Zoo animal nutrition: a historical approach and some general rules

Marcus Clauss & Jean-Michel Hatt

Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Switzerland

European Zoo Nutrition Conference 2015 Arnhem
Child of the wilderness ...

... or potato couch?

Feeding herbivores in zoos

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Feeding ruminants

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Zoo animal nutrition
- nutritional diseases
Approach to zoo animal nutrition

+ “do as we always did”

-
Historical approach
Approach to zoo animal nutrition

+ “do as we always did”
  based on experiences what has been working

- sometimes ‘experiences’ are mistakes one has been making for long time

“imitate the natural diet”
best approach
Example: Coati (Nasua spp.)

Alves-Costa et al. (2004)
Natural diets

2.2 Feeding

A. Knowledge of giraffe nutrition in the wild

It is important to know what giraffes are feeding on in the wild, when determining the proper diet in captivity.

2.2.1 Selection of feeding plants:

Hoffmann (1973) classifies the giraffe as a browser. Trees or shrubs because are the dominant food plants (for a compilation of literature references see section 4, part D), leaves and shoots making up the most important items of the diet (Table 2.1). Selectivity of feeding behaviour is characterised by Van Scott (1974) to be of an intermediate degree. Due to its large body size, a giraffe must cannot afford to feed as selectively as smaller ruminant species.

Table 2.1: Description of feeding behaviour

<table>
<thead>
<tr>
<th>Plant parts ingested</th>
<th>Importance to the diet</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves, small twigs</td>
<td>++</td>
<td>Leuthold and Leuthold (1972, 1978)</td>
</tr>
<tr>
<td>Some bark, flowers and fruits</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Leaves and shoots of trees and shrubs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herbaceous material (climbers, vines, tall herbs)</td>
<td>Up to 7%</td>
<td>Owen-Smith (1983)</td>
</tr>
<tr>
<td>Shoot tips</td>
<td>78%</td>
<td></td>
</tr>
<tr>
<td>Leaf stalks</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Flowers</td>
<td>3%</td>
<td>Fellows (1984a,b)</td>
</tr>
<tr>
<td>Pods</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

If new growing shoots are available (including young leaves, twigs and shoots), they represent the favoured food resource according to Smit et al. (1982). Older leaves are ingested when shoots are not available. Owen-Smith (1983) reports considerable amounts of woody material to be included in the diet (5% in the rainy and 15% in the dry season).
EltonTraits 1.0: Species-level foraging attributes of the world’s birds and mammals

*Ecological Archives* E095-178

Hamish Wilman, ¹ Jonathan Belmaker, ¹,2 Jennifer Simpson, ¹,3 Carolina de la Rosa, ¹ Marcelo M. Rivadeneira, ⁴ and Walter Jetz ¹,5,6

<table>
<thead>
<tr>
<th>Name</th>
<th>Scientific Name</th>
<th>Weight</th>
<th>Diet-Nutri</th>
<th>Diet-Verd</th>
<th>Diet-Vect</th>
<th>Diet-Wink</th>
<th>Diet-Junk</th>
<th>Diet-Scav</th>
<th>Diet-Next</th>
<th>Diet-Seed</th>
<th>Diet-Planto</th>
<th>Diet-Source</th>
<th>Diet-Certainty</th>
</tr>
</thead>
</table>
Approach to zoo animal nutrition

+ “do as we always did”
  based on experiences what has been working

- sometimes ‘experiences’ are mistakes one has been making for long time

“imitate the natural diet”
  best approach

depends on what you know about the natural diet, and what feeds are available
No easy-to-harvest packages of tiny invertebrates
Unavoidable detritus ingestion in myrmacophages

from McNab (1984)
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“imitate the natural diet”
  best approach depends on what you know about the natural diet, and what feeds are available
Example: Giant anteater (Myrmecophaga tridactyla)

Gull et al. (2015)
Natural diets

There are no secret, species-specific ingredients!

Formic acid in anteater formulas?
There is no single source of quantitative natural diet information on mammals.
Approach to zoo animal nutrition

+ 
“do as we always did”

based on experiences what has been working

- 
sometimes ‘experiences’ are mistakes one has been making for long time

“imitate the natural diet”

best approach

depends on what you know about the natural diet, and what feeds are available
Two traditions in imitating natural diets

Ratcliffe and Wackernagel

- a complete feed for each animal (group) (pelleted/extruded)
- atypical physical structure
- some nutrients difficult to limit
- behavioural deficits

