NUTRITIONAL DISEASES:
FROM BOTTLE FEEDING TO
GERIATRIC ISSUES

Marcus Clauss & Jean-Michel Hatt

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

EAZWV, Warschau 2014
Child of the wilderness ...

... or potato couch?

Feeding herbivores in zoos

Marcus Clauss
Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich
mclauss@vetclinics.uzh.ch

Feeding ruminants

Marcus Clauss
Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty
University of Zurich
mclauss@vetclinics.uzh.ch
Zoo animal nutrition
- nutritional diseases
Approach to zoo animal nutrition

+ “do as we always did”
Historical approach

Variations in Eastern Bongo (Tragelaphus eurycerus isaaci) Feeding Practices in UK Zoological Collections

D. J. Wright,1,* H. M. Omed,1 C. M. Bishop,1 and A. L. Fidgett2
Zoo Biology 30: 149–164 (2011)

Feeding practices for captive greater kudus (Tragelaphus strepsiceros) in UK collections.

Lucy A. Taylor1,*, Christoph Schwitter1, Norman Owen-Smith1, Michael Kreuzer2 and Marcus Clauss3
## Approach to zoo animal nutrition

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>+</strong></td>
<td><strong>“do as we always did”</strong></td>
<td><strong>-</strong></td>
</tr>
<tr>
<td>based on experiences what has been working</td>
<td>sometimes ‘experiences’ are mistakes one has been making for long time</td>
<td></td>
</tr>
</tbody>
</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
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
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
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
Example: Giant anteater (*Myrmecophaga tridactyla*)

![Graph showing faecal dry matter vs. acid-insoluble ash]

Gull et al. (subm.)
Example: Giant anteater (Myrmecophaga tridactyla)

Gull et al. (subm.)
Example: Giant anteater (*Myrmecophaga tridactyla*)

Gull et al. (subm.)
Example: Maned wolf (*Chrysocyon brachyurus*)

In various studies, e.g. Bueno *et al.* (2004)
Example: Coati (Nasua spp.)

- Insects: 24%
- Millipedes: 17%
- Spiders: 11%
- Gastropods: 1%
- Refuse: 3%
- Vertebtrates: 3%
- Fruits: 15%
- Plant parts: 26%

Alves-Costa et al. (2004)
Natural diets

Research Article:
Feeding practices for captive greater kudus (*Tragelaphus strepsiceros*) in UK collections.
Lucy A. Taylor*, Christoph Schwitter†, Norman Owen-Smith‡, Michael Kreuzer§ and Marcus Clauss§
Natural diets

Research Article

Feeding practices for captive greater kudus (Tragelaphus strepsiceros) in UK collections as compared to diets of free-ranging specimens

Lucy A. Taylor¹,², Christoph Schwitzer¹, Norman Owen-Smith¹, Michael Kreuzer³ and Marcus Clauss⁴
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. Tree or shrub browse 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 Soest (1984) to be of an intermediate degree. Due to its large body size, a giraffe just cannot afford to feed as selectively as smaller ruminant species.

<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>Lenthold and Lenthold</td>
</tr>
<tr>
<td>Stem, bark, flowers and fruits</td>
<td>+</td>
<td>(1972, 1978)</td>
</tr>
<tr>
<td>Leaves and shoots of trees and shrubs</td>
<td>++</td>
<td>Owens-Smith (1983)</td>
</tr>
<tr>
<td>Herbaceous material (stems, leaves, tall forbs)</td>
<td>Up to 7%</td>
<td></td>
</tr>
<tr>
<td>Shoot tips</td>
<td>78%</td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>14%</td>
<td>Pellow (1984a,b)</td>
</tr>
<tr>
<td>Flowers</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Peds</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 thorns), they represent the favoured food source according to Sasse et al. (1982). Older leaves are ingested when shoots are not available. Owens-Smith (1983) reports considerable amounts of woody material to be included in the diet (3% in the rainy and 15% in the dry season).
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)
- 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

Diet and Oral Health in Captive Amur Tigers (Panthera tigris altaica)

