2001). Worell (1997) recommended to feed frugivorous birds diets low in iron (< 65 mg Fe/kg DM). The average iron level (47.0 mg/kg DM) in the analysed diets did not exceed the value of 65 mg/kg DM. However, recent studies on mynahs (Mete *et al.*, 2001) recommended that dietary iron levels should not exceed 25 mg/kg DM. Almost all diets in this study contained more than this amount. In all cases where the iron content of the diet was higher than recommended, the largest contribution towards the iron content came from supplements and concentrates.

Nutrient *	Unit	Calculated		Literature		
		Mean	Min	Max	Recommended	Figs
Water %	70.1	55.3	81.6	>61	-	3
Gross energy	KJ/g DM	18.2	17.3	20.9	13.4-17.6	-
Crude protein	% DM	16.2	8.4	26.9	10	7.9 ± 4.2
Crude fat	% DM	8.0	3.7	17.0	-	3.5 ± 1.5
Ash	% DM	5.3	1.8	10.7	-	7.7 ± 1.5
Crude fibre	% DM	2.1	1.0	4.8	-	35.6 ± 10.8
NFE	% DM	68.4	48.9	82.2	-	32.1 ± 6.8
Ca	% DM	0.9	0.2	2.0	0.5-1.2	-
P	% DM	0.5	0.2	1.0	0.3-0.5	-
Ca:P	Ratio	1.8:1	1.3:1	2.6:1	1:1-2:1	-
Iron	Mg/kg DM	47.0	19.2	108.1	<25 / <65	-
Vit C	Mg/kg DM	703.9	122.5	1516.9	-	-

Table 2: Nutrient compostition of hornbill diets, fed by four Dutch and six US zoos, recommended dietary values and the composition of figs.

* Nutrient composition calculated with Zootrition™ software

Similar observations were also made in a recent study concerning frugivorous bats (De Boer and Van Hall, 2002). This again shows that the use of multi-mineral supplements and concentrates which are not especially designed for the species involved should be avoided as much as possible. Most of the time, usage of these kind of supplements or concentrates is a shot in the dark with unwanted side-effects. When supplements or concentrates are needed to provide a balanced diet, the use of specifically designed supplements or feeds is preferred. Even then, of course, correct dosage remains of utmost importance.
Because of its role in iron absorption and metabolism, it is also advisable to pay attention to the vitamin C content. However, there are no specific recommendations for frugivores.

The intake of water from food is important to hornbills as they rarely or never drink and it has to be ensured that dehydration is avoided (Kemp, 2001). Foeken and De Vries (2001) found that a diet containing approximately 27% moisture did not provide the water requirements of hornbills. The birds showed signs of dehydration and did not drink free water to compensate for the lower water content of the diet. In their study, the birds did well on a diet containing 61% moisture. When composing diets for captive hornbills, dietary moisture levels should be of concern.

The same study of Foeken and De Vries (2001) suggested a dietary crude protein level of approximately 10% at maintenance level. This value is comparable to the crude protein content of figs, a major constituent of their natural diet. Most diets for captive animals exceeded this level (mean 16.2%, see Table 2). Excess protein in captive diets may result in nutritional imbalances, which may lead to acidosis, poor bone mineralization, poor growth, reduced health- and breeding condition (Klasing, 1998; pers comm. Dierenfeld, 2001). Higher protein levels than suggested in the study of Foeken en De Vries (2001) could therefore be a risk for hornbills at maintenance level.
A striking difference to natural diet composition is the crude fibre content of diets for captive hornbills. Crude fibre contents of the diets investigated were on average ten times lower than in wild figs (Wrangham *et al.*, 1993). This low crude fibre content could be of consequence for gastro-intestinal health, but there are yet no further studies. The variation in diet and nutrient composition between institutions and the differences with recommendations show clearly that still much nutritional research and maybe also nutritional education is needed to improve the captive nutritional status of these attractive birds.

