12th European Zoo Nutrition Conference

Riga, Latvia

January 2023

#EZNC2023

Riga National Zoological Garden

Meža prospekts 1,
Ziemelu rajons,
Rīga, LV-1014
Latvia

Scientific Organizing Committee

Lauren Samet, Chester Zoo (ENG Chair)

Marcus Clauss, University of Zurich

Anouk Fens, Apenheul Primate Park; Amersfoort Zoo

Sarah Byrne, Dublin Zoo (ENG Co-Chair)

Sarah Depauw, Odisee University College

Foreword

Dear Friends and Colleagues

It is our great pleasure to welcome you to the 12th European Zoo Nutrition Conference in Riga, Latvia! Following on from 2021's first ever online European Zoo Nutrition Conference (EZNC) - thanks to the restrictions imposed by a global pandemic, we were not quite sure what the future held for an in-person event to see one another's faces outside of Zoom meeting screens. An additional consideration this year was also the news of another international crisis, that being the Russian invasion of Ukraine.

On behalf of the European Nutrition Group (ENG) we would like to send our thoughts and prayers to everyone that is being affected by the war in Ukraine, no words can remedy the current challenges being faced by millions of people across Europe at this time but our hearts are with you. The EAZA Emergency Fund for Ukrainian Zoos continues to fund raise money for zoos and aquariums in Ukraine to help cover expenses, like essential animal feed and utilities (if you would like to donate, please use the QR code below or click here: https://useplink.com/payment/0QGQi3DTKejUifIrdVzHx/).

For these reasons, this year more than any, I encourage you all to talk to each other during the conference (and not just to the people you came with!). Share knowledge, insights, contact details, jokes and laughter. Relish in the company of the people around you who also share an interest in this unique and fascinating area of animal husbandry because opportunities are few and far between! We are a reasonably small community, however a community is what we are. Speaking from experience, the support, knowledge, and friendship you can gain within this group of people is invaluable; and to spend time with each other face to face like this is one of the clear advantages to an in person conference as opposed to their online counterparts.

This year the organising committee is pleased to present you with a great variety of talks and the very best of the latest research and expertise from those delving deeper into specific fields. We have presentations on aquatic nutrition, insectivore diets, zoo culture and practice, alongside feeding practicalities, species-specific diet and nutrition research, a zoo visit that includes workstations for delegates, and a range of posters for your interest too.

Prior to the conference, the EAZA Academy in cooperation with the ENG Conference Committee organised a workshop (January 19th 2023) entitled "*Incorporating behavioural management into diet design and feeding systems: the next level of zoo animal nutrition*". This is an important and timely topic in animal nutrition and welfare, one that animal welfare assessment should be taking into account when creating species-specific welfare indicators. If you did not have the chance to attend the EAZA Academy then I recommend trying to speak to someone that did to find out more about this topic and the importance it has in our zoos.

The conference committee have done an amazing job in organising the EZNC2023 and I would like to thank them personally for always making the organisation of these events relatively easy and such a pleasure. I would also like to take this opportunity to formally introduce and welcome Sarah Byrne as the new ENG Co-Chair as of November 2022.

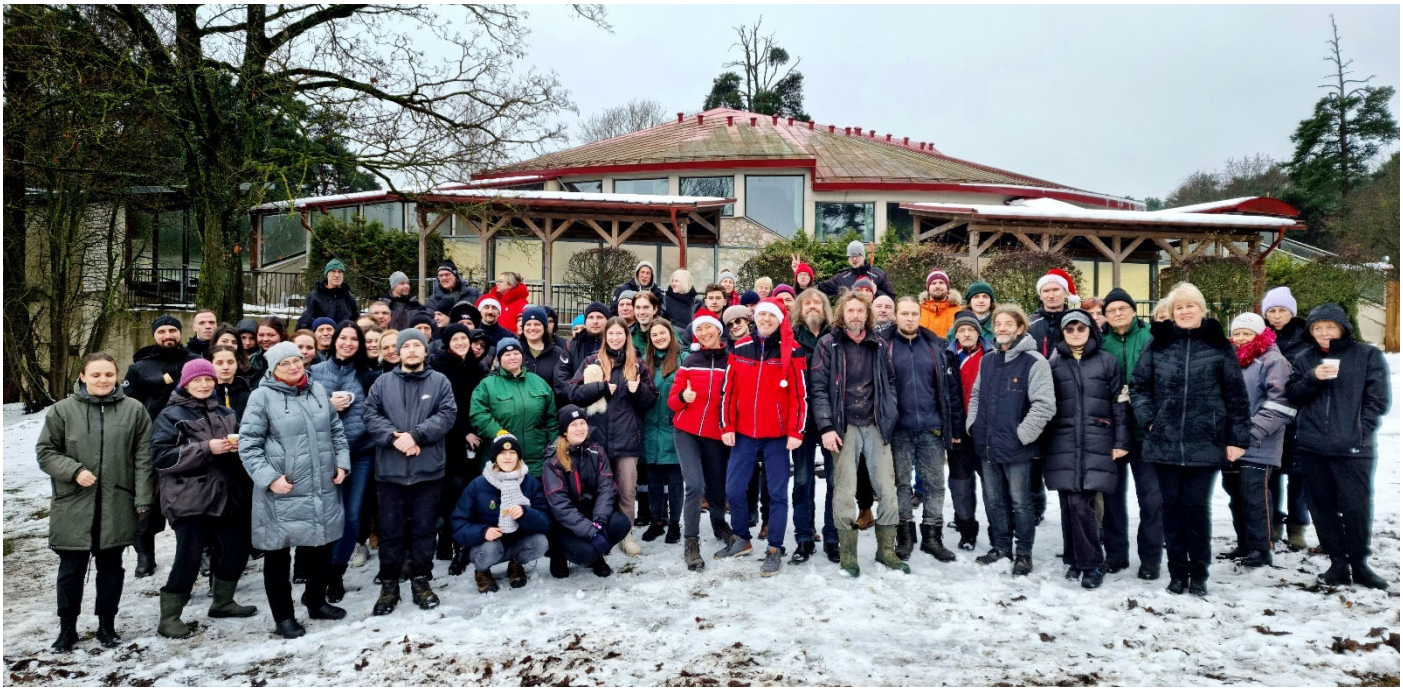
On behalf of the ENG Conference Committee we wish to thank all of our excellent sponsors - please make sure to visit their stands and talk to them about their products during coffee breaks. Thanks also to our wonderful colleagues at Riga Zoo, and all those kindly presenting talks and posters at this year's event - you have made EZNC2023 possible. Finally thanks to the EAZA Executive office, especially Lauren Florisson and Mirko Marseille who have supported us logistically with the event from conception amongst many other things.

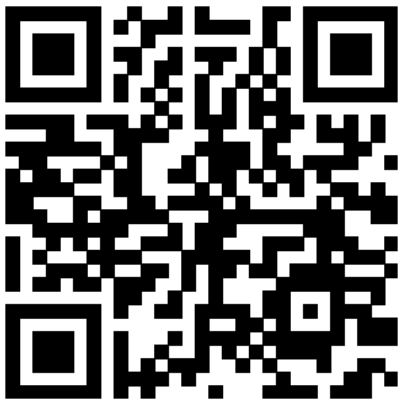
On behalf of the ENG, I am very pleased to welcome all of this year's delegates! We hope you have a great time, enjoy the conference, and go away with lots more than came with - make sure to wrap up and stay warm whilst in Riga!

Lauren Samet
Chair of EAZA Nutrition Group
Zoo Nutritionist, Chester Zoo
January 2023

Welcome words

Welcome to the 12th EAZA Nutrition conference hosted by Riga Zoo! Learn about innovative technologies and practices, participate in EAZA Academy Workshop and have meaningful discussions while experiencing the Latvian hospitality.
Riga Zoo is located in one of the oldest city district called Mežaparks (Forest Park), bordering Ķīšezers Lake. By entering the large gates built in 1912, you enter a world in which live 400 animal species from all over the world. The old buildings host modern expositions in which visitors can see animals in a habitat as close as possible as the one found in nature.
During the Zoo Visit on the 21st of January, participants of the EAZA Nutrition Conference will have a chance to take part in various workshops around Riga Zoo. The workshops will be scattered all over Riga Zoo in seven different locations: the Zebra Viewing Point, the Tiger House, the Amphibian House, the Terrarium House, the Tropical House, the Giraffe House and the Nutrition Kitchen. While going from one station to the next, each group will be led by a tour guide who will give participants insights into the history of Riga Zoo.
Our team of 160 people has been working hard to greet you with the warmest feelings so enjoy the fruits of our labor, gain knowledge, support and new friendships!





Scan to donate to the EAZA Emergency Fund for Ukrainian Zoos

Acknowledgments to our sponsors

We wish to recognize and thank the following companies which have contributed to the success of the European Zoo Nutrition Conference in Riga:

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- Granovit Zoo Feed
- Kiezebrink International
- St Laurent
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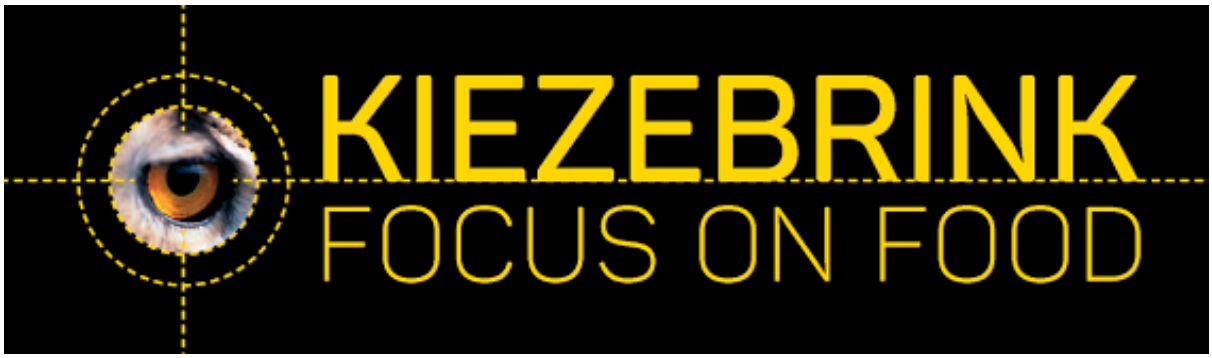

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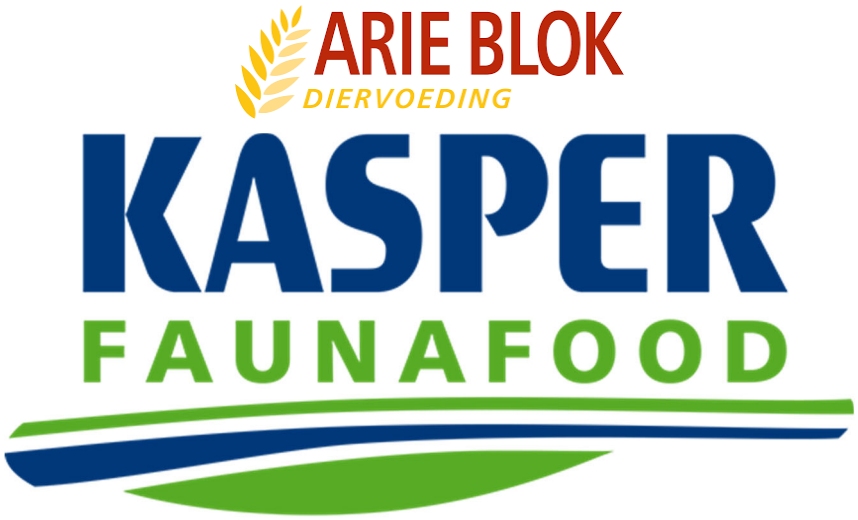


Arie Blok Animal Nutrition

Leidekkersweg 2a

3449 JH Woerden

The Netherlands

+31 341 35 83 38

www.arieblok.nl

info@arieblok.nl

Conference Venue Information

Riga Zoo: our host

All conference delegates are most welcome to visit Riga Zoo on any day before, during, and after the Conference. To enter the zoo you will just need to present your name badge. If you visit the zoo before registration, just mention at the entrance that you are attending the European Zoo Nutrition Conference.

On Saturday 21st January a visit to the zoo is part of the scheduled program. At 08:15 on Saturday morning we will meet and depart from the conference venue to the zoo (25mins by car).

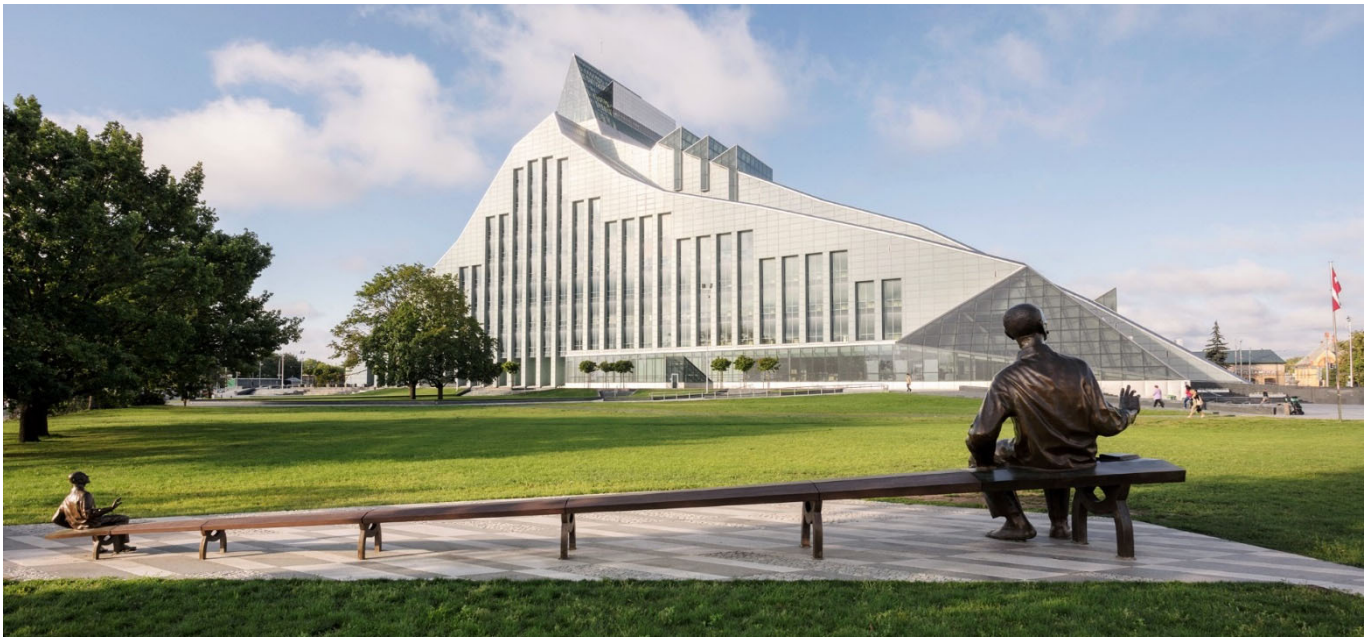
The venue

The event location and venue is at the Wellton Riverside SPA hotel in downtown Riga (Address: 33, 11. Novembra krastmala, Riga, LV-1050, Latvia).

The Panorama Hall will be the main conference hall and can be found on the 8th floor of the building. The pre-conference Academy course on 19 January will also be held in the Panorama Hall.

Farewell dinner

On Saturday 21st January, the conference dinner will be held at the Latvian National Library (located on the opposite side of the river to the conference venue). The dinner will start at 20:00. A bus will make three roundtrips between the venue hotel and the conference dinner location: Bus departures from the venue are scheduled at 19:00, 19:20, 19:40.