Hediger

- ‘natural’ feeds (forages, fruits/vegetables), that resemble the natural diet
- selective feeding possible
- available feeds differ from in nutrient content from the natural diet
Frugivores don’t eat supermarket fruit
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
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“use a suitable domestic species as model”
  ‘scientific compromise’ huge amount of knowledge
  species-specific peculiarities are easily overlooked
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations

James G. Morris

*essential food components

non-essential food components
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations* 

James G. Morris 

Many enzymes can be spared!
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations

James G. Morris

*essential food components
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris

- high protein requirement
- amino acids taurine and arginine
- arachidonic acid
- vitamin A (β-carotine useless)
- vitamin D
- niacin

not essential for dogs

essential nutrients:
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations

James G. Morris
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COPPER DEFICIENCY IN CAPTIVE BLESBOK ANTELOPE
(DAMILISCUS DORCAS PHILLIPSI)

Ellen S. Dierenfeld, Ph.D., Emil P. Dolensek, D.V.M., Tracey S. McNamara, D.V.M., and James G. Doherty, B.S.
**Approach to zoo animal nutrition**

- **“do as we always did”**
  - based on experiences what has been working
  - sometimes ‘experiences’ are mistakes one has been making for long time

- **“imitate the natural diet”**
  - best approach
  - depends on what you know about the natural diet, and what feeds are available

- **“use a suitable domestic species as model”**
  - ‘scientific compromise’
  - huge amount of knowledge
  - species-specific peculiarities are easily overlooked

- **“based on studies in zoo animals”**
  - ‘scientific approach’
  - financially and logistically challenging, difficulty in summarizing knowledge
Studies in zoo animals

- Case reports / case series
- Inventories of diets, pathological states, husbandry success
- Differences between free-range and zoo
- Epidemiological / controlled studies
Examples: case studies

DIETARY TAURINE SUPPLEMENTATION AND CARDIAC FUNCTION IN THE GIANT ANTEATER (Myrmecophaga tridactyla): PRELIMINARY FINDINGS

J. Andrew Teare, DVM, MS,¹* Alan D. Weldon, DVM, Dipl AVCIM,¹ and Nikolay Kapustin, DVM²
2009 PROCEEDINGS AAZV AAWV JOINT CONFERENCE

TAURINE DEFICIENCY IN MANED WOLVES (Chrysocyon brachyurus) MAINTAINED ON TWO DIETS MANUFACTURED FOR PREVENTION OF CYSTINE UROLITHIASIS

Sara E. Childs-Sanford, DVM¹* and C. Roselina Angel, PhD²
2004 PROCEEDINGS AAZV, AAWV, WDA JOINT CONFERENCE

no control group
The classic problem repertoire

Carnivore → Red meat → Calcium deficiency

Primate → Fruits & vegetables → Calcium deficiency

Fish-Eater → Thawed fish → Sodium- and vitamin B deficiency

Herbivore → Hay & grains → Acidosis, vitamin E- and calcium deficiency
Examples: inventories

Grisham and Savage (1990)

Marholdt (1991)

Müller et al. (2011)

no direct association
Examples: inventories

European Zoos

Range countries

European/NA Zoos

Sri Lanka
Myanmar

Kibby Treiber - Plenary (2015)
Studies in zoo animals

- Case reports / case series
- Inventories of diets, pathological states, husbandry success
- Differences between free-range and zoo
- Epidemiological / controlled studies
IRON STORAGE DISORDERS IN CAPTIVE WILD MAMMALS: THE COMPARATIVE EVIDENCE

Marcus Clauss, M.Sc., Dr. med. vet., Dipl. E.C.V.C.N., and Donald E. Paglia, M.D.

<table>
<thead>
<tr>
<th>Species</th>
<th>Individual case</th>
<th>Case series</th>
<th>Epidemiologic survey</th>
<th>Age dep</th>
<th>Comparison free-range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapirs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malayan tapir (Tapirus indicus)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;45,27&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mountain tapir (Tapirus pinchaque)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;45,27&lt;/sup&gt;</td>
</tr>
<tr>
<td>Baird's tapir (Tapirus bairdii)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;45,27&lt;/sup&gt;</td>
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<tr>
<td>Brazilian tapir (Tapirus terrestris)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;, blood&lt;sup&gt;d4&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;45,27&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rhinos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sumatran rhinoceros (Dicerorhinus sumatrensis)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(-) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(-) blood&lt;sup&gt;22&lt;/sup&gt;</td>
</tr>
<tr>
<td>Asian one-horned rhinoceros (Rhinoceros unicornis)</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(-) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(-) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(-) tissue&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(-) blood&lt;sup&gt;22&lt;/sup&gt;</td>
</tr>
<tr>
<td>White rhinoceros (Ceratotherium simum)</td>
<td>(+) blood&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(+) blood&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Black rhinoceros (Diceros bicornis)</td>
<td>(+) blood&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(+) histo&lt;sup&gt;a&lt;/sup&gt;, blood&lt;sup&gt;23,71,32,38&lt;/sup&gt;</td>
<td>(+) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(-) blood, tissue&lt;sup&gt;22,23&lt;/sup&gt;</td>
<td>(+) histo, blood, tissue&lt;sup&gt;22,23,64,71,73&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Examples: differences wild - zoo