Acknowledgements
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Effects of Tasco (a brown seaweed) and heat stress on immune function and antioxidant activity of wether lambs
K.E. SAKER, J.H. FIKE, H.P. VIET, D.L. WARD

Influence of lactulose as feed additive on chyme composition and intestinal microflora in pigs infected artificially with *E.coli* O139: K8[2] and *Salmonella Derby*
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Dietary effects on bifidobacteria and *Clostridium perfringens* in canine faeces
J. ZENTEK, B. MARQUART, T. PIETRZAK, O. BALLÈVRE, F. ROCHAT

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S. VANCAENEGHEM, Y. VAN DER STEDE, T. VERFAILLIE, F. VERDONCK, S. ARNOUTS, P. DEPREZ, E. COX, B.M. GODDEERIS

The impact of prebiotics during salmonellosis on nutrient retention and *Salmonella typhimurium var.* Copenhagen excretion in adult pigeons (*Columba livia domestica*)
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In vitro studies on the effects of short-chain fatty acids on the invasiveness of Salmonella
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Influence of PUFA on immune cell and tissue MAPK in the feline
K.E. SAKER, W.R. HUCKLE, B.E. COWING, J.H. HERBEIN

Efficacy of a hypoallergenic diet containing soy isolate hydrolysate for the diagnosis and management of food hypersensitivity in dogs: a multicentric field study
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Parenteral nutrition with or without early enteral nutrition in young dogs with parvovirosis
JÜRGEN ZENTEK[2], KERSTIN WILL, INGO NOLTE

Effects of dietary antioxidant supplementation before and after oral acetaminophen challenge in cats
A.S. HILL1, S.L. O'NEILL, M.M. CHRISTOPHER, Q.R. ROGERS

The effect of trial length on canine fecal microflora response to chicory ingestion
G.L. CZARNECKI-MAULDEN, A.R. PATIL

Influence of organic feeding and housing on 'health' parameters in organic pig fattening
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Effects of lactulose as feed additive on chyme composition and intestinal microflora of weaned piglets
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OBESITY & ENERGY BALANCE

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Modulation of uncoupling protein (UCPs) expression in adipose tissue, skeletal muscle, and liver in obese insulin resistant dogs
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M. CLAUSS, E. KIENZLE

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A.J. WATERS, C.J. NICOL, A.D. WILSON, P.A. HARRIS, H.B. DAVIDSON

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Distinct weight loss and elevated hepatic enzymes in horses caused by straw contaminated with Deoxynivalenol (case report)
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A model for the development of taurine deficiency in dogs by the use of cholestyramine
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The minimal dietary lysine requirement of kittens for maximal growth
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Rumen bypass of free methionine and lysine for double-muscled Belgian Blue bull
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Nitrogen requirements for maintenance of captive *Aceros* and *Buceros* Hornbills
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Some preliminary observations on herbivorous insect composition: nutrient advantages from a green leaf diet?
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The role of insects in primate nutrition: how is chitin utilized?
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Open trial to determine voluntary food intake in hospitalized cats
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Feed choice in pigeons with or without L-carnitine supplementation
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The use of n-alkanes to estimate diet composition, intake and digestibility in sheep fed mixed diets
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Food intake and body weight development of captive roe deer (*Capreolus capreolus*) fawns fed diets of different tannin content
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Investigations on ingestion, amounts and composition of casting and digestibility of organic matter in different birds of prey (kestrel, common buzzard and eagle owl)
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K. LEUS

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Herbivore insect composition

Herbivorous insect composition: you are what you eat?

E.S. Dierenfeld, Wildlife Conservation Society, USA; A.L. Fidgett, Chester Zoo, United Kingdom

*Three commonly cultured invertebrate prey items for feeding captive insectivorous animals include larvae of the meal beetle (*Tenebrio molitor*), crickets (*Gryllus *sp.) and wax moth larvae (*Galleria mellonella*). Mulberry silk moth larvae (*Bombyx mori*) have previously been reported as another potentially useful insect for feeding zoo insectivores (Frye and Calvert, 1989; Frye, 1992). While generally considered excellent sources of protein and fat, it has been suggested by some authors that the chitinous exoskeleton of invertebrates reduces overall nutrient availability (Frye and Calvert, 1989). Insects have been shown to be a poor source of vitamin A, and almost all published reports of invertebrate composition demonstrate them to be a poor source of calcium, with an imbalanced Ca:P ratio (see Table 1; Barker* et al.*, 1998; Klasing* et al.*, 2000; Finke, 2002).*

Composition of the rearing diet itself has been shown to have a significant effect on mineral content of invertebrate species (Allen and Oftedal, 1989; Anderson, 2000), and underlies the development of commercial products for rearing insects used as prey for insectivores. Recent chemical analysis of silk moth larvae (*Bombyx mori*), raised on a diet of fresh green leaves of white mulberry (*Morus alba*), and locusts (*Locusta migratoria*) raised on fresh-cut grass will add to the limited information currently available on invertebrate composition

Photo: Rod Doolaard/IZP

(Dierenfeld and Fidgett, in prep.). This article briefly discusses the limited data on composition and the potential contribution of fresh green foliage as a natural source of nutrients for enhancing invertebrates as food items.