Latvian National library also known as the Castle of light has been created by famous American architect of Latvian origin Gunars Birkerts as a symbol of Latvia's everlasting will for freedom, independence and knowledge.

Travel to downtown Riga

Travel from Riga airport to the conference venue is quite simple:

- Take bus 22 (every 15 min) - it will arrive exactly at the hotel front (crossing the road will take 5 minutes)
- Taxi - but official ones **ONLY** (Baltic Taxi - light green ones or red ones) outside of the terminal at the parking lot - should cost around €10 to get to the venue.

Thursday 19th January 2023

08:00	**Registration**
08:30	Zoo animal nutrition: the next dimension - Marcus Clauss
09:30	Introduction Workshop - Marcus Clauss & Sarah Depauw
10:00	**Coffee Break**
10:30	Workshop: Matching biological information with feeding strategies towards positive welfare - Sarah Depauw & Marcus Clauss
12:20	Giraffe feeding method: how stereotypies and other behaviours changed at Kolmården Zoo - William Walldén
12:30	**Lunch break**
13:30	The role of animal nutrition in improving zoo animal welfare - Anouk Fens
14:00	Introduction Workshop - Anouk Fens
14:15	Workshop: Designing modern zoo animal feeding systems
15:15	**Coffee Break**
15:45	Workshop: Designing modern zoo animal feeding systems
16:15	Group pitches
17:15	Feeding systems in Apenheul Primate Park - Anouk Fens
17:45	Feeding challenges for carnivores: a future vision - Marcus Clauss
18:00	**End of workshop**

Friday 20th January 2023

08:00	**Registration**
09:00	**Welcome**
Fish	
09:30	Kendall Clements (New Zealand): Marine fish ecology and feeding
10:30	Awot Teklu Mebratu (Belgium): The fish tank as a rumen? Indirect evidence from feeding beet pulp to tambaqui
10:45	**Break**
11:25	Johan Schrama (Netherlands): Feeding fish in zoo's: how to deal with diversity
12:10	Ton Weber (Netherlands): Practical feeding management of a large aquarium
12:40	Sander van Lopik (Netherlands): Fishing seas for conservation?
13:10	**Lunch break**
Carnivores	
14:00	**Sponsor pitches I**
14:15	Cellina Kleinlugtenbelt (Switzerland): Carnivore feeding in Europe
14:30	Annelies De Cuyper (Belgium): Fibre and health in felids and other carnivores
15:00	**Break**
Zoo Culture and Practice	
15:40	Anouk Fens (Netherlands): 'Many mouths to feed': The design and centralization of a walk-in Commissary at Amersfoort Zoo
15:55	Joeke Nijboer (Netherlands): Integrated Pest Management in zoo food facilities
16:10	Lauren Samet (UK): Identifying and sharing nutrition expertise across zoos
16:25	Jordyn Ellorin (USA): Feed risk management: Planning for emerging feed supply concerns at zoological institutions
16:40	**Poster pitches I**
17:10	Tatjana Ivasenko (Latvia): Riga Zoo Video
17:25	**Conclusion**
18:00	**ENG Working Group Meeting**

Saturday 21st January 2023

Zoo visit	
08:00	**Registration**
08:15	**Welcome & Zoo visit organisation**
09:00	**ZOO VISIT (with guided tours)**
11:00	**Break**
11:30	**ZOO VISIT (with activity stations)**
13:00	**Lunch break**
Insectivores	
14:00	Christine Osmann (Germany): The impact of a traditional in-house diet on the health of giant anteaters (*Myrmecophaga tridactyla*) and tamanduas (*Tamandua tetradactyla*) and aspects of switching to a complete diet – an overview
14:15	Anja Tschudin (Switzerland): Diets for insectivores: How a commercial diet is developed
14:30	Johanna Steinecker-Quast (Germany): Practical realisation and monitoring of a diet change in Giant anteaters and Tamanduas at Dortmund Zoo
14:45	Karoline Albig (Germany): Improving the diet of two large insectivore species in Zoo Halle
15:00	Ida Bähler (Switzerland): Scatter feeding in meerkats – encouraging natural feeding behaviour
15:15	Fabia Wyss (Switzerland): Creating an insectivores' paradise: Challenges of in-house breeding and feeding various types of invertebrates
15:30	**Break**
Zoo feeding practicalities	
16:10	**Sponsor pitches II**
16:25	Lily Bravo (UK): Feeding the Folivores: An analysis of zoo-housed koala (*Phascolarctos cinereus*) diet in the UK
16:40	Christopher Gee (UK): Browse provision at Chester
16:55	William Wallden (Sweden): Scaling up a new method to make browse silage
17:10	Lucie Brisson (France): Good hay for our herbivores
17:25	**Poster pitches II**
17:40	**Conclusion**
20:00	**Conference Gala Dinner** *(Bus departures from conference venue at **19:00, 19:20, 19:40**)*

Sunday 22nd January 2023

08:20	**Registration**
08:50	**Welcome**
09:00	Marcin Przbylo (Poland): Determining the palatability of commercial complete feeds used in the nutrition of Callitrichidae
09:15	Flore Viallard (France): Feeding interactions between emperor tamarins (*Saguinus imperator*) and Azara agoutis (*Dasyprocta azarae*) in a mixed enclosure
09:30	Geert Janssens (Belgium): Measuring vitamin D status in zoo primates through hair analysis
09:45	Rachel Jarvis (UK): Vitamin D in the European great ape population: what we know so far
10:00	Rebeka Šķērstiņa (Latvia): Wanted dead or alive: ethics and animal welfare in food choice
10:15	**Break**
10:55	Alessandro Di Marzio (Latvia): Raptor diets diversity based on species and their role in zoo collection
11:10	Elza Birbele (Latvia): Dietary guidelines for each developmental stage of the natterjack toad (*Epidalea calamita*)
11:25	Andrea Brenes (Costa Rica): Nutrient composition and season variation of native food items eaten by free ranging Great Green Macaws in Costa Rica
11:40	Clodagh Walsh (Ireland): Analysis of the nutritional components of Linnaeus's two-toed sloth (*Choloepus didactylus*) diets in UK and Irish zoos
11:55	Marcin Przbylo (Poland): Small ruminants may cope without concentrates, but also without produce: a case of southern pudu (*Pudu puda*)
12:10	Sarah Depauw (Belgium): Using indicators of positive animal welfare when evaluating nutritional changes in giraffes
12:25	**Poster award**
12:40	**Conclusion**
13:00	**Lunch break**

Poster Sessions

Group 1

Renārs Rozentāls (Latvia):	Healthy live snack for aquarium fishes
Line Enemark (Denmark):	The behavioral effects of feeding lean meat versus whole prey to captive jaguars (*Panthera onca*)
Ilona Roma (Latvia):	Zero km food for insects
Xinmei Wang (Belgium):	Feeding pangolins under human care: clues from their natural diet

Group 2

Renjie Yao (Belgium):	Nutrient analysis of stomach content in free-ranging wild boar
Benoît Quintard (France):	Effect of a transition to a fruit-free diet on primates' microbiome at Mulhouse Zoo
Flore Viallard (France):	Comparative survey of ruminant rations in zoological parks in France
Cathrine Sauer (Denmark):	A case of excess dietary vitamin D causing problems in captive Tasmanian wombats (*Vombatus ursinus tasmaniensis*)?
Mélodie Friedmann (Switzerland):	Activity budget and behaviour of giant otters (*Pteronura brasiliensis*) at Parken Zoo, Eskilstuna, Sweden

Information for Zoo Visit

Predicted Outdoor Temperature: -4°C–1°C (please check latest updates and dress appropriately)

Bus departure times

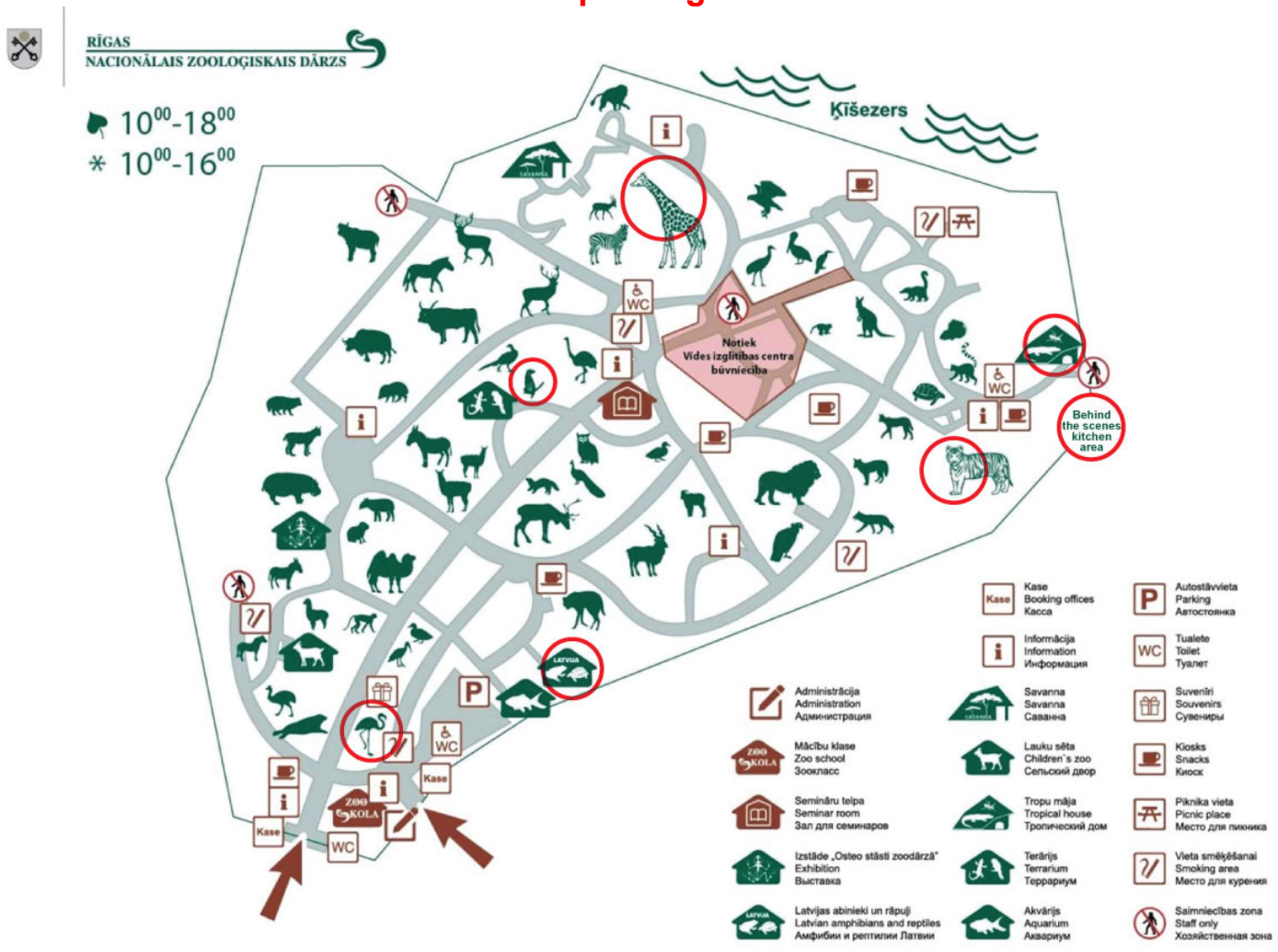
Conference Venue to Zoo: 08:15

Zoo to Conference Venue: 12:30

Workshop Stations:

- Zebra Viewing Point
- Tiger House
- Amphibian House
- Terrarium House
- Tropical House
- Giraffe House
- Nutrition Kitchen

Map of Riga Zoo



Diets of marine herbivorous fishes

Kendall D. Clements

School of Biological Sciences, University of Auckland, Auckland, New Zealand

Herbivorous fishes are considered critical to ecosystem processes in a variety of shallow marine habitats including coral reefs. Most marine herbivorous fishes belong to a relatively small number of fish families, with well-known examples being surgeonfishes (Acanthuridae), parrotfishes (Labridae), rabbitfishes (Siganidae), damselfishes (Pomacentridae), mullets (Mugilidae) and chubs (Kyphosidae). The photoautotroph assemblage that constitutes potential foods for these fishes is phylogenetically diverse and biochemically disparate. Fish taxa differ in their capacity to harvest, digest and assimilate these resources, and specialise to varying degrees.

The literature until very recently has been dominated by plant-based approaches, where herbivores are defined in terms of plant removal. In contrast, animal-based approaches focus on how photoautotroph resources satisfy the nutritional demands of herbivores. This talk will discuss the types of photoautotroph resources utilised by marine herbivorous fishes, how these are processed by the major fish taxa involved, and how these resources are partitioned by different fish taxa. Like terrestrial herbivorous vertebrates, herbivorous fishes lie along a spectrum from those that pass material through the gut rapidly and assimilate only easily digestible macronutrient components (rate maximisers) to those that employ symbiotic relationships with gut microbes to digest their food, a strategy that involves lengthy gut retention time and more complete digestion of foods (yield maximisers). Parrotfishes are the dominant group of rate maximisers on coral reefs, targeting protein-rich microscopic photoautotrophs such as cyanobacteria and microalgae that require little digestion. At the other extreme of this nutritional spectrum are kyphosid chubs, which are yield maximisers with a symbiotic hindgut microbiome that ferments refractory carbohydrate in macroalgae into metabolically useful short-chain fatty acids.

The talk will discuss diet and digestion in marine herbivorous fishes and argue that an animal-based approach involving nutritional mechanisms is key to developing an understanding of their dietary requirements in the wild and in captivity. Describing diet from a nutritional perspective often requires a variety of different approaches, from conventional gut content analysis in some species to various biomarker methods (e.g. stable isotope analysis, fatty acid analysis) and next-generation sequencing approaches such as diet metabarcoding in others. It is also important to consider trophic morphology, i.e. the capacity of different species to harvest and mechanically process different kinds of foods.

KEYWORDS: *Fish, seaweed, algae, cyanobacteria, hindgut fermentation*

k.clements@auckland.ac.nz

The fish tank as a rumen? Indirect evidence from feeding beet pulp to tambaqui (*Colossoma macropomum*)

Awot Teklu Mebratu[1,2], Leilani Vanhandsaeme[1], Yohannes Tekle Asfaw[3], Wouter Merckx[4], Marleen De Troch[5], Geert Paul Jules Janssens[1]

[1]Department of Veterinary and Biosciences, Ghent University, Belgium, [2]Department of Animal Reproduction and Welfare, Mekelle University, Ethiopia, [3]Department of Veterinary Basic and Diagnostic Sciences, Mekelle University, Ethiopia, [4]TRANSfarm, Engineering and Technology Group, The Catholic University of Leuven, Belgium, [5]Department of Biology, Marine Biology, Ghent University, Belgium

The “green water effect” is a concept based on the observation that fish often thrive better in water that is not completely clean. We hypothesized that fibrous feeds in the water may be converted into microbial matter as in the rumen, and that fish could feed on this microbial matter. We therefore added different concentrations of sugar beet pulp to tanks with tambaqui in addition to their pelleted diet. A total of 18 tambaqui fish (1616 ±107 g; 2 years old) were randomly divided over six similar tanks with 3 fish per tank and attributed to one of the six diet treatments: 0, 5, 10, 15, 20 and 25% beet pulp addition to an aqua-diet and reared for 8 weeks. Water samples were collected and water quality parameters (pH, ammonia-nitrogen, electric conductivity, total dissolved solids, dissolved oxygen and temperature) assessed and recorded twice a week for each tank. A 30-50% tap water renewal per week (10-17 L/day) in the recirculating aquaculture system (RAS) was done in individual tanks depending on the water quality parameters recorded. At the end of the experiment, whole-body crude fat was evaluated and fatty acids pattern were tested in the diet, longissimus muscle and water samples. There was quadratic change in whole-body fat content with increasing beet pulp with the highest being at 10% addition (18.2%; $P < 0.05$). Likewise, beet pulp caused quadratic increase in muscular concentrations of several fatty acids (C14:0, C20:0, C22:0, C16:1, C24:1, C22:6n-3, C16:1n-7, C18:1n-9; $P < 0.05$), but remarkably, many muscular fatty acid concentrations were associated independent of the beet pulp percentage. For instance, the correlation between myristic acid (C14:0) in muscle and tank water was 98% ($P < 0.001$) whereas this fatty acid showed no positive correlation between feed and water or between feed and muscle. The provision of beet pulp, a moisturous and fermentable fibre source, made the water quality hard to maintain, leading to variation between the tanks. We postulate that the aquatic microbial and invertebrate life in the tank benefited from the beet pulp, feeding on its turn the fish, according to a principle of an “external rumen” for the fish.
In conclusion, the beet pulp induced changes in the fish muscle fatty acid profile but some of the increased fatty acids were not higher in the beet pulp than in the basal diet, therefore seem to reflect the ingestion of aquatic organisms that grew on beet pulp as a substrate. The strong correlations between fish fat content and the microbial fatty acid profile may point to the importance of the green water effect in fish nutrition, similar to the function of the forestomach in ruminants. This serendipic finding matches the concept that many fish rely more on microbial matter from their environment as feed than usually observed in terrestrial vertebrates, will require further study to unravel the underlying mechanism.