+ fibre in herbivore diets
- iron deposits in organs
+ unsaturated (n-3) fatty acids in diets and body tissues
- tooth wear (browsers, bears)
+ dental calculus

Dental calculus

Relationship between diet, dental calculus and periodontal disease in domestic and feral cats in Australia

DE CLARKE\textsuperscript{a} and A CAMERON\textsuperscript{b}

\textit{Aust Vet J} 1998;76:690-693.

\textbf{Results}  
Dental calculus scores were significantly higher in domestic cats than in feral cats. There was no statistical difference in the prevalence of periodontal disease between the two groups.

\textbf{Conclusion}  
It can be inferred that diet may play a role in the accumulation of calculus, but a diet based on live prey does not protect cats against periodontal disease.

Figure 1. Calculus on the buccal surface of the upper fourth premolar tooth in a feral cat.
Examples: differences wild - zoo

- fibre in herbivore diets
- iron deposits in organs
+ unsaturated (n-3) fatty acids in diets and body tissues
- tooth wear (browsers, bears)
+ dental calculus
+ undesired GIT bacteria
+ feeding-related dysbehaviour

Removing Milk from Captive Gorilla Diets: The Impact on Regurgitation and Reingestion (R/R) and Other Behaviors

Kristen E. Lukas,1,2,3* Gloria Hamor,3 Mollie A. Bloomsmith,2,3 Charles L. Horton,3 and Terry L. Maple2,3

Zoo Biology 18:515 - 528 (1999)
Examples: differences wild - zoo

+ fibre in herbivore diets
- iron deposits in organs
+ unsaturated (n-3) fatty acids in diets and body tissues
- tooth wear (browsers, bears)
+ dental calculus
- undesired GIT bacteria
- feeding-related dysbehaviour
- obesity

Examples: differences wild - zoo

obesity
Examples: epidemiological/controlled studies

Social Factors Influence Ovarian Acyclicity in Captive African Elephants (*Loxodonta africana*)

Elizabeth W. Freeman,¹,²* Greg Guagnano,² Deborah Olson,³ Mike Keele,⁴ and Janine L. Brown¹

Females more likely to be acyclic had a larger body mass index and had resided longer at a facility with the same herdmates. Results suggest that controlling the weight of an elephant might be a first step to helping mitigate estrous cycle problems.
Examples: epidemiological/controlled studies

When feeding stops breeding – How inappropriate diets can reduce (or enhance) reproductive output

Christoph Schwitzer¹ & Katie Edwards²

¹Bristol Conservation and Science Foundation, Bristol ZOO Gardens, Clifton, Bristol, UK.
²Chester Zoo, Upton, Chester, UK.

Body condition scoring

- Non-breeding females scored higher BCS than proven females

P=0.004

courtesy Christoph Schwitzer
Nutritional Metabolic Bone Disease in Juvenile Veiled Chameleons (Chamaeleo calyptratus) and Its Prevention\textsuperscript{1–3} J. Nutr. 140: 1923–1931, 2010.

Stefan Hoby,\textsuperscript{4,5} Christian Wenker,\textsuperscript{5} Nadia Robert,\textsuperscript{4} Thomas Jermann,\textsuperscript{5} Sonja Hartnack,\textsuperscript{6} Helmut Segner,\textsuperscript{4} Claude-P. Aebischer,\textsuperscript{8} and Annette Liesegang\textsuperscript{7}.

Effects of starch and fibre in pelleted diets on nutritional status of mule deer (Odocoileus hemionus) fawns

S. McCusker\textsuperscript{1}, L. A. Shipley\textsuperscript{1}, T. N. Tollefson\textsuperscript{1,2}, M. Griffin\textsuperscript{3,4} and E. A. Koutsos\textsuperscript{4}.