Basic nutrient composition

Water content of silk moth larvae was higher than values previously reported for this species, and crude protein somewhat lower (Frye and Calvert, 1989). Despite these differences, silk moth larvae, stick insects and locusts should all be considered a good source of water for insectivores, as well as high in protein. Overall protein quality, however, depends on the amino acid balance. The combination of animal- and plant-based proteins, supplied by the insect and its gut contents, may provide a better amino acid balance than either diet separately.

	% DM			(IU/kg)		% DM	
Species	**Water (%)**	**Crude Protein**	**Fat**	**Vitamin A**	**Vitamin E**	**Calcium**	**Phosphorous**
Reared using artificial diets							
Mealworms *(Tenebrio molitor[1])*	62.9	51.8	31.1	811	30	0.12	1.42
Crickets (adult) *(Acheta domestica[1])*	73.2	64.3	22.8	811	81	0.21	0.78
Wax moth larvae *(Galleria mellonella[1])*	61.9	41.2	51.4	150	509	0.06	1.20
Silkworm larvae *(Bombyx mori[2])*	82.7	53.7	8.1	665	4	0.10	1.37
Reared using fresh-cut grass							
Locusts *(Locusta migratoria)*	40.5	52.7	32.6	2.9	18.9	0.04	0.43
Reared using mulberry leaves							
Silkworm larvae *(Bombyx mori)*	81.6	53.0	20.2	ND[3]	465	0.91	0.75

Table 1: Representative nutrient composition of selected invertebrate prey.

Data for insects reared on commercial diets compiled from [1]Baker *et al.*, 1998; [2]Finke, 2002; [3]ND = none detected

Herbivore insect composition

Dietary fibre constituents in insects should not be considered insignificant components of invertebrate-based diets (Dierenfeld and Barker, 1995). Various sources of fibre can be utilized by insectivores, improving both faecal quality and (potentially) gastrointestinal health (Graffam *et al.*, 1998). Fibre values quantified in the invertebrates analysed ranged from moderate to high (up to half the DM), and encompassed ranges reported for different life stages of termites consumed by anteaters and other myrmevores in nature (Redford and Dorea, 1984; Oyarzun *et al.*, 1996). The capacity to digest chitin would mean that rather than reducing nutrient availability, dietary bulk of insect exoskeletons could provide an additional energy source. However, combined with the plant cell walls found in gut contents of herbivorous insects, the result could be a nutrient dilution effect that would serve to modify otherwise energy-rich diets (Graffam *et al.*, 1998). These aspects need to be explored in the husbandry and management of insectivorous species, which often suffer from obesity in captivity. Crude fat content measured was similar to that of previous reports in silk moth larvae. Examination of the contribution of the fresh plant materials in providing essential fatty acids is suggested, to better understand the role of green plant extracts. In addition to readily available energy from simple lipids, the crude fat fraction includes components that may be of limited digestibility (for example, plant waxes and cutins from the surface of the leaves).

Vitamins

The crude fat fraction also contains carotenoid pigments, which may be of importance to overall health and reproduction of insectivores. Carotenoids have been identified in extracts from other invertebrates (Dierenfeld *et al.*, 1995), and may play an (as yet) unquantified role in the vitamin A nutrition of insectivores. Similar to other insects, minimal or no vitamin A activity was detected in extracts from the samples. It appears that insects, in general, do not have a dietary requirement for vitamin A (Bowers and McCay, 1940). It is conceivable that insectivorous species may have the ability to convert plant carotenoid presursors to active forms of vitamin A, but controlled studies have not been reported.

Another fat-soluble vitamin, vitamin E, was found in high concentrations for the mulberry-consuming insects compared with unsupplemented invertebrates previously examined (Pennino *et al.*, 1991; Barker *et al.*, 1998) and the locusts feeding on fresh-cut grass. Dietary sources of vitamin E activity include animal tissues as well as oily fish and fresh, dark green plant tissues. Dietary vitamin E deficiency has not been reported as a major problem for insectivorous reptiles (Dierenfeld, 1989), and most invertebrates examined appear to contain adequate levels of this nutrient relative to dietary requirements established for domestic carnivores (Barker *et al.*, 1998). Nonetheless, dietary needs of the insects themselves must be met.