KEYWORDS: *Beet pulp, tambaqui fish, microbials, water quality, fatty acid profiling*

AwotTeklu.Mebratu@UGent.be

Feeding fish in zoos: how to deal with diversity

Johan W. Schrama[1], Max Janse[2]

[1]Wageningen University, Aquaculture and Fisheries Group, P.O. Box 338, 6700 AH Wageningen, The Netherlands [2]Royal Burgers' Zoo, Antoon van Hooffplein 1, 6816 SH Arnhem, The Netherlands

Various species of fish are kept in managed aquaculture systems. This can be for different reasons like: for consumption by humans; as hobby (ornamental fish); and for display and conservation purposes (mainly in public aquaria and zoos). Especially for the latter, a large diversity of species is kept. The condition under which fish are kept in managed systems differs strongly: like salinity; water refreshment; type of waste management; stocking density; the presence/absence of a natural food web etc. The diet provided to fish should meet their nutritional requirements. Apart from the direct effect on the fish, the diet can also indirectly influence the fish through its impact on water quality by feed waste/spillage, faeces and metabolite excretion. In other words, the feed ratio, feeding method and diet composition are also important factors that determine the quality of environment in which the fish lives. Optimal feeding/balanced nutrient composition is a prerequisite for the well-being (health and welfare) of fish. Compared to terrestrial farm animals and pets, many more fish species are cultured and kept as ornamentals. Moreover, these fish species have a high diversity in feeding ecology and anatomy of the digestive tract. In contrast to terrestrial farm animals and pets, nutritional research has a shorter history and has been spread over a wider range of species. Consequently proper nutrition of fish is often facing the limited availability of information. In the presentation, various aspects of dealing with this diversity in fish species as well as husbandry conditions in relation to nutrition will be addressed like: differences in nutrient requirements between fish species; impact of physical condition feed/food type consumed (e.g. size & water content); individual differences between and within fish species; interaction between nutritional requirement and water quality; impact of feeding method and behaviour of fish; impact of fishmeal/oil replacement on diet formulations of fish feeds; impact of diets composition on water quality.

KEYWORDS: teleost fish; nutrition; feeding methods

johan.schrama@wur.nl

Practical feeding management of a large aquarium

Ton Weber

Rotterdam Zoo, The Netherlands

A healthy fish should be hungry and therefore easy to feed. However, feeding every individual fish to its needs can be quite a challenge in large aquarium systems - not only because of the tank volume, but sometimes more importantly because of the large mixed species-communities in these aquariums. Every extra animal in a tank means extra food competition, and in some cases even predator-prey competition. To make sure that the needs of every animal are met, we have to make choices in species composition, types of food, different ways of offering food, intervals of feeding, etc. But that is merely the basis - in keeping the fishes' welfare our priority we have to come up with innovations to increase their well-being. How do we keep both large individuals as sharks and schools of small bony fish well fed? The feeding management of several large aquarium systems in the Oceanium of the Rotterdam zoo will be discussed in this presentation. Examples of feeding will be given, feed types used, manners of feeding, mixed species tank feeding tactics, what other factors to keep in mind and more ideas on how to improve on this subject.

KEYWORDS: fish, shark, carnivore, predation, aquarium, management

t.weber@diergaardeblijdorp.nl

Fishing seas for conservation?

Sander van Lopik

Rotterdam Zoo, the Netherlands

As (EAZA) zoos and aquaria we believe we have a strong role to play in protecting nature and wildlife. We are trying to give our animals the best life possible. This includes serving a specific diet to our animals. Sometimes the best available diet for our animals includes processed complete feeds such as pellets or additive vitamin preparations. In many cases these processed complete feeds for omnivorous and carnivorous animals contain fish meal. Yet, we do not know the origin of this ingredient and which fish species it includes. There is little to zero control in which fish species are processed which could mean that we are feeding our hyena, flamingo or Komodo dragon endangered fish. However the same fish meal is used in many products for our beloved pets too. Millions of uncontrolled saltwater fish end up in stomachs of cats and dogs.
We should be aware that keeping our own animals both at home and in the zoo could have a negative effect on species in nature.
In Rotterdam zoo we would like to address this problem from different angles.
By making our own (vegan) fish feed we reduce impact on oceans in the zoo. For instance by using solely aqua cultured vegetable products, such as micro- and macroalgae. Especially for grazing saltwater fish such as mullets, surgeonfish and rabbitfish, but also freshwater grazers diet mismatches could be prevented. Currently herbivorous fish in aquaria get fed with carnivorous ingredients such as fish meal. By providing employees and visitors with proper information about animal feeds we want to show there is a sustainable choice to make. And with our breeding system project in Bonaire we are trying to give the oceans something back they desperately need after taking so many of its inhabitants. This presentation will outline Rotterdam Zoo's projects but focus on the design, production and use of our home-made fish feeds.

KEYWORDS: *Fish, complete feed, carbon pawprint*

s.van.lopik@diergaardeblijdorp.nl

Large carnivore feeding in European zoos and consideration on the use of fasting days in large carnivore husbandry

Cellina L.M. Kleinlugtenbelt[1], Anita Burkevica[2], Annelies De Cuyper[3], Marcus Clauss[1]

[1]Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Winterthurerstr. 260, 8057 Zurich, Switzerland
[2]Parken Zoo, Flackstavägen 13, 63222 Eskilstuna, Sweden
[3]Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent, University, Heidestraat 19 9820 Merelbeke, Belgium

Since many large mammalian carnivores do not hunt every day in their natural habitats, because given the right prey, they can gorge-feed more than their daily energy and nutrient requires. At the same time, there is a tradition of exposing these species to one or several fasting days per week in zoos. Because feeding management may particularly influence carnivore behaviour, we collected and recorded feeding routines for 11 large carnivore species in 44 European zoos in 7 different countries by personal visits and surveyed husbandry guidelines for large carnivores.
Carnivore guidelines did not suggest that fasting days should be preceded by gorge feeding, and most common practices observed at the zoos also did not include a gorge-feeding day prior to the fasting days. This raises the question why fasting days are implemented in zoo regime in the first place. Moreover, as a diet item, meat on bone was used by the majority of zoos, and carcass feeding was mainly practiced with small (rodents, rabbit, chicken), but hardly with large carcasses. Whereas many facilities reported a certain repertoire of feeding methods of varying potential enrichment value, during the visits themselves, most facilities used those methods of their feeding repertoire that can be considered less labour-intensive and less enriching. The number of facilities that only used a limited number of feeding methods was unexpectedly high, and methods like swing pole feeders, pulley feeders or self-serving feeders were not in use in any visited facility. Additionally, neither methods that require social carnivores to cooperate to access food, nor other feeding methods during which animals can actually fail to obtain their food (mimicking unsuccessful hunting) were reported. We suggest that these current feeding regimes of zoo carnivores should be re-assessed. The combination of fasting days with preceding gorge-feeding, together with frequently used strenuous physical activity and cognitive challenges linked to the feeding event, might have the potential to mimic natural behaviours more closely than current practices. A written feeding management plan including more challenging feeding methods could ensure that these feeding methods are not only used sporadically, but at a consistent frequency. Such an approach could at the same time ensure that appropriate resources in terms of equipment, diet items, and work time are available.

KEYWORDS: large carnivores, feeding methods, whole carcass, feeding enrichment, animal fiber, fasting days, gorge-fast regime

c.kleinlugtenbelt@gmail.com

Fibre and health in felids and other carnivores

Annelies De Cuyper[1], Mengmeng Sun[1], Sylvie D'Hooghe[1], Geert P.J. Janssens[1]

[1]Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University, Belgium

Work in cheetahs pointed to prominent improvement of health markers (fecal inflammation markers, nephrotoxins, occurrence of gastro-intestinal disease) when feeding whole carcass versus supplemented meat or processed foods (Depauw et al., 2013; Whitehouse-Tedd et al., 2015). The main difference between these diet types is the level of animal fibre. Because most animal fibre is proteinaceous, dietary macronutrient profiles may overestimate the need for digestible protein and underestimate the need or at least the natural intake of fibre in carnivores. An *in vitro* digestion study revealed prominent differences in digestibility between rat tissues (Sun et al., 2022). Animal fibre can be defined as the matter in an animal-based diet that passes enzymatic digestion and has similar effects as plant fibres. The impact of animal fibre on carnivore health is not yet fully understood. Observations in free-ranging brown bears suggest a fairly constant intake of fibre throughout the year, despite strong seasonal changes in actual diet items. The traditional methods for fibre analyses are not all (fully) suitable to accurately measure animal fibre. In addition, fibre has a chemical aspect (molecular make-up) as well as a physical aspect (food structure). In a recent study, we fed either minced or whole mice to domestic cats, showing that for instance the fecal profile of biogenic amines is affected; yet, the difference between mice and a processed kibble diet was still far larger than the effect of mincing, indicating that other aspects than just particle size are determining the proposed health effects of fibrous diets in carnivores (D'Hooghe et al., 2022). In a former study with dogs fed whole chicks minced at different particle sizes, changes in fermentation and passage rate were also negligible (De Cuyper et al., 2018). The processing itself (e.g. heating) may be partly responsible, so we are now comparing the fibre traits of petfoods before and after processing. Apart from characterising the fibre component in carnivore diets, the other challenge is to define how health can be measured in carnivores. Often, a kind of anthropocentrism can be perceived wherein intestinal microorganisms typically judged as beneficial for humans (e.g. Lactobacilli and Bifidobacteria) are assumed to be positive markers or health in carnivores as well. Yet, several of our studies demonstrated that a nature-like carcass-based diet actually shifts away from these microorganisms and rather promotes Clostridiaceae (cheetah: Becker et al., 2014; dog & wolf: Xu et al., 2021; domestic cat: D'Hooghe et al., 2022). Therefore, the more desired microbiome of carnivores is likely represented by Clostridiaceae. The link with host health is still not fully elucidated, and requires the identification of a non-invasive, species-independent inflammation marker. Nevertheless, evidence is growing that the "fibrous" character of whole-carcass feeding may benefit the health of at least carnivorous mammals.

KEYWORDS: *prey feeding, microbiome, Carnivory*

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geert.janssens@ugent.be

‘Many mouths to feed’: The design and centralization of a walk-in Commissary at Amersfoort Zoo

Anouk Fens

Dierenpark Amersfoort, Amersfoort, Netherlands

Proper animal feeding management is one of the important elements in the success of captive animal populations as nutrition can have beneficial effects on animal health and welfare. The zoo commissary and management practices are an important instrument in the feeding management of zoo animals. The commissary is a busy and dynamic environment, where preparation of diets for hundreds of animals take place, seven days a week, all year long. Therefore, the commissary requires to be an organised, well-oiled machine in which all work can be done efficiency but also hygiene standards can be lived up to. The design of the existing commissary facility in Amersfoort Zoo was outdated and did not have the capacity for all functions a modern commissary requires. Instead of renovating the old facilities, it was decided to design a new facility inside the zoo, open to the public. After a long process of development and designing, the new commissary was opened at the end of 2022. Within this highly modern walk-in building, visitors are able to behold the entire process of food preparation. With help of sightlines through walls made of glass, all different areas, from cleaning area till freezer equipment, are visible to the public. The new commissary is a centralized operation, meaning all food for the animals is weighed, prepared and stored by the commissary staff, before delivery to the animals within the zoo. The working area consists of several food preparation areas, freezer and refrigerators, storage rooms and an insect breeding room. Revision of procedures and working processes have been conducted in order to reduce the complexity of the centralized process. For example, diet preparation is now conducted with help of an online software tool in which diets are presented in a standardized format. Hygiene standards are followed up by color-coding equipment dedicated for use in specific working areas. Food delivery takes place by sustainable electro cars. These improvements, along with the employment of a nutritionist, are important first steps to elevate animal nutrition in Amersfoort Zoo to a higher level.

KEYWORDS: *zoo commissary, diet*

A.Fens@Apenheul.nl

Integrated pest management for zoo food facilities

Joeke Nijboer

NijboerConsultancy, Struisvaren 21, Bergschenhoek, The Netherlands

Pests are culture followers that means that they live in the same environment as humans and/or their animals. People consider them troublesome because of competition and because they despoil food, spread disease, lead to unhygienic conditions and cause annoyance and phobias.
Around 60 different species of mammals, birds and insects can be found in zoo food facilities and can be considered as pests. In order to control them, the biology of these species needs to be understood so that a systematic approach can be developed for prevention.
The basis of this systematic approach is called Integrated Pest Management (IPM). It consists of four steps: monitoring, habitat management, non-chemical control measures and, if these first steps have been ineffective, the use of chemical controls or biocides.
In this talk the four steps of the IPM model for the most common pests found in zoo food facilities, the brown rat (*Rattus norvegicus*), the house mouse (*Mus Musculus*), the German cockroach (*Blatella germancia*), the wheat weevil (*Sitophilus granarius*) and the housefly (*Musca domestica*), are described.
Similar steps should also be taken in zoo food facilities to keep other pest species under control.

KEYWORDS: *IPM, pests, brown rat, house mouse, German cockroach, wheat weevil and housefly*

joeke@nijboerconsultancy.nl

Identifying and sharing nutrition expertise across zoos

Lauren Samet[1] & Anouk Fens[2]

[1]Chester Zoo, Cheshire, UK; [2]Apenhaul Primate Park, Netherlands.