Nutritional Metabolic Bone Disease in Juvenile Veiled Chameleons (Chamaeleo calyptratus) and Its Prevention\textsuperscript{1–3}


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### Body dimensions

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Weight</th>
<th>SVL</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV</td>
<td>10</td>
<td>28.7 (15.2–34.2)</td>
<td>100.1 (90.4–108.8)</td>
</tr>
<tr>
<td>No</td>
<td>10</td>
<td>33.5 (13.2–15.7)</td>
<td>74.4 (68.1–79.7)</td>
</tr>
<tr>
<td>CaUV</td>
<td>9</td>
<td>58.2 (47.3–69.2)</td>
<td>144.2 (133.8–154.6)</td>
</tr>
<tr>
<td>CaA</td>
<td>9</td>
<td>60.5 (52.1–68.9)</td>
<td>144.2 (133.8–155.1)</td>
</tr>
<tr>
<td>CaAD</td>
<td>9</td>
<td>54.3 (38.1–70.5)</td>
<td>130.2 (117.6–150.9)</td>
</tr>
<tr>
<td>CaADUV</td>
<td>9</td>
<td>57.9 (38.2–77.6)</td>
<td>136.9 (113.8–165.7)</td>
</tr>
</tbody>
</table>

![Image of nutritional metabolic bone disease in juvenile veiled chameleons](image.png)
Examples: epidemiological/controlled studies

Hepatic Hemosiderosis in Common Marmosets, Cebuella Pygmaea: Effect of Diet on Incidence

Georgina F. Miller, Dennis E. Barnard, Ruth A. Woodward

Marmoset

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>%</th>
<th>mg/Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>7.50</td>
<td></td>
</tr>
<tr>
<td>Crude Protein</td>
<td>25.40</td>
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</tr>
<tr>
<td>Crude Fibre</td>
<td>3.70</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>10.50</td>
<td></td>
</tr>
<tr>
<td>N.F.E.</td>
<td>42.90</td>
<td></td>
</tr>
<tr>
<td>Starches</td>
<td>27.80</td>
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<tr>
<td>Sugars</td>
<td>7.80</td>
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<tr>
<td>Gross Energy</td>
<td>15.80</td>
<td></td>
</tr>
<tr>
<td>Dig. Energy</td>
<td>13.30</td>
<td></td>
</tr>
<tr>
<td>Met. Energy</td>
<td>12.00</td>
<td></td>
</tr>
<tr>
<td>Linoleic Acid</td>
<td>2.12</td>
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<tr>
<td>Linoleic Acid</td>
<td>0.27</td>
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</tr>
<tr>
<td>Calcium</td>
<td>2.16</td>
<td></td>
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<tr>
<td>Phosphorus</td>
<td>1.45</td>
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<tr>
<td>Phytate Phosphorus</td>
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<tr>
<td>Sodium</td>
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<td>Phosphorus</td>
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<tr>
<td>Potassium</td>
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<td>Magnesium</td>
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<td>Iron</td>
<td>358.00</td>
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<tr>
<td>Copper</td>
<td>18.00</td>
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<tr>
<td>Manganese</td>
<td>85.00</td>
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<tr>
<td>Zine</td>
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<tr>
<td>Cobalt</td>
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<tr>
<td>Indine</td>
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<tr>
<td>Selenium</td>
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<tr>
<td>Fluorine</td>
<td>54.00</td>
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<tr>
<td>Vitamin A</td>
<td>30142.00</td>
<td></td>
</tr>
<tr>
<td>Vitamin D3</td>
<td>11640.00</td>
<td></td>
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<tr>
<td>Vitamin E</td>
<td>105.60</td>
<td></td>
</tr>
<tr>
<td>Vitamin B1</td>
<td>27.70</td>
<td></td>
</tr>
<tr>
<td>Vitamin B2</td>
<td>18.20</td>
<td></td>
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<tr>
<td>Vitamin B6</td>
<td>14.10</td>
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<tr>
<td>Vitamin B12</td>
<td>39.40</td>
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<tr>
<td>Vitamin C</td>
<td>2996.00</td>
<td></td>
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<tr>
<td>Vitamin K3</td>
<td>5.90</td>
<td></td>
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<tr>
<td>Folic Acid</td>
<td>10.20</td>
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</tr>
<tr>
<td>Nicotinic Acid</td>
<td>92.70</td>
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</tr>
<tr>
<td>Pantothenic Acid</td>
<td>37.30</td>
<td></td>
</tr>
<tr>
<td>Choline</td>
<td>1951.00</td>
<td></td>
</tr>
<tr>
<td>Inositol</td>
<td>1649.00</td>
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<tr>
<td>Biotin</td>
<td>398.00</td>
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</tr>
</tbody>
</table>

$\Rightarrow$ Fe $\geq$ 350 ppm DM leads to massive liver damage
Examples: epidemiological/controlled studies

=> Fe ≥ 350 ppm DM leads to massive liver damage
Research in a zoo setting

- Lack of risk for zoo animals is usually a prerogative for a zoo study to be allowed.
- Studies that shall have relevance for **HEALTH** mostly by definition require setups of more and less healthy options/treatments.