Photo: Rod Doolaard/IZP

Herbivore insect composition

Fresh mulberry leaves are relatively rich sources of vitamin E (Dierenfeld *et al.*, 1990); drying forages results in up to 90% loss of this activity. A dry diet, even if based on natural plant materials, may result in a very different nutrient composition if original chemical content is not taken into account.

Minerals

The mineral content of these herbivorous insects is of considerable interest. Frye and Calvert (1989) described higher levels of Ca in the silk moth larvae they analysed compared with meal beetle larvae, but Ca:P ratios were nonetheless imbalanced (1:2.5). Silk moth larvae, and gravid female stick insects (but not males) analysed contained adequate levels of both Ca and P established for mammalian carnivores, as well as Ca:P ratios > 1:1. Mulberry leaves contain high levels of both Ca and P (ZOOTRITION™, 2002) and may be a good source of these nutrients for herbivorous invertebrates. By comparison, fresh cut grass has fairly low levels of both minerals (ZOOTRITION™, 2002), which might explain why locusts were not as compositionally enriched. The difference in mineral content with respect to reproductive state of the insects also deserves more investigation. Stick insects were especially high in Cu and Zn content (which may relate to insect haematology), and none of the samples appeared to contain excessive Fe concentrations (Dierenfeld and Fidgett, in prep.). The wide ranges of mineral concentrations suggests that insects utilized in diets of omnivorous species in wildlife feeding programmes should be analysed regularly to determine their contribution to (particularly) trace element nutrition. The actual availability of minerals to insectivorous species consuming silk moth larvae or stick insects has not been measured in any studies, but would be a logical next step. Overall mineral balance measured here falls within dietary ranges recommended for domestic mammalian carnivores (NRC, 1980), but mineral requirements for reptilian or avian carnivores have not been established.

Conclusion

In summary, the larvae of the silk moth feeding on mulberry may be useful insects for feeding captive insectivores. Nutrient profiles are comparable with those of other invertebrates commonly utilized, but dietary fibre content, and particularly vitamin E and Ca content, may be enhanced by feeding on this dark green leafy diet.

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Silkworm larvae were supplied by SoCal Silkworms (Temecula, California); locusts were raised at Chester Zoo, Chester, United Kingdom.

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HACCP based bacteriological study of the feed of fruit eating birds at Rotterdam Zoo

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A Hazard Analysis Critical Control Points (HACCP) based inventory study of the presence of bacteria in the feed of tropical fruit-eating birds during processing and feeding demonstrated that several critical control points could be identified. By changing processing methods at these critical control points a decrease in bacterial numbers could be established.

Introduction

A thorough understanding of avian nutrition is essential to secure the survival and productivity of the birds. Next to good nutritional values another important component to secure the survival of the birds is the microbiological quality of the feed. Many bacteria species can be pathogenic, for example *Salmonella* spp., *Proteus* spp., *Escherichia coli*, *Pseudomonas* spp., *Clostridium* spp., *Campylobacter* spp. (Herenda, 1996). Absence of these bacteria is important in order to prevent related diseases. Other bacteria such as *Enterobacteriaceae*, *Staphylococcus aureus*, *Streptococci* and *Lactobacillus* spp. can indicate the level of hygiene maintained during harvesting fruits and vegetables, or their treatment during the feeding process.

HACCP is a method developed in the USA to guarantee food safety. By controlling the production process, the quality of the end product is guaranteed. To detect the bacteriological quality of bird feed an exploratory study was done according to HACCP protocols. Results were used to detect bottlenecks in the feed manufacturing process and to show the importance of HACCP protocols in feed processing at zoos.

Material and methods

EXPERIMENTAL DESIGN

To analyse the risks in the process of feed making, the Rotterdam Zoo was visited twice. Each step in the feed processing was observed and the route that the feed covers throughout the zoo was described. The attendants were asked to tell about their daily routine, concerning the procedures they followed during feed making. To find out a bit more about kitchen hygiene, the employees were asked to tell how the kitchen, machinery and surfaces were cleaned, which product(s) were used, and how often cleaning was performed. From all the cages in the Victoria aviary two cages were chosen to be representative for all cages. For bacteriological examination samples were taken during processing of the feed: apple pieces, fruit mixture and mix. Furthermore samples were taken of the feed on the trays in the selected cages at noon. Finally samples were taken of the feed that had been stored in the refrigerator for one night (to be used next day), and of the remnants of the feed at noon the next day.

After an adjustment easy to execute for the keepers, feed samples were examined again.