Although appropriate animal nutrition makes up one fifth of the animal welfare domains, European zoos are still greatly lacking in resource to maximise this potential. “Resource” comes in many forms and one example is the employment of zoo nutritionist staff within collections to ensure diets are appropriate and food is fed out in a stimulating and naturalistic manner. At the time of writing the UK had only three animal nutritionists employed within permanent zoo staff amongst their collections. Meanwhile within EAZA’s European Zoo Nutrition Group (ENG), a further eight nutritionists were employed within this type of job role amongst European zoos and aquariums. Thankfully many other zoo animal and wildlife nutrition expertise exist outside of these immediate zoo-based roles (for example, academic researchers and veterinary specialists). However, at the time of writing, those identified and within the ENG totalled 30 people in contrast to the 307 collections that had full EAZA membership, and as such this resource was still limited. To recognise where further species’ nutrition expertise might lie across EAZA members, and to identify which TAGs do not yet have assistance from a nutritional specialist, part 1 of this talk presents results from the ENG’s survey of EAZA’s Taxonomic Advisory Groups (TAGs), EAZA Ex-Situ Programme (EEPs) leaders, and European Studbook (ESB) holders in the summer of 2022. The survey was advertised within the community via EAZA News, LinkedIn, the @EAZAnutrition Facebook page, and via ENG colleagues’ collections; 89 respondents took part. At least one representative from 41 of the 42 TAGs took part; 66% (59) respondents did not have (or did not know) whether their TAG/EEP/ESB affiliations had nutritional advisors (NAs), indicating 15 TAGs did not yet have NAs working with them. Of the 30 respondents that identified NAs, 77% (23) of answers were ENG members (specifically 4 individuals within the ENG), while outside of the ENG a further 10 names were cited. The ENG plan to use these data to offer support to TAGs that do not yet have support from a NA, as well as contacting those NAs not yet in the ENG to see if they would like to join as a member. Part 2 of this talk discusses the further resources available within our community to share zoo nutrition expertise, with a reminder of how we can use Species 360 and ZIMS for logging feeds and assigning nutrition based welfare indicators.

KEYWORDS: *Data sharing, EAZA, nutrition advisors, welfare.*

L.Samet@chesterzoo.org

Feed risk management: Planning for emerging feed supply concerns at zoological institutions

Jordyn Ellorin, MS[1], Andrea Fidgett, PhD[1] and Jennifer D'Amato-Anderson, MS[1]

[1]Wildlife Nutrition, San Diego Zoo Wildlife Alliance, San Diego, CA 92112, USA

Emerging diseases, disasters, and risks threaten modern diet management and create a need for ongoing contingency planning. At the beginning of the COVID-19 pandemic, San Diego Zoo Wildlife Alliance created Enterprise Risk Management (ERM) tables for the organization. ERM, commonly used in business, is a method to manage risks, monitor processes, and identify areas of opportunity to bring stability to an organization. Wildlife Nutrition utilized this method of risk identification to comprehensively evaluate our ability to secure food for the animals in our care and continue to provide nutritionally complete diets for all individuals.

Through adaptation of business ERM tables, rubrics were outlined with the goal to identify areas of risk, standardize reporting, and improve response strategies. These rubrics defined two major variables, likelihood and impact, through which each vendor, feed item, and species was assigned a rank. The likelihood rank identified how likely and how often to expect a break in supply. Feed items and vendors were each assigned a likelihood rank and any alternative vendors or feed items used historically were also recorded and assigned a rank. Travel distance of feed items to our organization, travel methods, past issues with vendor, size of operation, custom or widely available items, etc. were all considered during the ranking process. For the impact rank, species and their feed items were evaluated based on how critical an item was for the species, proportion of an item within a diet, and if there were any alternative feed items identified or available. These three factors determined the total impact rank. Species were grouped to the highest level possible as related to the feed item, but also allowed for flexibility based on life stage needs and clinical cases. For example, bird species could be grouped for feed items like trout, but for chick-rearing diets a specific size of trout may be necessary and thus was provided an individual score. When the impact and likelihood scores were combined, a final 'ERM score' was calculated which highlighted areas of risk for the team to focus on critical feed items which pivoted our purchasing and storage decisions. Additionally, during supply chain incidents that limited purchasing volumes, this data allowed for easy prioritization of feed items and target species.

In addition to preparing for supply chain issues, the ERM table records decades of institutional expertise and knowledge into a centralized location. This data can also be utilized to identify patterns and frequency of supply chain issues (seasonal, vendor specific, etc.) which allows a more proactive approach to future decisions and preparation for seasonal shifts. ERM tables are now a vital tool in our modern diet management to improve decision-making capabilities and adapt to emerging risks as we maintain an excellent standard of animal nutrition and health.

KEYWORDS: *Supply chain, feed items, diet alternatives, risk management*

jellorin@sdzwa.org

Animal nutrition at Riga Zoo

Tatjana Ivasenko[1], Ilona Roma[1], Julija Lauberte[1], Renārs Rozentāls[1], Guna Vitola[1], Solvita Valaine[1], Alessandro Di Marzio[1]

[1]Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, Ziemelu rajons, LV-1014 Riga (Latvia)

The correct design of specific diets, related to the particular requirements of each species, is fundamental to guarantee a good health status of the animals in a zoo collection. At Riga Zoo, the presence of a large number of species, often coming from distant areas, with specific dietary requirements represents a major challenge for the animal food department. The volumes of food and in some cases the particular requirements (e.g. lichens for forest reindeer) require a great logistical effort. The Zoo also produces part of the food necessary for our animals' diets. In this case, as well as for the purchased food, we pay a lot of attention to the quality of the raw materials. This presentation (a video) shows all the steps, from the reception of the feed until the moment it is consumed for our animals. It is intended as a way to show the participants of the conference our working methodology, especially for those exotic species that during the conference will not be visible in the outside facilities, and as a dedication to the important work that all the zoo staff performs daily to ensure the welfare of our animals.

KEYWORDS: *Zoo nutrition, specific diet, Zoo work, Video*

research@rigazoo.lv

The impact of a traditional in-house diet on the health of giant anteaters (*Myrmecophaga tridactyla)* and tamanduas (*Tamandua tetradactyla*) and aspects of switching to a complete diet – an overview

Christine Osmann[1], Johanna Steinecker-Quast[1,2], Anja Tschudin[3] & Annette Liesegang[4]

[1]Dortmund Zoo, Dortmund, Germany; [2]Allwetterzoo Münster, Münster, Germany; [3]Granovit Zoofeed, Granovit AG, Kaiseraugst, Switzerland; [4]Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

In Dortmund Zoo / Germany, giant anteaters and tamanduas were traditionally fed with an inhouse-mix, the so-called "Dortmund mixture", which was developed decades ago. Main ingredients were minced meat (preferably beef heart), a chitin source, dry dog food, boiled eggs, vegetables / fruits and oat flakes. The composition of this feed has been subject to various changes over the years. Empirically, it seemed to be an appropriate feed for these insectivorous species for a long time: Components were available all year round, the acceptance of the prepared food mix was good, and there was outstanding breeding success in both species: 65 giant anteaters have been bred at Dortmund Zoo (EEP and ISB keeper) within 44 years while 34 tamanduas were born here in 25 years. Furthermore, animals of both species reached a relatively high age of more than 15 years. Therefore, at first sight, there were no obvious reasons for adjusting the feeding regime. However, over the years, disadvantages of the “Dortmund mixture” emerged: The high carbohydrate content resulted in relatively high weights of the animals, which was assessed retrospectively as beginning obesity. Some older individuals of giant anteaters developed liver disease with ascites and suspected diabetes. In former times, there was one case of alopecia and severe spondylosis of the spine and osteoarthritis of large joints, probably because of an overdose of vitamins A and D in the diet. At present, vertebral spondylosis could also be observed in older giant anteaters. Probably due to the high-energy feeding, comparatively high birth weights of neonates of up to 2 kg body mass and two clinical cases of obstetrics had occurred. Enlarged hearts and – in one case – cardiac insufficiency developed in older individuals of giant anteaters. Taurine deficiency has been discussed as a cause of DCM / dilatated cardiomyopathy in this species, and taurine was so far not deliberately supplemented in the traditional diet. Among the tamanduas, cases of spine ossification, soft tissue calcification and kidney disease dominated in older animals; etiologically the high and variable proportion of fat-soluble vitamins in the dry dog food as a component of the own mixture, as well as additional supplementation of vitamins and minerals, were suspected as contributing factors. As a consequence of all facts, the decision was made to develop a diet more adapted to insectivorous species. Since 2018, a complete feed was established at Dortmund Zoo for giant anteaters and tamanduas in order to improve animal health in the long term.

KEYWORDS: *Giant anteater, Tamandua, Dortmund mixture, high energy content, beginning obesity, liver disease, spine and soft tissue calcification*

c.osmann@stadtdo.de

Diets for insectivores: How a commercial diet is developed

Anja Tschudin[1], Johanna Steinecker-Quast[2,3], Christine Osmann[2] & Annette Liesegang[4]

[1]Granovit Zoofeed, Granovit AG, Kaiseraugst, Switzerland; [2]Dortmund Zoo, Dortmund, Germany;3 Allwetterzoo Münster, Münster, Germany; [4]Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

Commercial complete feeds nowadays play a significant role in the diets of insectivorous zoo animals, slowly replacing home-mixed porridge type feeds. Although the transition is often protracted and difficult, commercial feeds offer some advantages, such as better standardization, sanitation, easier animal transfer to other zoos, and better control over nutrient content. Despite some improvements in feeding with feeds already available, nutrient-associated problems are still observed in insectivorous animals. Especially in giant anteaters (*Myrmecophaga tridactyla)* and tamanduas (*Tamandua spp*.), tissue calcification and spondylosis are common health problems.
Several examples will be used to show how the development of a feed, or an entire nutritional concept can proceed, and what steps are involved in a scientifically developed commercial feed: Based on literature data, case reports, data on natural diet, husbandry guidelines and with the help of a model animal species, the desired nutrient profile for the animal species and thus for the feed is defined. Suitable raw materials are then selected and combined in a way that ensures the nutrient profile is met. Technical feasibility, raw material availability and sustainability considerations are all factored into the decision. After a test production, the feed is tested on a small test population, the feedback on acceptance is evaluated and the formulation is adjusted if necessary. Nutrient analyses of the feed are used for quality assurance. Only through long-term use, husbandry feedback and feedback after animal transfers, evaluation of blood results and pathology reports, the success of the feed change will become measurable in the long term. For animal species for which a complementary feed rather than a complete feed is appropriate, e.g. sloth bears (*Melursus ursinus*) or armadillos (*Dasypoda*), additional considerations regarding the composition of the total ration become important. In insectivores, this is with particular attention to the calcium:phosphorus ratio and the vitamin A and D content of the ration.

KEYWORDS: *insectivore, diet, development, complete feed, complementary feed*

Anja_Tschudin@granovit.ch

Practical realization and monitoring of a diet change in Giant anteaters (*Myrmecophaga tridactyla*) and Tamanduas (*Tamandua tetradactyla*) at Dortmund Zoo

Johanna Steinecker-Quast[1,2], Christine Osmann[2], Anja Tschudin[3] & Annette Liesegang[4]

[1]Allwetterzoo Münster, Münster, Germany; [2] Dortmund Zoo, Dortmund, Germany; [3]Granovit Zoofeed, Granovit AG, Kaiseraugst, Switzerland; [4]Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

After several unsuccessful attempts to establish a complete feed for giant anteaters and tamanduas at Dortmund Zoo, a new attempt was started in 2018. Several parameters were intensively monitored within the framework of a scientific study. At that time, 6 giant anteaters and 4 tamanduas were kept at Dortmund Zoo. During a period of 6 months, the food intake was monitored daily and the weight and body condition were measured weekly by a newly established “hands-on” body condition score. Blood values of the animals were determined occasionally as part of routine examinations. In a first step, the previous feed (“Dortmund mixture”) was gradually replaced by a new complete feed. Afterwards, all animals were exclusively offered the new complete feed, and any other feeding, such as treats or feed items for enrichment, were stopped during this period. The anteaters were fed individually twice a day. The first portion was available for 2 hours in the morning, the second for the whole night. After initial weight losses the acceptance of the new diet improved continuously and a stable body mass was achieved in all animals.
The body condition score was also in an acceptable range for all animals. As most of the study took place in summer and the animals therefore spent a lot of time in the outdoor enclosures, a change in behavior could be observed: While the animals slept up to several hours during the day with the former “Dortmund mixture”, they were visibly more active with the new complete diet and used e.g., wood for enrichment purposes. The addition of sieved peat to the giant anteaters' rations clearly improved faecal consistency and is now used as a standard feature. The weight was continually monitored weekly, and after 3 years it became apparent that the weight of all animals continued to be stable. A female offspring born during the study period could be adapted successfully to the new diet after weaning and showed appropriate weight gain. The amount of feed nowadays even had to be reduced for some individuals, e.g., older animals with less daily activity and energy consumption, in order to keep body mass stable.
In conclusion, the new complete feed has important advantages compared to the previous Dortmund mixture, for example in terms of feed hygiene, preparation time and more natural ingredients. The feed continuity, which is important for giant anteaters, is also ensured, which was particularly evident after animals were transported to other zoos.

KEYWORDS: *Giant anteater, Tamandua, Myrmecophagidae, complete feed, diet change, Body Condition Score*

steinecker-quast@allwetterzoo.de

Improving the diet of two large insectivore species in Zoo Halle

Karoline Albig, Dennis Müller & Sven Zeidler

Zoologischer Garten Halle, Germany

In the last 20 years, commercially produced complete feed products for insectivore species have been developed, today even available in pelleted or extrudated form. With insect protein as primary protein source, these products constitute an adaptation to the natural diet of insectivores regarding not only protein, fat and fibre rate, but also macrominerals and trace elements. Anyway, the diet of large insectivores still varies widely among zoos.
Myrmecophagous species such as giant anteaters (*Myrmecophaga tridactyla*) have been kept successfully in Zoo Halle for more than 30 years, feeding on a diet which consisted mainly of meat-based products like high-quality dog food, shrimp shell flour and ground meat mixed with fruits, vegetables and vitamins. Only a few years ago, the diet of giant anteaters was adapted by replacing it partly with a supplementary feed containing poultry meal, shrimps and dried whole egg. With the introduction of another large insectivore species in 2021, the aardvark (*Orycteropus afer*), the diet of all insectivores in Zoo Halle was once more examined and reassessed. For aardvarks the original diet was replaced by a new commercial complete feed product developed based on current scientific research with significantly higher percentage of insect proteins and optimised calcium:phosphorus ratio. Over a period of four weeks, two female aardvarks were accustomed to the new product in four steps. The animals were monitored closely and weighed on two days per week. Furthermore, the food intake was weighed as well as leftovers if present. After four weeks 100% of the original product were replaced and until today the aardvarks are solely fed on the new product. The acceptance of the new feed was constantly high during the entire observation period. No weight loss or change in faeces consistency were observed. In a second approach, the supplementary feed for the giant anteaters in Zoo Halle will be replaced by the new complete feed as well. Unlike in the aardvarks, the product only represents 50 - 60% of the anteater's diet and will be replaced to this maximum percentage. Known to be challenging in acceptance of new products, only one young female will be chosen to participate. Results will be presented as well in this presentation.

KEYWORDS: *Aardvark*, a*nteater, diet switch, insectivore, complete feed*

karoline.albig@zoo-halle.de

Scatter feeding in meerkats – encouraging natural feeding behaviour

Ida Baehler[1], Karin Federer[2], Fabian Klimmek[2], Sebastian Weber[3], Leyla Davis & Marcus Clauss[1]

[1]Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, [2]Walterzoo Gossau Switzerland, [3]Zoo Zürich Switzerland

Enhancement of zoo husbandry an important aim of modern zoos. Animals in our care should have the chance to live out their species-specific behaviours in the best possible way. The nutritional aspect is an important part of animal husbandry, which may still require optimization. There are big differences between how animals feed in the wild and what they are offered in zoos. In meerkats (*Suricata suricatta*), for example a large variety of feeding regimes have been reported in zoos. Their husbandry feeding guidelines differ greatly from the species' natural feeding behavior shown in the wild. Our aim is to design a feeding regime, based on fundamental patterns observed in meerkats feeding in the wild.
With a scatter feeding regime, we offer the meerkats insectivore-based extrudates as frequently as possible over a large area in the facility. The behaviour of meerkats is studied over several weeks, with either a conventional feeding regime (offering a variety of food on a small area/ in bowls once or a few times a day) or a scatter feeding regime (distributing small insectivore extrudates over a large area, 16 -24 times a day). The animals' behaviour is evaluated every five minutes throughout the day to analyze how the feeding regime affects their daily activity. The meerkats show a strong increase in foraging behaviour during the scatter feeding regime. Moreover, feeding-related aggressions or monopolizing food behavior can no longer be observed. Frequent feeding stimulates the animals over and over to forage for food. Meerkats in the wild spend several hours per day foraging. Thus, scatter feeding stimulates a clear tendency to get closer to the natural behaviour of this species.
Our study demonstrates that a scatter feeding regime is a valuable way to avoid feeding-related aggression and keeping the animals busy and active during the day. As a result, this regime allows zoo-housed meerkats to act out more natural behaviours. Importantly, this is accomplished without increasing the workload for the animal care staff due to the automated system. The results of this study confirm impacts of nutritional aspects for more natural animal husbandry.