L. I. Haberstroh, D.V.M.*
D. E. Ullrey, Ph.D.**
J. G. Sikarski, D.V.M., M.S.*
N. A. Richter, D.V.M.***
B. H. Colmery, D.V.M.*
T. D. Myers, D.D.S.****

A SOFT VERSUS HARD DIET AND ORAL HEALTH IN CAPTIVE TIMBER WOLVES (Canis lupus)

K.M. Vosburgh, B.S.*
R.B. Barbiers, B.S.*
J.G. Sikarskie, D.V.M., M.S.*
D.E. Ullrey, Ph.D.**
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
Traditions in imitating natural diets
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
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris

essential nutrients:
- high protein requirement
- amino acids taurine and arginine
- arachidonic acid
- vitamin A (β-carotene useless)
- vitamin D
- niacin

not essential for dogs
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris
Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations*

James G. Morris
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. AVCM,2 and Nikolay Kapustin, DVM1

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)

Feeding type | n | Acidotic changes of the rumen mucosa (%)
--- | --- | ---
Grazer | 13 | 23
Intermediate | 30 | 27
Browser | 24 | 83

Marholdt (1991)

no direct association

Müller et al. (2011)
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

e.g. Taylor et al. (2013), Clauss & Paglia (2012), Clauss et al. (2007), Wenker et al. (1999), Kaiser et al. (2009), Taylor et al. (2014), Clarke & Cameron (1998)
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.

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.

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

Great ape R/R
Great ape R/R

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)

Special Articles

Regurgitation in Gorillas: Possible Model for Human Eating Disorders (Rumination/Bulimia)

EDWIN GOULD, PH.D.
Department of Mammalogy, National Zoological Park, Smithsonian Institution, Washington, D.C.

MIMI BRES, M.S.
Department of Biological Sciences, The George Washington University, Washington, D.C.
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
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 Schwitzer & Katie Edwards

Bristol Conservation and Science Foundation

Body condition scoring

- Non-breeding females scored higher BCS than proven females

P=0.004

courtesy Christoph Schwitzer
Examples: epidemiological/controlled studies

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{2*}

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}

Examples: epidemiological/controlled studies

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


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{2,8}

<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>26.7 (19.2–34.2)</td>
<td>100.1 (80.4–108.8)</td>
</tr>
<tr>
<td>No</td>
<td>10</td>
<td>13.5 (11.3–15.7)</td>
<td>74.4 (69.1–79.7)</td>
</tr>
<tr>
<td>CaAUV</td>
<td>9</td>
<td>58.2 (47.3–68.2)</td>
<td>144.2 (133.3–156.1)</td>
</tr>
<tr>
<td>CaA</td>
<td>9</td>
<td>56.5 (45.1–46.9)</td>
<td>144.2 (133.3–156.1)</td>
</tr>
<tr>
<td>CaADUV</td>
<td>9</td>
<td>54.3 (38.1–70.5)</td>
<td>130.2 (117.6–150.0)</td>
</tr>
<tr>
<td>CaAD</td>
<td>9</td>
<td>57.9 (38.2–77.6)</td>
<td>136.8 (117.6–150.7)</td>
</tr>
</tbody>
</table>

**A** 220

PGCT vertebral column

BMD (g/cm\textsuperscript{2})

- UV
- No
- CaAUV
- CaA
- CaADUV
- CaAD

- 60
- 100
- 140
- 180
Examples: epidemiological/controlled studies

Hepatic Hemosiderosis in Common Marmosets, *Callithrix jacchus*: Effect of Diet on Incidence and Severity

Georgina F. Miller,1 Dennis E. Barnard,1 Ruth A. Woodward,1 B. Michael Flynn,1 and Jeff W. M. Bulte2

=> Fe ≥ 350 ppm DM leads to massive liver damage
Examples: epidemiological/controlled studies

=> Fe ≥ 350 ppm DM leads to massive liver damage
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
Where is the information?
Where is the information?
Where is the information?
Where is the information?
Where is the information?
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
... from bottle feeding to geriatric issues ...
Bottle feeding

- ... is it reasonable?
- ... is it feasible (in terms of logistics)?
- ... do you have a recipe and a dosage scheme?
Mammal milk composition