Bacteriological analysis

In the samples, determinations were made for total aerobic count in *Enterobacteriaceae, E.coli, Staphylococcus Aureus, Streptococcus, Lactobacillus*, yeast, mould, *Yersinia, Salmonella* and *Pseudomonas.*

Results

HAZARD ANALYSIS

The hazard analysis is described in Table 1.

Bacteriological study

During the three days in which samples have been taken, all samples showed the same trend. The CFU (colony forming units) numbers decline after mixing, when the apple pieces are added to the fruit paté. This is the first moment when all the ingredients of the bird feed were present in the sample. The fruit paté contains fewer bacteria compared to the apple pieces. At 13:30h, when the feed has been in the cages for three hours, faecal *Enterococcus* spp., *E.coli* and *Lactobacillus* sp. were found in the samples. *Staphylococcus aureus* was not found until the feed was taken out of the refrigerator at 08:30h the next morning. The results found for *Pseudomonas* spp. were very variable, in time and between the sampling days and no *Yersinia* or *Salmonella* were found.

Fruit eating birds

Production process	Hazard	Critical Control Point
1. Fruit supply to Rotterdam Zoo	> Contaminated when delivered	> Check when delivered by employees general kitchen
2. Storage of fruit in stock-room	> Contamination during storage	> Fence against vermin
3. Processing in general kitchen	> Contamination during handling	> Hygiene during work kitchen and proper cleaning of materials and machines
4. Transport of cut fruits to aviary	> Rise of temperature, contamination by birds and vermin	> Seal and clean the trays properly Quick transport
5. Processing in aviary kitchen	> Dirty hands, kitchen or materials	> Hygiene during work, proper cleaning, one contaminated ingredient visual judgment of fruits and vegetables
6. Transport to exhibits	> Contamination during handling	> Hygiene during work
7. Tray in exhibit	> Rising temperature, contamination by birds and vermin	> Few bacteria in base-feed, pest control, feed not too long in exhibit
8. Tray in refrigerator	> Contamination during storage	> Regular cleaning of refrigerator
9. Tray in exhibit	> Rising temperature, contamination by birds and vermin	> Few bacteria in base-feed, pest control, feed not to long in exhibit

Table 1: HACCP analysis of feeding process

After introducing some adjustments by making some extra feed and storing this feed in a closed box in the refrigerator, the bacterial growth was significantly limited. Instead of handing out the feed that had been in the cage all day and in the fridge all night, a clean tray with some of this spare feed was given at 08:30h in the morning. Bacteriological results of the feed after the change were used to compare the effect of the adjustment in relation to the usual situation, as found during the study of the bacterial course during the day.

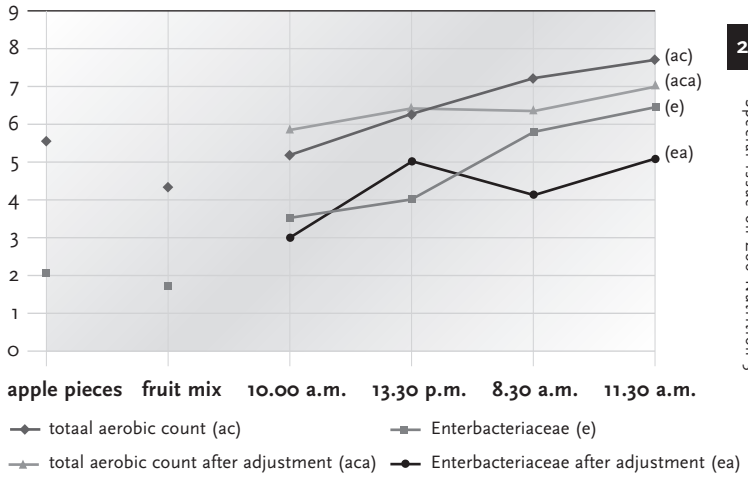

Figure 1: Comparison between the numbers of bacteria in the normal situation (see apple pieces and fruitmix) and after adjustment (10:00 a.m.) in log/g of the feed sample.

Discussion and Conclusion

The goal of this explorative study was to describe the bacterial growth in the diet using a HACCP strategy, both during preparation and during the time the feed could be consumed. Limitation of bacterial growth by adjustment of the manufacture process and feeding strategy was checked by an experimental change in the feeding process.
The study demonstrated that there was little variation between the days of sampling. A similar trend of infection was found over time: a high level after mixing, an increase during the day, no growth in the refrigerator, another rise in bacterial numbers leading to even higher concentrations found in the remnants the next morning in trays previously fed.
Mixing the ingredients proved to be a critical control point. There is always a risk that one of the ingredients is contaminated. If contamination is present, it will spread through the whole feed mixture. Another point of concern is the material used in the preparation of the feed. A very important critical point was also the personal hygiene of the attendants.