KEYWORDS: *meerkat, foraging, scatter feeding, husbandry, welfare, nutrition*

ida.baehler@uzh.ch

Creating an insectivores' paradise: Challenges of in-house breeding and feeding various types of invertebrates

Fabia Wyss, Björn Lehner & Thomas Aerni

Zoo Basel, Switzerland

A large and still growing reptile and avian collection, and especially breeding of these animals, warrants a large variety of available food invertebrates. Zoo Basel has traditionally bred smaller amounts of invertebrates in-house; each section had their own breeding. In 2013, an invertebrate breeding section was created, dedicated to breed various types of insects under controlled conditions for the needs of the growing insectivore collection. The largest amounts are bred from crickets (*Gryllus assimilis*) with up to 16'000 animals/week, reaching about 750'000 animals per year followed by locusts (*Locusta migratoria)* with up to 9'000 animals per week. Flying (wild type) and flightless fruit flies (*Drosophila melanogaster*), earth worms (*Dendrodrilus rubidus*), beetle (*Pachnoda marginata*) larvae, house flies (*Musca domestica*), firebrats *(Thermobia domestica*), small and large snout moths (*Galleria mellonella, Achroia grisella*), Madagascar hissing cockroaches (*Gromphadorhina portentosa*) and Dubia roaches (*Blaptica dubia*) are bred in lower quantities and partially on command of the respective sections. Factors like the reproduction rate and speed, climatic requirements for breeding, nutritional requirements, but also their potential as pest animals with uncontrolled reproduction were decisive for the choices. Different temperature and moisture requirements are difficult to achieve if only one room for the invertebrate breeding section is available, and the use of incubators with specific climates may be considered for certain invertebrates.
The decision whether to feed an invertebrate alive, freshly dead, or frozen and thawed, depends on the type of insectivore and its environment as well as the type of invertebrate. Enrichment is the biggest advantage of feeding live invertebrates additionally to having a regular supply (e.g. for fruit flies in a pot). Beside the more and more controversial feeding of live animals, other disadvantages related to the lifestyle and the behavior of the respective invertebrates should be taken into consideration. For example, crickets tend to hide in dark spaces and reappear only during night times, which makes them inappropriate for a diurnal animal.
If invertebrates are humanely killed prior to be fed out, boiling or direct freezing are the two methods used in Zoo Basel. Boiling is the preferred method and used for smaller quantities and if invertebrates are fed out freshly on the same day. However, this is impractical for larger quantities that go to the frozen storage, because they would have to be dried again before freezing. Also, in our experience, boiling water is not hot enough for larger insects with thick chitin shells (e.g. larger beetles, cockroaches); therefore, these are directly frozen in their holding containers to avoid stress as much as possible. Limited guidance is available about how to humanely kill an invertebrate, because invertebrates are not covered in animal welfare regulations in most countries. As a general consideration, methods should minimize the potential of pain and stress, be safe and terminal, but should still be compatible with the animals' use and purpose after death.

KEYWORDS: *Invertebrates, in-house breeding, insectivore nutrition, humane killing*

Fabia.Wyss@zoobasel.ch

Feeding the folivores: An analysis of zoo-housed koala (*Phascolarctos cinereus*) diet in the UK

Lily Bravo, Kerry Hunt & Marianne Freeman

University Centre Sparsholt, Sparsholt, Winchester, ENGLAND. SO21 2NF

The koala (*Phascolarctos cinereus)* is an epitomised dietary specialist, feeding almost exclusively from the foliage of eucalyptus, however, while being highly selective within this narrow dietary range. There are several factors that are not sufficiently understood hypothesised to influence preference, with previous research primarily assessing the role of secondary plant compounds. Literature has indicated selectivity towards younger foliage; however, this has not been formally quantified. A nutritional preference study was conducted for three koalas at a zoological collection in the United Kingdom. Comparison was made between eight species of eucalyptus grown on and off site. Behavioural observations first took place to assess preferred eucalyptus variety and leaf age. Samples of selected and unselected leaves were nutritionally analysed to obtain protein, nitrogen, moisture, and fat content, to assess for correlations between nutrition and selection. Association between selection and leaf age was also tested. Results found no significant correlation between the investigated nutritional compounds and selection ($P>0.05$), suggesting a wider combination of nutritional factors to denote preference. However, a significant association between leaf age and selection was identified, quantifying the preference for young over mature foliage ($P<0.001$). Significant preference for certain varieties over others was also observed ($P<0.001$). The results indicate *E. aggregata and E. viminalis* to be examples of preferred eucalyptus from which both young and mature foliage is consumed in significant amounts. Differences in leaf age selection was also observed between eucalyptus grown on and off site. This research forms the initial stages of a wider study and which is hoped to be used to minimise feed wastage in zoos and best practice management techniques for feeding koalas outside of Australia.

KEYWORDS: *koala, preference, foliage, nutrient, eucalyptus, selectivity*

lilithbravo1308@gmail.com
kerry.hunt@sparsholt.ac.uk

Practical operational management of browse plantations and browse silage at Chester Zoo

Christopher Gee

Chester Zoo, Cheshire, UK

This presentation gives an overview of the planning and day-to-day management of the 36 acre browse plantation at Chester Zoo, UK. The zoo predominantly grows nine species of willow (*Salix*) for browse including plots of *vars. Endurance, Terra Nova, Advance, Paramore*, and *Resolution*. Chester Zoo's Animal and Plant Logistical Services (APLS) deliver fresh browse 365 days a year around site to the zoo's ungulate and elephant teams. The animal species fed browse at the zoo include Rothschild's giraffe (*Giraffa camelopardalis*), black rhino (*Diceros bicornis*), greater one-horned rhino (*Rhinoceros unicornis*), Asian elephants (*Elephas maximus*), okapi (*Okapia johnstoni*) and bongo (*Tragelaphus eurycerus*); however smaller amounts of browse are also supplied weekly to the zoo's bird and small mammal teams.
APLS harvest an average of 800 willow trees per day during the UK's summer months (March–October). Meanwhile, during winter months, (November-February) the team manage offsite browse collection services at fifteen land holdings across Cheshire & North Wales (including golf clubs, woodlands and farmland). In addition to the fresh winter browse supply from offsite collection, the team also produce willow leaf silage to increase the quantities of leaf matter that can be fed to browsing species over winter. For example, in 2022, they produced 35,000 liters of willow leaf silage that was barreled during summer months using a system that included help from the zoo's corporate volunteer scheme. This talk will discuss sustainable management of the plantations, wildlife-friendly harvesting, logistical practicalities of management, and the zoo's future aspirations for feeding larger quantities of fresh browse and silage out to a greater number of species at the zoo.

KEYWORDS: *Browse, Willow silage, Logistical services*

C.Gee@chesterzoo.org

Scaling up a new method of silage browse

William Walldén

Kolmården Zoo, Sweden

As with most zoos, Kolmården is struggling to provide more browse for our animals, especially during the winters as we are located in Sweden. We do not have access to a lot of winter green browse. Frozen browse demands a lot of space and energy. This leaves silage as the only reliable option, although producing the necessary amounts is quite labour intensive.
From 2016-2019, we tried several different ways of making browse silage.
In the summer of 2022, we tried scaling up our most promising method, making 7 tons of browse silage in within 10 days, with plans on doing more.
A local farmer helped us construct a little machine from plywood and two cheap boat winches. We placed our freshly cut browse between the plywood and folded the branches one time if needed. When the space between the plywood was filled, we used tension bands and the winches to roll the browse and press it tightly, making a bale of about 200 kg. At the end of the day, we drove the browse to a nearby farm and put bale plastic on them. Before putting the plastic on we cut of any weird pointing branches and put one layer of old plastic around for extra protection. To make sure that the branches did not penetrate the plastic we put 14 layers of bale plastic after putting the extra plastic in between.
We will be analyzing the silage during the autumn and make calculations on how much actual food this silage resulted in for different browsing species such as giraffes, tapirs and gorillas. This way we can see how this method can economically benefit us, making it possible to feed even more browse.
Experience from earlier years showed us that for some species, browse silage is more palatable than fresh browse. This gives us the opportunity to utilize tree species grown within the park which usually go to waste, such as *Alnus glutinosa*.
We hope that sharing our way of making silage of whole browse, 1.5 meters – 3 meters tall, can inspire other institutions to come up with more efficient methods, making it possible to provide a greater quantity of browse for a larger group of animals throughout all seasons.

KEYWORDS: *Browse, Silage*

William.Wallden@kolmarden.com

Good hay for our herbivores: how can we best meet the nutritional needs of our species?

Lucie Brisson & Benjamin Lamglait

ZooParc de Beauval & Beauval Nature, 41110 Saint-Aignan, France

Forage is a major part of most rations for many species of herbivores kept in zoos. However, assessing the quality of this basic food is not always easy. At ZooParc de Beauval, in addition to classic morphological criteria (color, odor, etc.)[1], we use simple parameters for nutritional analysis that make it possible to select better quality forage and also to distribute the different forages according to the specific needs of the species[1,2]. Indeed, depending on their feeding habits, some species have a greater need for a forage of "lower nutritional quality" providing less protein and more poorly digestible fiber or, on the contrary, for a much more leafy and protein-rich forage[2].
We use the ratios

$$\frac{\textbf{Neutral Detergent Fiber (NDF)} \% \; for \; 90\% \; dry \; matter \; (DM)}{\textbf{Protein} \% \; for \; 90\% \; dry \; matter}$$

and

$$\frac{\textbf{NDF} \; g/kg \;\; DM}{\textbf{Total Nitrogen Matter (TNM)} \; g/kg \; DM}$$

to roughly differentiate the nutritional needs of herbivorous species and to select the most suitable forages. We regularly analyze forages from the same source from one year to the next to achieve a better knowledge of its characteristics and a good anticipation of the annual supply according to nutritional criteria. We use a regular monitoring and reporting system to refine the quality of the forage from one year to the next and to better forecast the consumption of different forages. Finally, animal keepers are regularly trained in your institution to the criteria that allow for proper storage and morphological evaluation of forage remains essential to support the overall process of improving the quality of these feeds.

KEYWORDS: *hay quality, Neutral Detergent Fiber, Total Nitrogen Matter*

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lucie.brisson@zoobeauval.com

Determining the palatability of commercial complete feeds used in the nutrition of Callitrichidae

Marcin Przybyło[1], Olga Lasek[1], Wojciech Bielatowicz[2], Kamil Żerdzicki[3], Aleksandra Drabik[1], Małgorzata Sochacka[1], Aleksandra Stec[1] & Łukasz Różański[4]

[1]Department of Animal Nutrition and Biotechnology, and Fisheries, University of Agriculture in Krakow, Poland [2]Silesian Zoological Garden, Poland; [3]Zoo Wojciechów, Poland; [4]The Municipal Zoological Garden in Warsaw, Poland

Feeding diets based solely on commercial produce and insects may lead to nutrient deficiencies in captive callitrichids. Therefore, current feeding recommendations indicate the necessity to include commercial, complete feeds in the daily rations for this group of animals. Because gels, jellies or cakes are not conducive to dental health, pellets and extrudates are the most popular and easy to use physical forms of complete feeds. However, several observations in zoos showed that the palatability and intake of such feeds may be unsatisfactory. Making “mashes”, wetting down, using different flavourings or soaking in liquids such as fruit juices and caffeine free teas are tactics of increasing the palatability of the pellets, although not recommended. On the European feed market, there are several pellets and extrudates designed specifically for callitrichids, as well as for other primates or insectivorous mammals. The aim of this study was to evaluate the palatability of the most popular commercial primate feeds used in the nutrition of callitrichids in several polish zoos and private breeding facilities. The palatability of the pellets was evaluated by the pairwise preference test on several species: common marmoset (*Callithrix jacchus*), Goeldi’s marmoset (*Callimico goeldii*), golden-headed lion tamarin (*Leontopithecus chrysomelas*), golden lion tamarin (*Leontopithecus rosalia*), golden-handed tamarin (*Saguinus midas*), white-lipped tamarin (*Saguinus labiatus*) and pygmy marmoset (*Cebuella pygmaea*). Briefly, each day (morning) two tested feeds were offered to a family group of primates for 24 hours (2 g of pellet/100 g of body weight). In addition to commercial feeds, similar amounts of produce, insects and gum were offered during the study. Preference of intake of 8 feeds was tested: 3 for callitrichids, 3 for leaf-eating primates, 1 for all primates and 1 for insectivores. Feed refusals were weighed and preference ratios for each tested feed and family group of monkeys were calculated. Then, preferences were ranked using a pairwise comparison chart. In general, all tested feeds were not willingly ingested. Complete feeds were not completely eaten by primates, except most of the feeds readily consumed by lion tamarins. The average percentage of intake for most tested feeds did not exceed 40% of the daily dose. Only one of the three tested callitrichids feeds was very willingly eaten, probably due to the high degree of insects in its composition and its unique physical structure. The other two feeds dedicated to callitrichids were generally preferred to a similar or even lesser degree compared to those dedicated to leaf-eating primates (bearing in mind the latter’s high level of fiber and reported low palatability). In conclusion, the palatability and intake of complete feeds by callitrichids may vary greatly and were not satisfactory, at least during short-term observations. Taking into account the latest nutritional recommendations for callitrichids, indicating the essential need to include complete feeds in the rations, the palatability and ingestion level should be one of the most important criterions when choosing the feed to be used.