Data from A. Riek (2008)
Mammal milk composition

Data from A. Riek (2008)
Mammal milk composition

Data from A. Riek (2008)
## Mammal milk recipes

### Tabelle 1: Rezepte für hausgemachte Milchaustauscher für verschiedene Species

<table>
<thead>
<tr>
<th>Futtermittel</th>
<th>für Hund</th>
<th>Katze</th>
<th>Katze¹</th>
<th>Rotwild</th>
<th>Rehkitz</th>
<th>Hase</th>
<th>Igel</th>
<th>schweinchen</th>
<th>Hamster</th>
<th>Chinchilla</th>
<th>Seehunde</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteil in %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magerquark</td>
<td>40</td>
<td>15</td>
<td>15</td>
<td>5</td>
<td>36</td>
<td>65</td>
<td>60</td>
<td>38</td>
<td>40</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>Rinderhack, fettarm</td>
<td>–</td>
<td>8</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Heringsfilet</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
<td>12</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Elgelb</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>3</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Magermilch</td>
<td>43</td>
<td>68,2</td>
<td>76</td>
<td>66</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>42</td>
<td>33</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Rahm (30 % Fett)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>27</td>
<td>28</td>
<td>25</td>
<td>–</td>
<td>7</td>
<td>11</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Wasser</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>40</td>
<td>–</td>
</tr>
<tr>
<td>Fencheltee</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>18</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Vollmilch</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>35,5</td>
<td>–</td>
<td>48</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Lactose</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0,8</td>
<td>36,5</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Speiseöl</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>–</td>
<td>–</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fischöl¹</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mineralfutter²</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2,15</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

¹) Dieses Rezept müssen bei langfristiger Verwendung 40 mg Taurin und 380 mg Nachtkerzenöl pro 100 ml zugesetzt werden.
²) unbedingt, sonst geringe Verdaulichkeit des Fettes → Verschmutzung des Schwimmbecks (MEYER und WIESE-TWELE, unveröffentl.)
³) Mit ca. 20 % Calcium, 5–8 % Phosphor, für Seehunde sind 10 % Calcium günstiger.

Das Rezept für die Seehunde ist in Anlehnung an eine von MEYER und WIESE-TWELE (unveröffentl.) bei der Heuleraufzucht überprüfte Mischung berechnet. Im Originalrezept ist ein milchreiches Alleinfutter für Hunde enthalten, das nicht mehr im Handel ist, daher wurde es durch andere Komponenten ersetzt. Alle übrigen Rezepte sind entsprechend der Milchzusammensetzung berechnet, jedoch nicht praktisch erprobt.

From Kienzle & Landes (1995)
Mammal milk recipes

**TAPIR**
(Tapiridae tapirus indicus)

### Mother's Milk Comparison

<table>
<thead>
<tr>
<th>Diet</th>
<th>% Protein</th>
<th>% Fat</th>
<th>% Lactose</th>
<th>% Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td>36.3</td>
<td>21.7</td>
<td>42.0</td>
<td>15.7</td>
</tr>
<tr>
<td>Milk 1</td>
<td>33.3</td>
<td>20.3</td>
<td>35.0</td>
<td></td>
</tr>
</tbody>
</table>

### Milk Substitute

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>42/25</td>
<td>57.0</td>
<td>1.3</td>
</tr>
<tr>
<td>20/14</td>
<td>43.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Mixing Directions

The dry powders may be blended together and stored in a closed container following label directions. This allows the blended milk replacer to be reconstituted more quickly when needed. Mix 15.7 grams of powder with 84.3 grams of water or 1.0 volume of powder to 2.5 volumes of water to make a milk of 15.7% solids.
Mammal milk recipes

BIBLIOGRAPHY

Values numbered are from data published by the following individuals:


# Milk replacer calculations

**WildAgain Wildlife Rehabilitation, Inc.**

## Wild mammal nutrition resources

<table>
<thead>
<tr>
<th>Insolubility Issues with Milk Replacer Powders: An Easy Fix</th>
<th>Online</th>
<th>Download (PDF) click below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife rehabilitators caring for young mammals prepare milk replacement formulas. Most rehabilitators, over the years, have dutifully followed the mixing instructions indicated on product labeling. Instructions generally say to add water, gently stir, and the liquid formula is ready to use. This paper discusses issues related to these products lack of complete solubility. Laboratory tests performed to measure insolubility and minor adjustments to formula preparation that easily address these issues.</td>
<td><a href="#">Click Here</a></td>
<td><a href="#">Click Here</a></td>
</tr>
</tbody>
</table>

## Powdered milk replacer product tests - March, 2012

Discussion of test results on 8 recent lots of commercial powdered milk replacement products, including Fox Valley (5 products), PetAg (1 product), and GNC (1 product). Presents new information on solubility, mineral levels, adherence to Guaranteed Analysis, physical characteristics and labeling issues, as well as trends. Tests on additional recent lots expected in April, 2012.

<table>
<thead>
<tr>
<th>Milk Replacer update - January, 2011</th>
<th>Online</th>
<th>Download (PDF) click below</th>
</tr>
</thead>
<tbody>
<tr>
<td>This update discusses research on commercial powdered milk replacer products and issues in wildlife rehabilitation from 2010 through January 2011, as well as a few of the broader issues about milk replacers that have prompted a variety of results and opinions. It also reviews an example of a newly developed 'recipe' that squirrel rehabilitators have found to be effective during 2010, including possible reasons for its success and implications for other recipes.</td>
<td><a href="#">Click Here</a></td>
<td><a href="#">Click Here</a></td>
</tr>
</tbody>
</table>

## Nutrition calculator - newly expanded functionality (May 31, 2013)

This expanded WildAgain Nutrition Calculator provides a tool to calculate the nutritional composition and ideal value for milk replacer powders used by wildlife rehabilitators. The dropdown list allows the user to select from and compare commonly used milk replacer powders from multiple manufacturers as well as compose ‘recipes’ — and then compare that information to research studies of the mother’s milk for several common species of mammals rehabilitated in North America. The calculator also allows the user to add other products or research studies for other species that are not on the provided lists. It’s user-friendly and easy to use. The Calculator does not suggest or endorse a specific or mix of product(s) for individual species; recipes or amounts of formula to be fed; or specific feeding frequencies. Those decisions...
Milk replacer calculations

WildAgain Wildlife Rehabilitation, Inc.

WildAgain’s Nutrition Calculator (Updated 3/30/12)

The calculator is a series of worksheets that provide the nutritional component analysis for various powdered milk replacer products when mixed with water. The calculator is in the form of a Microsoft Excel Spreadsheet, so you do need to have a copy of Excel on your computer. When you click on the link below to the calculator, your browser will likely begin the download process, or it may bring up the calculator in Excel automatically. Either way, the calculator is easy to use and fairly self-explanatory. If you download the calculator, please check back periodically, as new products and lots will be added from time to time.

The Calculator has newly expanded functionality as described below!

1.) Multiple manufacturers, products, individual lots and ingredients.

Previously limited to just a handful of milk replacers produced by one manufacturer, the calculator now provides a selection of over 50 products, individual lots and supplemental ingredients. The user may select up to 6 products or ingredients concurrently from an easy to use drop-down menu when evaluating a formula. The detailed Typical Nutritional Analysis is also provided for each of the individual products and ingredients. The input may be either in volume (parts) or by weight (in grams). Some users prefer to enter the values in grams to alleviate creating inaccurate results because of measurement error.

2.) Allows user to input up to 3 custom products or ingredients.

If the calculator does not already include a specific product, the user has the option to input up to three custom products. The user will need to have certain data about the composition of the product or ingredient (such as % solids, % protein, etc.) as well as the weight in grams of 1 tablespoon of the product or ingredient.
Milk replacer calculations

**Nutritional Calculator for Powdered Milk Replacer Products**

Specifically designed to calculate formulas for wild mammals

**STEP 1**
Choose the products: 
- Heavy whipping cream
- Water

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>Volume in parts</th>
<th>Weight in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy whipping cream</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>Water</td>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
</tbody>
</table>

**STEP 2**
Enter data EITHER into col. A OR col. B - BUT NOT BOTH.
1. Enter in column A the ratio of your desired formula mix.
2. Enter in column B the weight of the products being mixed.