To limit the bacterial growth, an experiment was done not replacing the food to the cage the next morning. Instead, a clean tray with clean food (that had been placed immediately in the refrigerator after mixing), was placed in the exhibit. The result of this experiment was a much smaller growth in bacterial numbers than found in the normal situation.
This study demonstrated that a HACCP based bacteriological study could identify critical control points in the processing and feeding strategy of tropical birds in the Rotterdam Zoo.

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The role of insects in callitrichid nutrition

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Marmosets and tamarins belong to a group of primates known as the callitrichids. They are a popular exhibit in many zoos due to their striking pelage and active nature. Good husbandry techniques and a suitable captive environment contribute to their successful breeding. A balanced and natural diet, which provides the optimum nutrition but also promotes natural feeding behaviours, is vital if zoos are to produce healthy, viable breeding groups.

Primates display a large diversity of insectivory, with the amount of insects voluntarily consumed ranging from none in the case of the strict folivores, to a diet almost exclusively composed of insects in the more primitive groups including tarsiers and galagos. Marmosets and tamarins fall in the middle of this range with some relying more on insects as a dietary component than others. In the wild white-fronted marmoset (*Callithrix geoffroyi*) spends up to 20% of the day foraging for insects (Passamani, 1998) and insects make up 40% of the total food consumed by the cotton-topped tamarin (*Saguinus oedipus*) (Garber, 1980) and by the red-handed tamarin (*Saguinus midas midas*) (Pack *et al.*, 1999).

The exoskeleton of insects contains a large amount of a substance known as chitin. It is the chitin, combined with proteins, that makes the exoskeleton hard. Chitin is also found in the shells of crabs and other marine invertebrates. Little evidence exists about mammalian digestion of chitin (Fleagle, 1999). There are a number of means by which chitin could be digested: through mechanical, biochemical or microbial processes within the primate mouth and gut.

To investigate whether callitrichids might be digesting chitin, which represents a major component of their diet, a study of their insect-eating habits was undertaken. This included determining

- the chitin content of a variety of insects – developing a 'chitin budget' for the common marmoset (*Callithrix jacchus*); and
- investigating the gut of callitrichids to see how it might digest chitin.

Methods

The Van Soest Acid Detergent Fibre method was used to determine the chitin content of two insect species, namely crickets (*Acheta domestica*) locust nymphs and adult locusts (*Schistocerca gregaria*). These insects were chosen, as they are commonly available to zoo animals in the United Kingdom. The chitin content of the whole insect and their separate body parts was measured, as marmosets and tamarins do not always ingest the entire insect, particularly if it is a large winged species such as an adult locust. Samples of gut tissues and contents were collected opportunistically from six *C. jacchus* for microbial investigation.

Two feeding trials were conducted using ten pairs of common marmosets, which had never had insects as part of their diet.

The first trial was the control in which the animals were fed their normal diet, which did not include insects. The faeces were collected every 24 hours and the chitin content was measured using the Van Soest ADF method. They were then fed a diet including crickets and after an adaptation period of two weeks the faeces were collected every 24 hours and the chitin content was measured. Using the data obtained estimation of the amount of chitin being ingested was made. This allowed a 'chitin budget' to be formulated for *C. jacchus*.

Results

Using the Van Soest ADF method to measure the chitin content of ten of each different insect type and their body parts the following results were obtained (see Table 1).

Insect	Head	Thorax	Abdomen	Legs	Wings
Adult cricket	3.02	2.94	4.21	2.44	1.58
Locust nymph	3.24	3.53	2.59	3.45	1.31
Adult locust	5.04	13.94	4.88	7.93	10.28

Table 1: Chitin content of different insect body parts (mean %)

The chitin budget measured the amount of chitin consumed and the amount excreted to give an overall estimate of its digestibility in callitrichids. The results displayed in Figure 1 show the difference in the chitin content of faeces.