KEYWORDS: *tamarin, marmoset, pellet, palatability*

m.przybylo@urk.edu.pl

Feeding interactions between emperor tamarins (*Saguinus imperator*) and Azara agoutis (*Dasyprocta azarae*) in a mixed enclosure

Flore Viallard[1], Anais Watrelot[2], Kévin Schlax[2],

[1]Nutrioo, Zoo Nutrition Office, France; [2]Parc d'Isle, France

Mixed species enclosures in zoos are becoming more common. These enclosures allow different species to interact with each other. Although this mix increases behavioural diversity, management is more complex, particularly with regard to feeding. In the Parc d'Isle (France), emperor tamarins (0.3) and Azara's agoutis (0.2) live together in an aviary. In the wild, tamarins are arboreal and drop food on the ground which the agoutis ingest. At Parc d'Isle, the tamarins received a diet of vegetables, fruits, insects, NWM pellets, tamarins cake and gums, and the agoutis a diet of vegetables, fruits, insects, nuts, rodents pellets and leaves (Table 1). During the study conducted from May to July 2022, scan sampling observations were made after the morning and midday meals for about 90 minutes, for a total of 54 hours, and the food remains of the two species were weighed. Calculations of nutrient concentrations and energy were performed using the Zootrition software. At the time of the observations, it was noted whether the individual was eating, sorting, stealing or otherwise in order to record the frequency of stealing by species, the food stolen from the other species and whether the stealing behaviour was associated with any other behaviour of the species. Stealing is defined as taking food from the other species' diet. The diet that disappeared from the dishes designated for the agoutis was close to that offered (98.8% of food offered disappeared as determined by weighing leftovers and controlling for desiccation), unlike that of the dishes designated for the tamarins (47.5%). The keepers are not worried about the quantity of leftovers because the body condition of the animals remained stable. Weight monitoring was started as a result of the study. Without accounting for food stolen by the tamarins from the agouti dishes, intake from the tamarin dishes theoretically changed for fat (from 5.9 to 7.4% in dry matter from offered to ingested, respectively), NDF (from 10.9 to 5.8% in dry matter) and ME (493 to 246 kJ/day). Primate pellets were consumed only to a small extent by tamarins (19.2% of the offered amount), whereas all tamarins' steals involved rodent pellets distributed at the same time to agoutis. All tamarins steal occurred during the morning meal with a mean of 3.3 stealing by day for the group, when the pellets were given to both species in addition to the vegetables and tamarins cake for the tamarins. There was no stealing by tamarins at lunchtime, although the agoutis received fruit at this meal. The agoutis consumed the food that fell on the ground in the morning and at noon, mainly leafy vegetables. They retrieved 3.75 times less food from the tamarins than the other way round. The time spent sorting (their own food) and stealing (the other species' food) was correlated for tamarins as well as for agoutis. Agoutis sort less than tamarins. While we would expect the agoutis to ingest the tamarins' diet and create an imbalance in nutritional intake, we see that in this case of mixing, it is the tamarins that steal the most food and cause a risk of imbalance in their diet and that of the agoutis. The number of rodent pellets stolen by the tamarins was not quantified, so the nutritional impact is unknown, but it was observed that one stealing corresponds to one rodent pellet, i.e. an average feed intake of 4.4 g of rodent pellets per tamarin per day (compared to 2.9 g of primates pellets intake by day). In estimation, the agoutis consume 84% of the pellets offered to them, which allows them to thrive despite stealing. Also, they have permanent access to foliage thanks to the vegetation of the enclosure. In mixed spaces, the palatability of the diet and the distribution arrangements (shape of the dishes, spatial arrangements, access to other species, frequency) are important factors to consider.

Table 1 : Nutritional composition table of the pellets distributed in the study. The information is obtained from the suppliers.

Pellets	Primates	Rodents
Protein (%DM)	25.7	14.4
Fat (%DM)	3.7	2.5
Fibre (%DM)	16.9 (NDF)	4.4 (crude fiber)
Non-fiber carbohydrate (%DM)	41.7	62.8

KEYWORDS: *Tamarins, agoutis, mix, interactions, diet*

nutrioo.zoonutrition@gmail.com

Measuring vitamin D status in zoo primates through hair analysis

Geert P.J. Janssens[1], Tim Bouts[2], Alicia Quiévy[2], Padraig Maher[3], Lina Zgaga[3]

[1]Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium
[2]Pairi Daiza, Brugelette, Belgium
[3]Trinity College, Dublin, Ireland

Vitamin D status in animals is important because it regulates calcium homeostasis, hence affecting skeletal health. The need for proper vitamin D provision however goes beyond prevention of rickets and osteochondrosis, comprising effects on immune competence and even mental health. Depending on the species, the vitamin D requirement is fulfilled by a combination of dietary intake and dermal synthesis when exposed to UV-B radiation (sunlight or artificial). Animals that originate from a tropical habitat, where sunlight is abundant, may experience a lower *de novo* synthesis when housed in zoos that are located in temperate regions, especially when staying mainly indoors behind glass in cold periods. A previous data analysis of existing chimpanzee 25-OH-cholecalciferol ($25OHD_3$) titres indicated that vitamin D status is indeed distinctly lower in western European zoos compared with the wild, and that winter further decreased the status. Therefore, monitoring of vitamin D status in zoo primates is warranted. Although blood analysis is the common method to screen for vitamin D status, this requires either containment or anaesthesia of primates, or requires laborious training to allow voluntary blood drop sampling from a finger.
Recently, a method was validated to measure $25OHD_3$ in human hair. If such a non-invasive method would work for zoo primates, this would facilitate an easier and more animal-friendly process to monitor vitamin D status. Therefore, we performed a pilot study in a group of lemurs in Pairi Daiza zoo to see if $25OHD_3$ could be measured, and if the values would relate to their lifetime in a temperate climate zoo.
Because of a veterinary check, a number of primates, with ages ranging from 1 to 20 years, had to be anaesthetised, allowing individual sampling of a small bunch of hair. The group consisted of 6 ringed-tailed lemurs (*Lemur catta*), 9 black-capped squirrel monkeys (*Saimiri boliviensis*), 2 red ruffed lemurs (*Varecia rubra*) and 3 black-and-white ruffed lemurs (*Varecia variegata*). Vitamin D was extracted from the hair according to Zgaga et al. (2019), and $25OHD_3$ measured using tandem liquid chromatography mass spectrometry, a gold-standard method for the assessment of $25OHD_3$. When plotting the results in function of age, a significant decline in hair $25OHD_3$ concentrations was observed ($r=-0.525$; $p=0.018$), although this effect was confounded with species. The squirrel monkey hairs (3.9±0.9 µg/g) had twice as high $25OHD_3$ concentrations as the lemurs (2.2±0.7 µg/g) ($P<0.001$). The higher concentrations in the squirrel monkey hairs may partly be related to their younger age, but because the ring-tailed lemurs were of similar age, it is more likely because the squirrel monkeys, as New World primates, are supplemented with vitamin D_3. Yet, when evaluating the age effect in only the ring-tailed lemurs, the hair $25OHD_3$ concentration still tended to decline with age ($r=-0.789$; $p=0.062$).
Although screening in larger populations is needed, including comparison with blood results, this pilot already shows promising results for the use of hair samples in non-invasive long-term monitoring of vitamin D status in zoo primates and maybe other species.

KEYWORDS: *primates, cholecalciferol, non-invasive screening*

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Geert.Janssens@UGent.be

Vitamin D in the European great ape population: what we know so far

Rachel Jarvis[1,2], Sophie Moittié[2,3], Phillipa Dobbs[2], Matyas Liptovszky[2,4] & Kerstin Baiker[1,5]

[1]University of Nottingham, UK; [2]Twycross Zoo, UK; [3]St George's University, Grenada; [4]Perth Zoo, Australia; [5]City University, Hong Kong

Vitamin D can be obtained from dietary sources as well as sunlight (UVB radiation) exposure. In many species, vitamin D is important for overall health and its deficiency is associated with a range of disorders, including cardiovascular disease, which is a major cause of death in zoo-housed great apes. Vitamin D deficiency is widespread in the global human population, and given the genetic similarity and shared risk factors between humans and non-human great apes, it was hypothesised that there could be cause for concern in the European zoo population. An initial study on European zoo-housed chimpanzees focused on assessing the vitamin D status of animals from a variety of geographic locations and husbandry conditions. Serum samples (n=245) from 140 chimpanzees, from 32 zoos, were used for measurements of 25-OHD2, 25-OHD3 and total 25-OHD using liquid chromatography and tandem mass spectrometry (LC-MS/MS) at a single, accredited laboratory. Information pertaining to the health, husbandry and diet of the individuals was gathered via an accompanying questionnaire. Human reference intervals were used to interpret vitamin D status, as none currently exist for the other great apes. There were significant seasonal differences in vitamin D status, and a notable proportion of chimpanzees in each season had insufficient vitamin D. Outdoor access in the months prior to sampling was a key predictor of vitamin D status. There was no observed effect of the diet or supplementation on vitamin D status, though the nature of the dietary data made this difficult to assess. We are expanding our investigations to include gorillas, orangutans and bonobos (from Europe and beyond) based on our findings in chimpanzees and we are inviting zoos and sanctuaries to take part in this. It is anticipated that our research will initiate discussions within the zoo community about vitamin D from a nutrition perspective. Having identified the factors that affect vitamin D status in great apes, this in turn will help zoos make evidence-based decisions regarding management practices and may also have an impact on our knowledge about the relationship between vitamin D and overall health, including cardiovascular disease, in great apes.

KEYWORDS: Chimpanzee, Gorilla, Orangutan, Bonobo, 25-hydroxyvitamin D, Health

Rachel.Jarvis@nottingham.ac.uk

Wanted dead or alive: ethics and animal welfare in food choice

Rebeka Šķērstiņa, Elza Birbele & Alessandro Di Marzio

Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, LV-1014 Riga (Latvia)

The use of live food in zoological collections is a constant source of debate, with multiple approaches being implemented. The debate can be divided between "internal" (professionals within captive care) or "external" (public) to the zoo world. Generally, there is a certain rejection by part of the public to the use of live prey, especially regarding the use of animals that more commonly generate empathy such as mammals. The public is also more likely to accept this practice if it is performed behind the scenes. It is an approach where animal welfare, although sometimes considered, may not be priority. The focus in this case is more on the visual impact of such a practice, especially in the case of families with children. Additionally, each country has its own national regulations and public perception may be different.
Internally in the community of zoo professionals, although it must be considered that the practice may negatively affect the keepers who implement it, the debate should be centered primarily on animal welfare - both predator and prey. Positive stimulation of predatory instincts (environmental enrichment), pain and stress for the prey and in turn injury to the predators, sanitary risks, conditions of the facilities are some of the factors that should be considered. For this reason, we consider the Nutrition Conference a good event to point out the situation, presenting the latest research results on this issue, combined with the data provided by each participant of the conference. On this basis we hope to generate a purposeful discussion to address the "elephant in the room".

KEYWORDS: live feeding, ethics, welfare, policy

research@rigazoo.lv

Raptor diets diversity based on species and their role in zoo collection

Alessandro Di Marzio, Elza Birbele & Rebeka Šķērstiņa

Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, LV-1014 Riga (Latvia)

Raptors are predators, in many cases facultative or obligate scavengers depending on the species. The gastric system of raptors is designed for a protein-rich diet, with a well-developed proventriculus and only rudimentary gizzard. The pancreas (important for protein digestion) is well developed, the intestines are medium to short in length. Usually, they have only a rudimentary caecum. Comparing the gastrodigestive system, raptors can be divided in two groups: raptors with a crop (Falconiformes and Accipitriformes) and raptors without a crop (Strigiformes). This anatomical feature has an impact on the volume that can be fed during each meal. Raptors regurgitate pellets, the remains of undigested prey material, which form within the gizzard. The consistency of the pellets varies according to species (e.g., osprey pellets are very soft). Owl pellets contain bones of their prey, a material normally absent in the pellets of other raptors. Investigating pellet contents can provide a number of information on the health status of raptors. Raptors present in modern zoological collections can have several functions (trained animals for show, animals for public exhibition, breeders), and for each one of them nutritional needs are different. When preparing the diet for raptors, we have to consider the energy requirements and the amount of food we need to supply. The basal metabolic rate (BMR) is used to calculate the basic energy requirements of raptors. In the formula:

BMR (kcal) = 78 (kcal/kg$^{0.75}$) * body weight (kg)$^{0.75}$

78 is the coefficient for raptors and 0.75 is the scaling exponent. For Maintenance energy requirement (MER) the energy requirements to be added to the BMR are calculated, depending on the activity of the birds; 1.5*BMR for birds in cage, up to 2.5*BMR for growing juveniles, up to 2.6*BMR for bird with intense exercise (flying training/breeding). The daily intake of food is usually calculated as a 6-8% body weight (b.w.) for large raptors (eagles, vultures, buzzards), 10-15% b.w. for medium size raptors (mainly Accipitridae, Strigiformes) and 20-25% b.w. for small size raptors (mainly Accipitridae, Strigiformes). Well-designed diets, with a wide variety of prey as close as possible to their natural diet, guarantee a better health status of the animals and allow to reduce vitamin supplementation. Reproducing the natural diet can be difficult in the case of vultures, obligatory scavenger birds, although these birds accept fresh meat. Recent studies have demonstrated the anatomical adaptations of these birds, which can therefore be classified as "gulpers", "rippers" and "scrappers". In captivity, these adaptations should be taken into account to provide good environmental enrichment for vultures, by means of a diet that stimulates the different types of feeding.

KEYWORDS: *Raptor, diet, training, breeding, vulture*

research@rigazoo.lv

Dietary guidelines for each developmental stage of the natterjack toad (*Epidalea calamita*)

Elza Birbele, Linda Zauere, Ginta Jansone, Renārs Rozentāls, Rebeka Šķērstiņa & Alessandro Di Marzio

Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, LV-1014 Riga (Latvia)

Amphibian captive breeding programs represent an important tool in the fight against the disappearance of many species. An important factor to consider is nutrition, in order to obtain healthy breeders and offspring. Deficiencies or excess of vitamins, minerals and proteins can cause important health disorders in animals. The insurgence of lingual squamous metaplasia and metabolic bone disease, two of the most frequent pathologies in captive amphibians, are related to calcium, vitamin A and vitamin D3 deficiencies. Protein levels in the diet are associated with reproduction. Multiple factors must be considered in diet preparation. In anurans, for example, metabolic rates are higher than in caudates, and are also higher for terrestrial species compared to aquatic species. Species and life stage of the animal also changes the energy demands; so this must be added to the calculation of hyperphagic and hypophagic (brumation-correlated) periods. The main invertebrates used in the diet of captive amphibians (house crickets, *Acheta domesticus* and mealworms *Tenebrio molitor*) do not provide adequate amounts of vitamin A, with risk of reproductive problems such as poor reproductive success, reduced tadpole survival and immune system dysfunction, therefore possibly having significant impacts on the success of amphibian breeding programs. *Epidalea calamita* is a European species of toad, present from Portugal to Russia and has adapted to life in heathland and sandy environments. *Epidalea calamita* tadpoles are benthic, living at the bottom of temporary ponds and scrape similar food from submerged vegetation and substrate. Laboratory tests have shown that diets high in protein (46% of dry matter) favor the development of significantly longer bodies and broader heads and hind limbs, with good growth, development and survival. In this contribution we evaluate in detail the dietary requirements of *Epidalea calamita* in captivity for proper captive breeding, examining examples of diets used in Riga Zoo and Copenhagen Zoo breeding programs. All material is part of the guidelines for the management of *Epidalea calamita*, written by the Copenhagen Zoo team in collaboration with the Riga Zoo team.

KEYWORDS: *Amphibians, breeding, tadpole*

research@rigazoo.lv

Nutrient composition and season variation of native food items eaten by free ranging Great Green Macaws (*Ara ambiguus*) in Costa Rica

Andrea Brenes-Soto[1,2], Olivier Chassot[3]

[1]Animal Nutrition Research Center, University of Costa Rica; [2] Animal Science Department, University of Costa Rica, [3]World Comission on Protected Areas, IUCN

Great green macaws have a limited distribution along humid lowlands in Central and South America. In Costa Rica, their nesting areas are located in the north of the country, in which the species has been declared as endangered. Apart from to studies of the macaws' status in nature, there are also studies on their distribution, abundance and the seasonality of the main food items they consume. Free-ranging great green macaws have a distinct preference to eat fruits of mountain almendro (*Dipteryx panamensis*) from September to April, and titor (*Sacoglottis trichogyna*) from April to August, when almendro is scarce. The objective of this study was to determine the nutritional composition of these two natural diet items, in order to compare them to diets offered in captivity. Samples of mature fruits from both species were collected in the forest in two periods of time, at the beginning and at the end of fruiting season (n=6 each for each fruit and season). Nutrient composition (dry matter, protein, fat, gross energy, NDF, ADF) was determined at the Laboratory of the Animal Nutrition Research Center, whereas mineral content (Ca, P, Mg, K, Fe, Cu, Zn, Mn) was analysed at the Laboratory of Soil and Foliage of the University of Costa Rica. Data analysis was performed using univariate ANOVA, evaluating the effect of the variables (season and species) on nutrient composition. Statistical significance was accepted at $p<0.05$. The nutrient composition varied depending on species in the content of dry matter, crude protein, fat, NDF, phosphorus and copper ($p<0.05$), with almendro showing higher values. Likewise, significant differences were found in the nutrient content by season only in the levels of crude protein and potassium ($p<0.05$), with higher values at the beginning of fruiting season. Almendro and titor may be considered principally as a source of energy and fiber, and results showed that their nutrient content keeps stable along the year, though almendro showed higher nutrient levels. Calcium:phosphorus ratio is lower in the beginning of the fruiting season compared with the end of the season (0.9:1 vs 1.5:1), suggesting that green macaws might use alternative sources of these minerals to cover their needs.
Great green macaws are frugivores and granivores, as other similar species of parrots. These birds feed on different components of around 37 species of trees; titor fruits represents 65-95% of diet when almendro is scarce, while in almendro´s fruiting season, this species represent 80% of the diet. Despite the preference of these two species, several authors have reported that these animals can also obtain some nutrients from flowers, leaves and gravel, especially during the breeding season and the period of nursing and feeding their chicks. These food items showed high values of fibre, which is something that deserves further studies to determine its role in the digestion and nutrient utilisation of these birds.