**Formula components as a % of mother’s milk in nature**

- Solid
- Protein
- Fat
- Carbs.
- ME kcal/kg
- Ash & CO2
- Ca
- P
- Ca:P ratio

Click on the blue cell to select a species and research study. If your species or study is not included in the list, go to the "Custom Input" tab in this workbook.

Experience has generally shown that when a formula contains more than 75-80% of the solids contained in mother’s milk, the formula is too rich for the animal to successfully digest, often causing GI upset.
Milk replacer calculations

Click on any of the blue cells to select a product.

**STEP 2**
Enter data in either cell A or cell B:
1. Enter in column A the ratio of your desired
2. Enter in column B the weight of the product

**STEP 1**
Choose the products:
- Heavy whipping cream
- Water

**Products**

<table>
<thead>
<tr>
<th>Solid</th>
<th>Protein</th>
<th>Fat</th>
<th>Ca</th>
<th>P</th>
<th>CaN ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
</tbody>
</table>

**How does this formula compare to mother's milk?**

**STEP 3**
Choose a species (and research study):

- Formula components as a % of mother's milk in nature
- Solid
- Protein
- Fat
- Ca
- P
- Ca/P ratio

www.Ewildagain.org

Click on the blue cell to select a species and research study.

If your species or study is not included in the list, go to the "Custom Input" tab in this workbook.

Experience has generally shown that when a formula contains more than 75-80% of the solids contained in mother's milk, the formula is too rich for the animal to successfully digest, often causing GI upset.
Milk replacer calculations

Nutritional Calculator for Powdered Milk Replacer Products
Specifically designed to calculate formulas for wild mammals

**STEP 1**
Choose the products:

- Heavy whipping cream
- Water

**STEP 2**
Enter data EITHER into cell A OR cell B - BUT NOT BOTH.
1. Enter in column A the ratio of your desired formula mix.
2. Enter in column B the weight of the products being mixed.

**STEP 3**
Here are the values for that formula:

- Protein
- Fat
- Carbs
- ME kcal
- 
- 
- Ca
- P
- Ca:P ratio

www.Ewildagain.org

How does this formula compare to mother’s milk?

**STEP 3**
Choose a species (and research study):

- Cottontail Jenness&Sloan
- Cottontail O’Fallon
- Cottontail Average
- CustomResearchStudy1
- CustomResearchStudy2
- CustomResearchStudy3
- EacGraySquirrel Shaul
- EacGraySquirrel Nixon&Harper
- EacGraySquirrel Average
- Raccoon Shaul
- Opossum Barker
- Opossum Jenness&Sloan
- RedFox O’Fallon

Click on the blue cell to select a species and research study. If your species or study is not included in the list, go to the “Custom Input” tab in this workbook.

Experience has generally shown that when a formula contains more than 76-80% of the solids contained in mother’s milk, the formula is too rich for the animal to successfully digest, often causing GI upset.
Milk replacer: mixing problems

WildAgain Wildlife Rehabilitation, Inc.