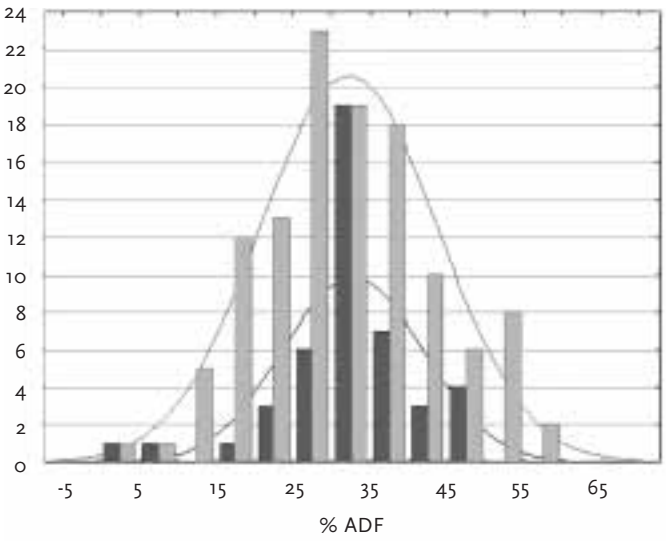

Figure 1: Acid Detergent Fibre (ADF) content of faeces from diet with insects (insect ADF in grey) and diet without insects (control ADF in black).

It can be seen that there is a slight increase in the chitin content when the animals were eating insects, however the difference was not significant. (Mann-Whitney U test: $U = 2469$, $z = 0.69$, $p = 0.49$).

Microbes were successfully grown from gut content samples obtained from the small intestine, caecum and large intestine. These may be capable of degrading chitin but further work is necessary to determine this.

Discussion

Primates in general show a diverse array of adaptations in the gut and a capacity to consume diets that are high in structural carbohydrates. It is probable that several primate species have a chitin-degrading enzyme, chitinase, in their digestive tracts; to date only a few primate species including *Perodicticus potto* and *Galago senegalensis* have been demonstrated to contain this enzyme (Lambert, 1998).
It is likely that chitin may also be broken down by microbial fermentation (Lambert, 1998).
The chitin measurement results show no significant difference between the two feeding trials. This may indicate that chitin is being digested but this procedure needs to be repeated in order to be confirmed.
The microbial results show that most bacterial growth occurred with samples taken from the caecum. This was the expected outcome as the caecum is the site of fermentation for substances similar to chitin, which are normally difficult for primates to digest, and therefore harbours the microbes necessary for such processes (Lambert, 1998). The marmosets have a large caecum, which is believed to facilitate the digestion of plant exudates (Fleagle, 1999) and potentially chitin.

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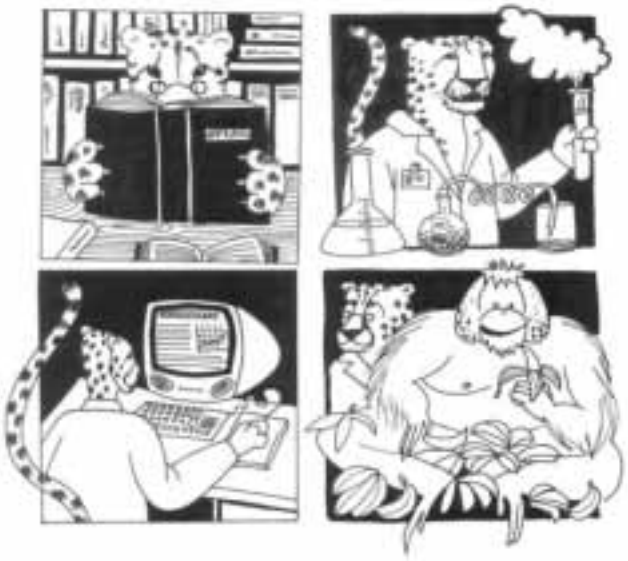
Zoo Animal Nutrition

Tables and Guidelines

Walter L. Jansen
Joeke Nijboer



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JNS Proceedings information

The Joint Nutrition Symposium has been held from 21 to 25 of August 2002 in Antwerp Zoo. The JNS meeting was organised by several groups.
Abstracts from this conference can still be obtained and will cost € 30 including postage and packaging.
Contact Prof. Geert Janssens for more information: e-mail: geert.janssens@rug.ac.be

As a follow up to this conference several papers have been or will be published:

The European Zoo Nutrition Group (EZNRG) is publishing:

Zoo Animal Nutrition Vol. III

More information about this book can be found on page 15.

EAZA Zoo Nutrition News, special issue 3

This special edition of EAZA News is sent to all conference participants and to all EAZA members. Extra copies can be obtained by sending € 12 per copy to the European Zoo Nutrition Centre. For more information contact: info@EZNC.org

Comparative Nutrition Society (CNS)

The proceedings of the CNS symposia are available by contacting the
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Or use the online order form. Look at www.cns.org for more information.
Proceedings from CNS conferences held in 1996, 1998 and 2000 can also be ordered.