KEYWORDS: *Great green macaw, free-range diet, Dipteryx panamensis, Sacoglottis trichogyna*

brenes.andrea14@gmail.com

Analysis of the nutritional components of Linnaeus's two-toed sloth (*Choloepus didactylus*) diets in UK and Irish zoos

Clodagh Walsh[1,2], Kerry Hunt[1] & Marianne Freeman[1]

[1] University Centre Sparsholt, Sparsholt, Winchester, SO21 2NF, England
[2] Dublin Zoo Saint James' (part of Phoenix Park), Dublin 8, Ireland

Sloths are a poorly studied folivore and currently lack species-specific research with no studies having directly analysed the nutritional composition of their diet in the wild. Some studies have been published on zoo diets; however, direct comparison between collections is not common in the literature. A nutritional assessment was performed on nine zoo diets of *C. didactylus* from eight zoological collections across the United Kingdom and Ireland. Diets were obtained and compared against one another to see if there were significant differences in the nutritional content between collections. Analysis focused on average dietary provision per sloth for the following nutrients: crude protein (CP), crude fibre (CF), ether extract (EE), and nitrogen-free extract (NFE). Zootrition™ was used to determine the nutritional content of each diet. Results showed there were variations in the quantity of food provided per sloth. Statistical analyses revealed that there were significant differences in the nutritional composition of diets between collections (CP $p < 0.001$; CF $p < 0.001$; EE $p < 0.001$; NFE $p < 0.001$) Common disorders associated with sloths in captivity include malnutrition, digestive diseases, bloating and urolithiasis, with inadequate nutrition playing a potential role in the cause of these. Browse is recommended for this species; however, only five out of nine diets (55.6%) included browse. Diets were compared to the recommendations by Bissell (2021) showing all diets exceeded the minimum protein content recommended, but fibre contents were lower than recommended. This may be due to the limited browse provision as this is often recommended for this species to improve digestive health and nutritional profile of the diets. Conclusions drawn from this study highlight the importance of nutritional research in order to improve the health and welfare of *C. didactylus* in zoos.

KEYWORDS: *browse, Zootrition, zoo diets, comparative nutrition*

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kerry.hunt@sparsholt.ac.uk

Small ruminants may cope without concentrates, but also without produce: a case of southern pudu (*Pudu puda*)

Marcin Przybyło[1], Anna-Maria Sanecka[1], Aleksandra Stec[1], Grzegorz Rolik[2], Mariusz Szędzielorz[2] & Paweł Górka[1]

[1]Department of Animal Nutrition and Biotechnology, and Fisheries, University of Agriculture in Krakow; Poland [2]Zoo Opole, Poland

Produce (fruits and vegetables) are commonly used in the diets for zoo ruminants, as very willingly ingested diet components, especially as treats in medical training or in the case of low total feed intake, particularly in browsers. However, produce are high in sugar (mono- and disaccharides) which are rapidly fermented in the rumen to short-chain fatty acids, and this may lead to a pH drop below the optimum. Moreover, increased intake of produce by captive ruminants raises concerns, due to possible negative impact on roughage intake, rumination, fiber digestibility and gastrointestinal health. The aim of the study was to determine the effect of produce level used in the diet on feed intake, eating behaviour and rumination in southern pudu. Three adult males of pudu were allocated to 1 of 3 treatments according to 3 × 3 Latin square design and fed diets without (P0) or with moderate (P250; 250 g/day; ~10% of predicted dry matter (DM) intake) to high (P500; 500 g/day; ~20% of predicted DM intake) inclusion of produce (mixture of apples and carrots; 50 : 50 as fed) in the diet, with *ad libitum* access to lucerne hay and browse. Dry matter intake of lucerne hay decreased linearly ($P < 0.01$) with increasing amount of produce in the diet; however, the total DM intake was not affected. Inclusion of produce in the diet linearly increased the intake of water soluble carbohydrates by approximately 108% in P250 and 217% in P500 compared to P0 ($P < 0.01$), but linearly decreased the intake of crude protein, crude fat, NDF, ADF and ADL ($P < 0.05$). Increased intake of produce led to a tendency of linear decrease of total eating time (min/day) and a tendency to linearly increase of total eating rate (g DM/min; $P \leq 0.10$). Rumination time (min/day) was reduced linearly by 9% and 67% in P250 and P500 diet, respectively, compared to P0 ($P = 0.03$). Scratching (n/day) behaviour incidents increased linearly with increased produce inclusion in the diet ($P = 0.05$). Collectively, the presence of produce in the diet of pudu significantly increased the intake of sugars, decreased the intake of roughage (lucerne hay) and rumination time, without impacting total DM intake. Produce may affect behaviour and feed intake patterns, and hence health and welfare of zoo ruminants. Simultaneously, it is worth noticing that high DM intake (255 g/day; estimated 2.5% of body weight) and nutrient intake were observed in pudu on the diet without produce and also concentrates. While a pelleted diet may serve to safely provide minimum mineral levels, such a diet better reflects the natural diet of this species in its natural environment. Using such a high-forage diet, with some minimum of mineral provision, may be beneficial for gastrointestinal health of this and similar species.

KEYWORDS: *pudu, browser, fruit, vegetable, sugar*

m.przybylo@urk.edu.pl

Using indicators of positive animal welfare when evaluating nutritional changes in giraffes

Sarah Depauw[1], Leen Verbist[1], Jeroen M.G. Stevens[1,] Marina Salas[2]

[1]Odisee University of Applied Sciences, Agro- and Biotechnology, Sint-Niklaas, Belgium; [2]Antwerp Zoo Centre for Research and Conservation, Royal Zoological Society of Antwerp, Antwerp, Belgium

The impact of changes in diet and feeding management on welfare in giraffes is often assessed using indicators of (potential) negative welfare, such as oral stereotypies. Here we combine these with indicators of positive welfare, such as time spent ruminating, feeding and feeding with tongue. Five Kordofan giraffes (*Giraffa camelopardalis antiquorum*) housed at Zoo Planckendael were observed during wintertime before and one year after the following four dietary changes had been implemented: 1) the overall diet was increased in fibre and decreased in sugar and starch; 2) browse was provided year-round, at a minimum of 10% of total dry matter intake, with a variety of at least five browse species, including browse with thorns; 3) feeding frequency was increased from two to four times a day, with the highest browse provision in the last feeding round to allow more browsing during the night; 4) the new diet was offered exclusively in slow feeders and enrichment tools that required tongue manipulation. Behaviour was assessed during 10 days pre- and 10 days post implementation of dietary change. During each day 4 hours of data were collected between 8:00h and 16:00h (daytime) and 8 hours between 16:00 and 8:00h (night-time) in randomised sessions of 20 minutes, resulting in a total of 120 hours of observations per period (40h daytime and 80h night-time). Results show that oral stereotypies, accounting for 2.9% of daytime and 1.0% of nocturnal observations, significantly decreased after the diet change to 1.9% and 0.5%, respectively. In addition, indicators of positive animal welfare improved. Rumination during the daytime remained stable at approximately 20% before and after the dietary change. However, nocturnal rumination increased significantly from 26.7% to 38.7% after the diet change. Furthermore, the time spent feeding increased significantly during the daytime from 24.5 to 43.4% and at night-time from 17.6% to 28.7%. As intended, this increase in feeding time consisted only of feeding with tongue, as feeding with mouth dropped from 5.1% during the day and 6.3% at night to 0% after the diet change. The body condition score of all giraffes remained stable throughout the dietary changes despite a 20% decrease in the pellet and the reduction of 75% of produce, leaving only one kg of leafy greens per animal during winter time. The unaltered body condition indicates an increase in roughage intake which is supported by the fact that this herd ruminated more after the diet change. Our results show an overall improvement in giraffe welfare through the combination of four changes in the feeding regime. Positive welfare indicators prove to broaden our insights on the impact of a diet change on the animal's welfare. Rather than developing feeding strategies only to reduce indicators of negative welfare, including indicators of positive welfare when developing and implementing new feeding strategies can keep zoo staff motivated to work towards 24/7 lifelong welfare.

KEYWORDS: *Giraffes, feeding management, positive welfare indicators*

sarah.depauw@odisee.be

The behavioral effects of feeding lean meat versus whole prey to captive jaguars (*Panthera onca*)

Line Enemark[1,2], Marcus Clauss[3], Linn Lagerström[4], Anita Burkevica[4], Jenny Gustafsson[4], Julia Johnsson[4], Peter Lundgren[4], Helle Lottrup Halkjær Rhode[1,5]

[1] University of Copenhagen, Department of Veterinary and Animal Sciences, Section for Animal Welfare and Disease Control, Groennegaardsvej 8, DK-1870 Frederiksberg C Denmark
[2] Present address: Mølleparken 458, DK-7190, Billund, Denmark
[3] Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Winterthurerstr. 260, 8057 Zurich, Switzerland
[4] Parken Zoo, Flackstavägen 13, 63222 Eskilstuna, Sweden
[5] Present address: University of Copenhagen, Faculty of Health and Medical Sciences, Centre for Online and Blended Learning. Øster Farimagsgade 5,DK-1353 København K, Denmark

Modern zoos aim to enhance the natural behaviour whilst ensuring optimal health conditions for their captive animals. Feeding presents an obvious opportunity for this, as natural feed items may stimulate natural feeding behaviour without compromising the nutritional requirements. In carnivores, like jaguars (*Panthera onca*), feeding behaviour, such as hunting, killing, dissecting, consuming, and guarding the prey, would take up a certain proportion of the time budget in the wild. The challenge of carnivore feeding is to stimulate natural feeding behaviour without using live prey. The objective of this study was to investigate how two different feed types (lean beef and whole rabbits) affect the behaviour of three captive jaguars for the first six hours after feed presentation.
When analyzing the frequency of different behaviors for six hours after feeding, results confirm that feeding behaviour occurred significantly more when fed whole rabbits, particularly during the first hour after feed presentation. However, even though feeding time increased by more than 300%, in terms of the overall proportion of a 24-hour budget, this represents a change of less than 1%. The frequency of stereotypic behaviour remained the same for the two feed types in the six hours after feeding. Increasing the observation period from six hours to 24 hours, and especially feeding with larger carcasses, that would allow the jaguars to feed from it repeatedly and require more complex handling, could lead to a larger effect on their feeding regime, including the activity budget and specific behaviours.

KEYWORDS: *Jaguar, Panthera onca, behavior, feeding, lean meat, whole carcass.*

lineenemark@gmail.com

Activity budget and behaviour of giant otters (*Pteronura brasiliensis*) at Parken Zoo, Eskilstuna, Sweden

Mélodie Friedmann[1], Anita Burkevica[2], Jenny Gustafsson[2], Julia Johnsson[2], Peter Lundgren[2], Marcus Clauss[1]

[1]Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Winterthurerstr. 260, 8057 Zurich, Switzerland
[2]Parken Zoo, Flackstavägen 13, 63222 Eskilstuna, Sweden

One of the main roles of modern zoos is to ensure the welfare and conservation of their captive animals, and for this, it is highly recommended to provide cognitive stimuli, commonly known as enrichments, as well as a good habitat management and an adequate nutrition. The assessment of animal welfare includes the observation of their behaviours. One frequently used approach is to compare the activity budget in zoo animals with their wild conspecifics, carefully interpreting resulting differences. Here, we use this method on giant otters kept under a feeding regime with three fixed feeding times during the keeper's working day, and additionally with ice-blocks containing fish suspended above the pool, thawing over time and thus releasing fish well into the night. As otters have high intake requirements, we expected this time-delayed food dispensation to make our subjects spend a lot of time foraging. Nevertheless, results show a lower feeding proportion than reported in the literature for the species in the wild (27% vs. 64% of 24 h), which is likely related to the fact that zoo animals did not have to hunt live prey. Zoo animals also spent less time for scent-marking (1% vs. 9%), possibly due to the absence of other conspecific groups in their vicinity. By contrast, there was a higher proportion of resting (34% vs. 21%) and especially affiliative behaviours (14% vs. 1%), suggesting that shifts in the activity budget between natural habitats and zoos need not always be interpreted as indicators of reduced welfare. A social behaviour of "calling family members to food", also known from the wild, was observed repeatedly during the experiment; this happened invariably when one family member was awake at a time fish fell from the thawing block into the pool, and the other family members were asleep. Thus, the present study suggests that extending food distribution in time, and in particular into the night time, might develop some other indicators of welfare in captive giant otters than an increased feeding activity, and calls upon further investigations with delayed feeding methods for this and other species.

KEYWORDS: *activity budget, behaviour, feeding enrichment, Pteronura brasiliensis, welfare, zoos*

melo.friedmann@gmail.com

Effect of a transition to a fruit-free diet on primates' microbiome at Mulhouse Zoo

Benoît Quintard[1], Irène Vonfeld[1], Flore Viallard[2], Cécile Lang[3], Julie Brunet[3]

[1]Parc Zoologique et Botanique de Mulhouse, France
[2]Nutrioo, France
[3]Institut de Parasitologie et de Pathologie Tropicale, University of Strasbourg, France

Numerous studies have recently demonstrated a strong correlation between microbiome changes and health concerns in both human and veterinary medicine (e.g. chronic gastrointestinal disease, obesity, diabetes).[1-4] Stress, housing conditions, and diet are adjustable factors that can directly affect the microbiome of animals in zoological gardens.[3,4] The study of its development following life condition changes is thus of interest from a veterinary perspective. A microbiome follow-up using 16s ribosomal sequencing was implemented before and after a switch to a fruit-free diet in 2 cebid (*Ateles fusciceps robustus, Sapajus xanthosternos*) and 3 cercopithecid species (*Cercopithecus hamlyni, Cercopithecus roloway and Cercopithecus lhoesti*), analyzing one faecal sample before for all species but Roloway monkeys for which 2 samples were collected, and 3 samples taken 2 months after diet change.
Although microbiome richness decreased in all species, with a mean drop of 61000 operational taxonomic units (OTU) (38%), the diet switch led to a mean rise of 1.52 of α-diversity (Shannon index) in four of the five studied species. This can be explained by a better distribution of relative abundance of each OTU like an increase of *Prevotella* ($p = 0.0625$; $\alpha = 0.1$), an abundant genus found in the microbiome of wild populations of these species[5]. Similarly, dietary transition led to a decrease of the *Firmicutes/Bacteroidetes* ratio ($p = 0.0625$; $\alpha = 0.1$), this ratio being positively correlated with disease outbreaks.[1]
The switch to a fruit-free diet seems to have a beneficial impact on captive primates' microbiome and consequently on their digestive health.