Wild mammal nutrition resources

<table>
<thead>
<tr>
<th>Insolubility Issues with Milk Replacer Powders: An Easy Fix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife rehabilitators caring for young mammals prepare milk replacement formulas. Most rehabilitators, over the years, have dutifully followed the mixing instructions indicated on product labeling. Instructions generally say to add water, gently stir, and the liquid formula is ready to use. This paper discusses issues related to these products lack of complete solubility, laboratory tests performed to measure insolubility and minor adjustments to formula preparation that easily address these issues.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Powdered milk replacer product tests - March, 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion of test results on 8 recent lots of commercial powdered milk replacement products, including Fox Valley (6 products), PetAg (1 product), and GNC (1 product). Presents new information on solubility, mineral levels, adherance to Guaranteed Analysis, physical characteristics and labeling issues, as well as trends. Tests on additional recent lots expected in April, 2012.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milk Replacer update - January, 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>This update discusses research on commercial powdered milk replacer products and issues in wildlife rehabilitation from 2010 though January 2011, as well as a few of the broader issues about milk replacers that have prompted a variety of results and opinions. It also reviews an example of a newly developed 'recipe' that squirrel rehabilitators have found to be effective during 2010, including possible reasons for its success and implications for other recipes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrition calculator - newly expanded functionality (May 31, 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This expanded WildAgain Nutrition Calculator provides a tool to calculate the nutritional composition and ideal value for milk replacer powders used by wildlife rehabilitators. The dropdown list allows the user to select from and compare commonly used milk replacer powders from multiple manufactures as well as composite 'recipes' --- and then compare that information to research studies of the mother's milk for several common species of mammals rehabilitated in North America. The calculator also allows the user to add other other products or research studies for other species that are not on the provided lists. It's user-friendly and easy to use. The Calculator does not suggest or endorse a specific or mix of product(s) for individual species, recipes or amounts of formula to be fed, or specific feeding frequencies. Those decisions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Online</th>
<th>Download (PDF) click below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click Here</td>
<td>Click Here</td>
</tr>
<tr>
<td>Click Here</td>
<td>Click Here</td>
</tr>
</tbody>
</table>
Solubility Issues with Milk Replacer Powders—An Easy Fix

ALLAN M. CASEY, III AND SHIRLEY J. CASEY
WILDAgain WILDLIFE REHABILITATION, INC.
Solubility Issues with Milk Replacer Powders—An Easy Fix

Allan M. Casey, III and Shirley J. Casey
WildAgain Wildlife Rehabilitation, Inc.

A SIMPLE SOLUTION

As demonstrated by the laboratory tests and clearly shown in Table 1, an easy remedial action was developed and tested. Guided by the laboratory test results, simply using the hotter water temperature, premixing four hours prior to use, and storing in the refrigerator, the amount of unwetted powder is reduced by 76 percent, on average, between the 23 products/lots tested, as shown comparing Group 1 and Group 4 in Table 1. Some products resulted in zero percent unwetted powder using this preparation method.
Bottle feeding – weight control
Geriatric issues

INTRODUCTION
With the increasing knowledge and implementation of proper husbandry and medical care for zoo and aquarium species, many animals in captivity now live well past their average life expectancy in the wild. Many facilities may have a number of animals that are considered geriatric (age-related). Animal keepers should know the longevity data for the species they care for, so that they know when that species becomes geriatric. They should also be aware of the accurate age of the individual animals they are responsible for. Old age itself is not a disease or a diagnosis; however, geriatric animals have special care requirements due to changes that occur in the body due to aging and medical conditions that are commonly seen, and so they often require more time and attention than young healthy animals. Gerontology is the study of aging and geriatrics; human physicians have this formal specialty, but veterinarians do not. Zoo veterinarians, however, are usually very skilled and experienced in geriatric medicine, due to the high numbers of geriatric animals they care for. Proper husbandry throughout an animal’s life can not only extend its life but prevent or delay some common geriatric diseases. Additionally, the most difficult of decisions, euthanasia, must often be made when assessing quality of life for an animal that has a terminal disease. Animal keepers that are emotionally and professionally bonded to a animal need to undergo the grief, loss, and sense of responsibility they feel when an animal dies.

This chapter will provide basic information about geriatric animals and the care they need from their keepers. After studying this chapter, the reader will understand:

- the importance of the keeper knowing the typical longevity of the species and age of the individual animal
- the effect of proper husbandry in preventing or managing common geriatric diseases
- the current care requirements of geriatric animals in zoo settings
- nutrition and feeding changes of geriatric animals
- the importance of diagnosis in determining treatment, palliative care, or euthanasia for a geriatric animal
- the what, when, who, how, and ethics of euthanasia of geriatric animals
- grief management and help resources for the animal keeper.