European Society of Veterinary and Comparative Nutrition (ESVCN) / European College of Veterinary and Comparative Nutrition (ECVCN)

Journal of Animal Physiology and Animal Nutrition (JAPAN)

Evolving from the Joint Nutrition Symposium, a special issue will be edited for the Journal of Animal Physiology and Animal Nutrition.
Guest-editor Geert Janssens (Ghent University) is assisted by co-editors of each participating society: Joeke Nijboer for EZNRG, Marianne Diez for ESVCN, Dave Baer for CNS and Dottie Laflamme for AAVN.
The special issue will contain about 14 full papers on diverse nutrition-related subjects. Please visit http://allserv.ugent.be/~gjans/jns for the updated information on expected publication date, content, etcetera.

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Nutrition meeting held at Safari Beekse Bergen

J. Nijboer and W. Jansen, EZNC, Amsterdam, the Netherlands
(on behalf of ENG)

A meeting between TAG, EEP and ESB nutrition advisors and other individuals interested in European zoo animal nutrition took place at Safari Beekse Bergen, the Netherlands, on 27-28 March 2003.

It was established that nutrition is crucial because:
- Nutritional problems can be detrimental to the immediate health, reproduction, welfare and longevity of animals or species;
- Uncontrolled and inappropriate nutritional regimes are often a waste of resources;
- Freedom from thirst and hunger are two of the five freedoms for animals;
- The impact of new EU regulations on nutrition related issues, such as food and hygiene.

A new name was agreed upon, the European Nutrition Group or ENG, since as a group we can more effectively provide assistance and guidance on this topic. ENG will work closely with EAZA, our primary role being to act as a filter for providing high quality relevant nutrition information to zoos. However, in association with the various disciplines encompassed by the EAZA Research Group.

The group identified the following important nutrition projects:
- Nutrition & feeds databases;
- Nutrition & reproduction;
- Nutrition & longevity;
- Nutrition & health;
- Nutrition & regulatory aspects;
- Nutrition & educational training.

Formal criteria will be identified for individuals who want to become a member of ENG. The European Zoo Nutrition Centre (EZNC) has offered to act as the executive office for ENG. ENG intends to work closely together with the AZA Nutrition Advisory Group (NAG).
To become a member of ENG please contact EZNC (details below) and information will be sent to you as soon as the membership criteria are finalised.

ENG members will be strongly encouraged to contribute to the group by acting as specialist advisors to TAG, EEP or ESB programmes. In this capacity, they will assist in establishing formal, peer-reviewed nutrition guidelines for the 'Management in Captivity' section of Husbandry Guidelines, thereby supporting the work of these programmes by addressing specific nutritional concerns.

Several nutrition advisors for TAG, EEP and ESB's have already been suggested or appointed:

– European mink EEP	*Joeke Nijboer*
– EAZA Felid TAG	*Kristina Johanson*
– Cheetah EEP	*Kristina Johanson*
– EAZA Parrot TAG	*Andrea Fidgett*
– EAZA Pigeon and Dove TAG	*Joeke Nijboer*
– Guenon EEP	*Mauvis Gore*
– European lynx ESB	*Walter Jansen*
– EAZA Pigs and Peccary TAG	*Kristin Leus/Alastair McDonald*
– Ecuadorian amazon EEP	*Andrea Fidgett*
– Okapi EEP	*Joeke Nijboer/Jurgen Hummel*
– EAZA Tapir and Hippo TAG	*Andy Beer*
– EAZA Equid TAG	*Andy Beer*
– Woolly monkey EEP	*Walter Jansen*
– European otter EEP	*Alfred Melissen*

Other persons are discussing with TAG chairs, EEP coordinators and ESB keepers about the possibility to become their nutrition advisor.
In cooperation with the TAG, EEP or ESB, the target for the nutrition advisors is to set up a nutrition guideline based on the 'Feeding Section for husbandry guidelines of European Association of Zoos and Aquaria'. This has been developed by the ENG and EZNC to support the TAGs, EEPs and ESBs on nutritional issues.

The Fourth European Zoo Nutrition Conference will be held from 21 to 23 January 2005 in Leipzig, Germany. EZNC will act as the conference coordinators and circulate more details when they become available.

If you have additional information regarding the above list or would like to request/suggest a nutrition advisor for your programme, please contact EZNC.

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