- Typical ‘risk-free’ nutrition studies in zoos with potential relevance: inventories, epidemiological studies.
- Typical ‘risk-free’ nutrition studies in zoos with less potential relevance: measuring digestibility and digesta passage on used diets.
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+ “do as we always did”
  based on experiences what has been working

- sometimes ‘experiences’ are mistakes one has been making for long time

“imitate the natural diet”
best approach

depends on what you know about the natural diet, and what feeds are available

“use a suitable domestic species as model”
‘scientific compromise’
huge amount of knowledge

species-specific peculiarities are easily overlooked

“based on studies in zoo animals”
‘scientific approach’

financially and logistically challenging, difficulty in summarizing knowledge
Where is the information?
Where is the information?
Table 7: Practical Diet for Asian Tapir (*Tapirus indicus*)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Amount</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High fiber (ADF 20%) herbivore pellet</td>
<td>1500 g</td>
<td>10% CP, 3% Fat, 25 ppm Cu</td>
</tr>
<tr>
<td>2</td>
<td>Roots (tump, carrot, sweet potato)</td>
<td>1000 g</td>
<td>May be reserved to reinforce management behaviors</td>
</tr>
<tr>
<td>3</td>
<td>Browse, variable species</td>
<td>1-1m section</td>
<td>Constant portion of this diet but difficult to quantify mass provided</td>
</tr>
<tr>
<td></td>
<td><strong>Items 1-3 offered AM in holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>High fiber (ADF 20%) herbivore pellet</td>
<td>2600 g</td>
<td>15% CP, 3% Fat, 25 ppm Cu</td>
</tr>
<tr>
<td>5</td>
<td>Roots (tump, carrot, sweet potato)</td>
<td>1000 g</td>
<td>May be reserved to reinforce management behaviors</td>
</tr>
<tr>
<td>6</td>
<td>Greens (dandelion, kale, collard)</td>
<td>350 g</td>
<td>May be reserved to reinforce management behaviors</td>
</tr>
<tr>
<td>7</td>
<td>Alfalfa hay</td>
<td>2650 g</td>
<td>&gt;18% CP, &lt;32% ADF</td>
</tr>
<tr>
<td></td>
<td><strong>Items 4-7 offered PM in holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Banana, with peel</td>
<td>325 g</td>
<td>May be reserved to reinforce management behaviors</td>
</tr>
<tr>
<td>9</td>
<td>Psyllium fiber</td>
<td>60 g</td>
<td>This supplement was added as prophylaxis against sand colic</td>
</tr>
<tr>
<td></td>
<td><strong>Items 8-9 mixed together; offer as indicated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Salt block, plain</td>
<td>ad libitum</td>
<td>Offered in a secure manner that prevents overconsumption</td>
</tr>
</tbody>
</table>

Target bodyweight range = 350-375 kg (770-827 lb).

Downar, 2001; Stevens, 1968; Padilla & Dowler, 1994; Lintzenich & Ward, 1997; National Research Council, 2007; Janssen et al., 1999; Murphy et al., 1997; Clausen et al., 2009.
Where is the information?
Captive Management Husbandry Manuals

This Husbandry Manual Register is in two parts;

1. The first section is an index of Mammal Taxonomic Orders. Click on the Taxonomic link to be taken to the relevant section within the second section of the Registry. Please note that Husbandry Manuals are not currently available for all groups or species.

2. The second section provides the contact details for the Husbandry Manuals known to us from the taxonomic group you have selected, listed by Taxonomic Family.

If the contact details for a specific Manual has changed or you know of, or are searching for, a specific Manual which is not listed here, please contact me and I will endeavour to assist.

Many of the following Husbandry Manuals are available from one or more of the regional Zoo Management Associations; unfortunately in most cases you need to be a financial member of the relevant Association in order to be eligible to obtain a copy of a Manual. However, wherever possible, contact details for obtaining a copy directly from the authors (or elsewhere) is provided.
Where is the information?
Where is the information?

The Feeding and Nutrition of Herbivores

Olav T. Ofstedal, David J. Baer, and Mary E. Allen

The Feeding and Nutrition of Carnivores

Mary E. Allen, Olav T. Ofstedal, and David J. Baer

The Feeding and Nutrition of Omnivores with Emphasis on Primates

Olav T. Ofstedal and Mary E. Allen
Where is the information?

not in any one place