KEYWORDS: *Microbiota, zoo primates, diet switch*

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nutrioo.zoonutrition@gmail.com

Zero km food for insects

Ilona Roma, Aleksandrs Napolovs, Aigija Ladiga & Alessandro Di Marzio

Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, Ziemelu rajons, LV-1014 Riga (Latvia)

The Insectarium of Riga Zoo has more than 50 species of terrestrial invertebrates. Many of these species (e.g., katydids, stick insects, leaf insects, leaf-cutter ants, locusts) require fresh leaves as diet. As the Riga Zoo is located in Mezaparks (one of the oldest public parks in Europe), during the summer season fresh plant material (raspberry leaves) is collected in the surroundings of the Zoo. For the winter season, the team of the Insectarium in collaboration with the Gardening department grow young oak (*Quercus robur, Quercus rubra*) and wheat sprouts. Using a system of shelves equipped with lighting systems, they sprout seeds and acorns to provide fresh green material for invertebrate feeding. The Insectarium team has developed a method for growing oak sprouts on a small area for an uninterrupted supply of insects during the winter season from October to May. The method includes: picking acorns, sorting, storing, sprouting, planting, using. About 350 excellent healthy acorns are used. These acorns are collected in rural areas (to avoid the harmful effects of urban pollution) and carefully selected by our entomologists. The Gardening department grows wheat sprouts, which are necessary for growing food locusts (*Locusta migratoria*). The methodology used allows the production of 3-4 kg of wheat sprouts per day.

KEYWORDS: *Entomology, sprouts, winter diet*

research@rigazoo.lv

Healthy live snack for aquarium fishes

Renārs Rozentāls, Margarita Jegorova & Alessandro Di Marzio

Riga National Zoological Garden (Riga Zoo), Meza prospekts 1, Ziemelu rajons, LV-1014 Riga (Latvia)

The advances in the production of industrial food for ornamental fish provide a wide variety of foods specially designed for the basic needs of aquarium fish. However, the integration of the diet with live food is a tool to increase the health of the fish. The use of aquatic invertebrates stimulates the natural predatory behaviour of fish, fulfilling an environmental enrichment role. The higher palatability of this type of food facilitates the feeding also of those fish that are more difficult to feed in aquariums. Due to their small size, aquatic invertebrates also represent an excellent source of food for the fry; moreover, the movement of the invertebrates is a stimulus for the fry, facilitating their feeding. It is very important to carefully select the source of aquatic invertebrates. Many species (e.g. *Daphnia* sp.) have a water depurative function. Invertebrates reared in polluted water can bioaccumulate environmental pollutants that will ultimately harm the health of the fish. At Riga Zoo we breed aquatic invertebrates in outdoor pools, incorporated in the area dedicated to insects and pollinators. The water is subjected to regular quality controls, ensuring the invertebrates' food safety. During the summer, invertebrates are collected daily to be fed to the fish and for the production of frozen food to be used during the winter. Thanks to this system, the aquarium is constantly supplied with adequate food for the fry and adult fishes.

KEYWORDS: *Fish diet, aquatic invertebrates, enrichment*

research@rigazoo.lv

Hypervitaminosis D in captive Tasmanian wombats *(Vombatus ursinus tasmaniensis*)

Cathrine Sauer & Sara Abreu

Center for Zoo and Wild Animal Health, Copenhagen Zoo, Denmark

Routine health checks of 3.2 presumably healthy Tasmanian wombats (*Vombatus ursinus tasmaniensis*) were carried out under general anaesthesia. Survey radiographs revealed large unilateral nephroliths and multifocal muscular and subcutaneous metastatic calcifications in two animals. These findings, together with elevated circulating levels of vitamin D (25-hydroxycholecalciferol) in all five individuals, led to the diagnosis of vitamin D toxicosis. A diet review was conducted to investigate the cause of the problem. All animals were fed macropod pellets (Waterhouse Feeds, UK), rabbit pellets (NAG, Denmark), sweet potato, whole maize plants and freshly cut grass for *ad libitum* consumption. Keepers weighed offered and leftover feed items for seven days during September 2022 to get a crude intake estimate for each food item. Nutrient requirements specifically for wombats have yet to be established, so calculated nutrient concentrations of the diet were compared to recommendations for a range of other herbivorous species. Key findings of the diet analysis included low fibre (32% DM, recommended: 40 – 55% DM) and an excessive vitamin D content (1.5 IU/g DM, recommended: 0.3 – 1.0 IU/g DM). A new diet was formulated to correct imbalances by replacing the pellets with a higher fibre/lower vitamin D option, limiting the use of root vegetables, and increasing the amount of forage. Following implementation of the new diet, changes in feed intake, behaviour, weight, and faecal consistency will be regularly monitored, together with relevant clinical parameters for nutritional status, renal function and progress of the calcified lesions.

KEYWORDS: *Vombatidae, hypervitaminosis D, nephrolithiasis*

csj@zoo.dk

Comparative survey of ruminant rations in zoological parks in France

Flore Viallard[1], Sébastien Lefebvre[2], Anaïs Bédué[2],

[1]Nutrioo, Zoo Nutrition Office, France ; [2]VetAgro Sup, France

During qualitative discussions with zoo feed managers in France, it was noted that the formulation of ruminant rations is often based on agronomic knowledge and advice from feed and pellet suppliers. However, the breeding objectives and species characteristics are very different in these two types of husbandry systems. Zoos must adapt rations to the food requirements and behaviour of each species, but also ensure the financial and logistical sustainability of the food they offer. Faced with these latter imperatives and the lack of resources to guide them, French zoos may be unaware of the basics of feeding ruminants, especially browsers, and may overlook the nutrient composition of their diets. We present here the results of a survey on the feeding habits for ruminants in zoos. The objective of this questionnaire is to assess the current practices in French zoos.

Table 1. Percentage of zoos using each of the feeds in their ruminant diets

	Grazer	Browser
Hay (dried grass)	100%	20%
Alfalfa (dried)	25%	71%
Browse	5%	40%
Pellets (starch or cellulose based)	97%	95%
Fruits and vegetables	65%	40%

The survey was sent to 97 zoos in France and 15.4% (15 zoos) responded. The questionnaire consisted of 36 questions on zoo nutrition practices. The answer has allowed the identification of 63 ruminant species and their rations.

Zoos provide a wide range of diets for the ruminants they keep (Table 1). Grass hay is the most commonly used forage, except for browsers (71% of zoos provide alfalfa hay compared to 89% for European giraffe facilities [1]). However, only 40% (compared to 80-96% in giraffe [1, 2]) of browsing ruminants have access to browse on a daily basis. Furthermore, 20% of French zoos do not provide foliage to browsers. Pellets are an important part of the ruminant ration in zoos, and the majority of rations offer fruits and vegetables that are not part of the natural diet. The differences in diet between captive and wild animals, and zoo and farm animals, may also impact tooth abrasion [3]. Forage analysis (CP, NDF, ADF, energy, minerals) is not a common practice in the nutritional strategy of French zoos (Table 2) and limits the nutrient analysis of herbivore rations. Zoos develop a large part of their rations based on field experience (61.5%) and/or word of mouth (15%), especially from their suppliers.

Using agronomic advice to formulate herbivore rations has its limits, particularly with regard to the wear of teeth, fibre fractions for browsers, and the introduction of feeds rich in starch or highly fermentable sugar, especially when nutrient analyses are not common practice. French zoos seem to be moving away from agronomic practices necessary to support their ration formulation and from the literature available for captive exotic ruminants. It can be useful to evaluate and improve feeding management precisely and individually in French zoos and to accompany them in the progression of their methods.

KEYWORDS: *Ruminant, browser, husbandry practices, agronomy*

Table 2. Percentage of zoos conducting laboratory analysis related to their ruminant husbandry.

	Yes	No
Drinking water analysis	33%	67%
Hay and alfalfa analysis	20%	80%

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nutrioo.zoonutrition@gmail.com

Feeding pangolins under human care: clues from their natural diet

Xinmei Wang[1,2], Geert PJ Janssens[3], Bowen Xie[1,2] & Yanni Wang[1,2] & Jing Li[1,2] & Jia Xu[4]*

[1]College of Chemistry and Life Sciences, Zhejiang Normal University;
[2]Key Laboratory of Wildlife Biotechnology and Conservation and Utilization of Zhejiang Province;
[3]Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University;
[4]Department of Veterinary Medicine, Faculty of Agriculture, Jinhua Polytechnic

Effective ex-situ conservation of pangolins requires appropriate nutrition to maintain a healthy population. Studies have found the type of food used in successful pangolin protection agencies quite variable in nutritional composition. We aimed to compare the wild diet and successful diets of managed pangolins, to outline the key factors of successful ex-situ maintenance, and the strategies to improve their conservation success in animal care centres and in the wild. In terms of wild diets, the crude protein of ant insects was very high (55.4 ±3.7 g/100g), with minor amounts of carbohydrates, and varying levels of crude fat, total sugar and ash. The crude protein content of pangolins' wild foods, such as *Tetramorium bicarinatum*, *Camponotus herculeanus* and *Coptotermes formosanus*, was significantly higher than that of other foods ($P = 0.04$), such as eggs, milk and common cat food. In addition, the nutrient profile of different species of termites and ants and even the same species of termites and ants but different types (queens, soldiers, etc) can display differences. In addition to basic nutrients, ants were also rich in formic acid, which was mainly used for defence, trace marking and antibacterial action. It may be interesting to evaluate if this has a role for intestinal health. The ant epidermis also contains chitin, which may support digestive characteristics and gut health but may also serve as energy source. Based on the existing literature and our own practical experience, it is clear that the main difference between diets in the wild and in human care of pangolins is that the latter contains less insects, and more carbohydrates and non-protein substances than the former. Moreover, water soluble carbohydrates (WSC) (5.0 ±5.9% vs 14.6 ±10.1%) and crude fat (18.9 ±4.7% vs 24.0 ±5.7%) of wild ants were lower, but the protein (53.9 ±6.3% vs 43.9 ±10.0%) and neutral detergent fiber (NDF) (16.4 ±5.9% vs 13.3 ±3.5%) contents were higher, with a similar acid detergent fiber (ADF) level. The mineral and vitamin concentrations of the ants also exceeded many common food items, such as oil, meat, eggs, and fish. However, not much is known about the bioavailability of minerals from ants and termites. The content of vitamins in wild pangolin diets is significantly higher than that of diets in human care, such as vitamin E, vitamin A and vitamin B2, with deficiency of these vitamins under human care reported in the literature [1,2]. Although many successful dietary formulae have been developed, the pangolin's nutritional needs are still less well studied. A diet with the nutrient concentrations observed in the wild may add to successful ex-situ conservation.

KEYWORDS: *Pangolins, natural diet, captive feeding, nutritive value*

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Geert.Janssens@UGent.be

Nutrient analysis of stomach content in free-ranging wild boar

Renjie Yao[1], Sofie Weckx[1], An Cools[1], Dominiek Maes[2] Sam Millet[1,3] and Geert P.J. Janssens[1]

[1]Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University, Belgium
[2]Department of Internal Medicine, Reproduction and Population Medicine, Faculty of Veterinary Medicine, Ghent University, Belgium
[3]ILVO, Melle, Belgium

Although domesticated pigs belong to the most studied species in terms of nutrition, reports on the diet of wild Suidae are often limited to descriptive data on diet items. Extrapolation of diet recommendations from domesticated pigs to wild suids, or even non-producing domestic pigs, may overlook differences between the nutritional needs for high-producing animals and those for longevity and health. More information on the diet of wild suids may also reveal preferential and digestive traits that can inform a better husbandry. We here focus on wild boar (*Sus scrofa*), a species that is widespread in Eurasia and has been introduced to other continents. For the study, Belgian hunters were contacted to notify when a wild boar was shot. The stomach of the animal was removed and the stomach content was collected, transported to the lab and frozen until analysis. Stomach contents of 10 animals (4 females, 6 males) were collected between February and July 2018. The estimated age was lower than 2 years, and body weights ranged from 12 to 65 kg. The entire stomach content was freeze-dried and ground. Subsamples were subjected to macronutrient analysis (dry matter, ash, crude protein, ether-extract, neutral-detergent fibre (NDF), acid-detergent fibre (ADF), and acid-detergent lignin (ADL)) and mineral analysis (Ca, P, Mg, Na, K, Fe, Zn, Cu, Mn) as well as acid insoluble ash. All results are expressed on a dry matter basis. The results were compared with 5 available commercial diets for “hobby pigs” with a t-test. The nutrient concentrations in the stomach content were more variable than the composition of commercial diets: for instance, the stomach content had an average crude protein percentage of 15% with a standard deviation of 5% (versus 15 ±1% CP in the hobby pig diets). The fibre fractions (NDF, ADF, ADL) also strongly varied: for instance, the average ADF % was 14 ±11%, with values up to 35%. This made it hard to detect significant differences with the hobby pig diets, but when calculating the difference between NDF and ADF (NDF-ADF %) – as an estimate of fermentable fibre – the hobby pig diets showed a markedly higher value: 16 ±16% versus only 5 ±4% in the wild boar stomach contents (P = 0.007). Stomach ash content was also highly variable, with values up to 28% ash (of which 19% acid-insoluble ash). This likely originated from ingestion of soil (suggested by an average Fe concentration of 4689 ±3789 mg/kg in the stomach contents versus 110 ±42 mg/kg in the hobby diets), but also from animal matter (bone) as shown by high Ca and P concentrations in some samples. Many other minerals (Cu, Zn, Mg, K) had significantly lower concentrations in the stomach contents than in commercial diets.
Although we acknowledge that stomach contents are only a “snapshot” of the diet, the diet of wild boar appears highly variable, in agreement with their opportunistic omnivorous behaviour. More importantly, the fibre profile in diets for hobby pigs may be too fermentable. In addition, the optimal provision of microminerals and maybe other micronutrients in suids may deviate from common recommendations.

KEYWORDS: *Sus scrofa*, diet composition, wild

Geert.Janssens@UGent.be

(Workshop contribution)

Giraffe feeding method: how stereotypies and other behaviour changed at Kolmården Zoo

William Walldén

Kolmården Zoo, Sweden

Kolmården Zoo in Sweden holds one of the most northern-living giraffe herds in the world. This comes with challenges, both nutritionally and management-wise. As the outdoor temperature ranges below zero for 3-5 months each year, Kolmården's giraffe herd spends extended periods of time indoors. Stereotypical behaviours such as licking of the internal enclosure walls has been commonly observed by animal care staff. This presentation discusses a trial performed with the aim to minimize stereotypies and raise the welfare standard of the animals.

First, we investigated time budgets of our giraffe using video surveillance and established how this compared to time budgets of wild giraffes. Based on the results, the next aim was to come up with solutions to allow the giraffes at Kolmården opportunities to express more natural behaviours to improve their welfare.

We put up four synchronised camera traps and filmed the giraffes for 10 seconds every 5 minutes around the clock. We registered all behaviours per individual between 5:00 and 20:00 for five consecutive days. Between 20:00 and 5:00 we registered the same behaviours but as a group. This was then repeated after we made changes in our routines.

The first period we fed the giraffes both in feeding cribs and slowfeed barrels for three days, whilst they were fed only in slowfeed barrels for the other two days. Comparing these different ways of feeding and the giraffe's behaviour we saw a big enough pattern do decide to stop using the cribs. From this week we found out that our giraffes spend an average of over 50% of the observed time feeding, but almost 10% of the time performing oral stereotypies. Signs of other stereotypic behaviour were not found.

A few weeks later we repeated the study. We could see a significant change in their behaviour. The extent of this change differed between individuals, but always was in the direction of a reduction of stereotypies and an increase in feeding time.

The night behaviours changed drastically. The resting time went from over 70%, down to below 40%, while the nightly feeding increased from below 10% to 25%.

We find this to be an interesting development, due to the fact that we only changed up to 30% of how the food was presented. We conclude that further research into the matter is needed. Making access to food difficult for zoo herbivores, without endangering overall food intake, may be an important contribution to shift activity budgets in a desired direction.

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William.Wallden@kolmarden.com

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