AGING AND LIFE SPAN
When evaluating an animal’s life span, resources should include species-specific books and articles, and special study or husbandry managers. Species-specific longevity data is available in many cases (Weigl 2005). Information exists on the internet, but it must be scrutinized carefully and its origin must be determined. Often differing information or age ranges will be found. For some species, information about life span in the wild and in captivity may not be well known. It is important to realize the differences between life span in the wild and life span in captivity, and longevity records. Depending on the species, animals may typically live either longer or shorter lives in captivity; however, in modern facilities with proper animal management (husbandry), nutrition, and veterinary care, the majority of species live longer (and may breed longer) in captivity. For example, camels used to be considered old in their last ten, but now they frequently live past the age of thirty. A longevity record refers to the age of the oldest individual of a species ever documented. For example, the Guinness world record (Guinness World Records 2005) for the oldest human is a French woman who died at 122 years of age; however, the United Nations reports that the average life expectancy for a woman in France is 84. In the United States it is 88 for women and 79 for men. In Sweden the average life expectancy is 84. Animal managers and keepers may unrealistically expect their animals to reach the same age as the “record holder” but it is important to be realistic about an individual’s life span. It will vary between individuals and can be heavily influenced by environmental factors.
Geriatric issues

NUTRITION AND FEEDING CONSIDERATIONS

As animals age, they may need modifications to their daily rations due to decreased metabolism and/or decreased activity. Depending on the species, they may benefit from changes in the composition of their diet based on recommendations by veterinarians and zoo nutritionists. For an animal with a certain disease, prescription diets may be used. Prescription diets made for dogs and cats may be used in similar nondomestic patients. These diets must be prescribed by a veterinarian, just as medication is. Also, the diets can be specially formulated by animal nutritionists to provide the proper nutrients that geriatric animals require. Dietary supplements (or nutraceuticals) can also assist in the treatment of many chronic diseases. One example is the previously mentioned use of nutraceutical chondroprotectives for arthritis (Stringfield 1999). Finally, diets may need to be presented differently for animals with chronic disease. Some adjustments might include the softening of hard food for an animal with missing teeth, addition of extra water for an animal in CRF, improvement of flavor to encourage an animal to eat, and so on. For example, a geriatric fox in chronic renal failure that has lost molars due to previous tooth disease may benefit from having its prescription dog chow soaked or ground up, or may be switched to the canned version of the diet. Sometimes, as animals in decline become picky eaters, keepers may be challenged to provide diet items they will eat while still maintaining a balanced diet for them.
Geriatric issues

European Association of Zoo- and Wildlife Veterinarians (EAZWV)
5th scientific meeting, May 19 - 23 - 2004, Ebeltoft, Denmark.

DIETARY AND VETERINARY MANAGEMENT OF A LINGUAL ABSCESS IN A GERIATRIC CAPTIVE BLACK RHINO (*Diceros bicornis*) WITH IRON STORAGE DISEASE

*J-M. HATT¹, C. WENKER², J. CASTELL³ and M. CLAUSS³*
Geriatric issues

• typical sign: loss of condition
  – monitoring
Condition monitoring

Body Condition Index Scores

1. All ribs (shoulder to pelvis) visible, some ribs prominent (spaces in between sunken in)
2. Some ribs visible (spaces in between not sunken in), shoulder and pelvic girdles prominent
3. Ribs not visible, shoulder and pelvic girdles visible
4. Backbone visible as a ridge, shoulder and pelvic girdles not visible
5. Back rounded, thick rolls of fat under neck

Diagnostic characters pertaining to scores in photographic scale.

If it is difficult to decide between two points on the scale, as the scale is composed of odd numbers, the score represented by the intervening even number is assigned.
Geriatric issues

• typical sign: loss of condition
  – monitoring

• tooth wear – adjust physical form of diet
  (roughage/pellets; whole prey/minced meat)

• reduced digestive ability – adjust energy
  content (‘concentrates’)
Geriatric issues

• typical sign: loss of condition
  – monitoring

• tooth wear – adjust physical form of diet
  (roughage/pellets; whole prey/minced meat)

• reduced digestive ability – adjust energy
  content (‘concentrates’)
Announcements

• Nutrition software
Announcements

- Nutrition software

- Next zoo nutrition conference
European Zoo Nutrition Conference

Feeding zoo animals for health, welfare and conservation

22-25 January 2015
Burgers Zoo, The Netherlands

www.eaza.net