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
Whose zoo animal's diet is this?

- strawberries
- mangos
- plums (w/o stones)
- apricots/peaches (w/o stones)
- apples
- pears
- ananas
- leek
- lettuce
- tomatoes
- cooked pasta/cooked rice with raisins
- oat flakes
- dry bread
- yoghurt
- minced meat (1x/week)
Whose zoo animal's diet is this?

- strawberries
- mangos
- plums (w/o stones)
- apricots/peaches (w/o stones)
- apples
- pears
- ananas
- leek
- lettuce
- tomatoes
- cooked pasta/cooked rice with raisins
- oat flakes
- dry bread
- yoghurt
- minced meat (1x/week)
- ... and grass hay ad libitum (is hardly eaten)
Whose zoo animal’s diet is this?

• strawberries
• mangos
• plums (w/o stones)
• apricots/peaches (w/o stones)
• apples
• pears
• ananas
• leek
• lettuce
• tomatoes
• cooked pasta/cooked rice with raisins
• oat flakes
• dry bread
• yoghurt
• minced meat (1x/week)
• ... and grass hay ad libitum (is hardly eaten)
Diet of lowland tapir (*Tapirus terrestris*) in El Rey National Park, Salta, Argentina

Silvia C. CHALUKIAN,¹⁴ M. Soledad de BUSTOS²⁴ and R. Leonidas LIZÁRRAGA³⁴

*Integrative Zoology* 2013; 8: 48–56
Tapir

Development of zoo feeding regimes

corcepts from agriculture
(production animals – use production potential)
human consumption habits
Development of zoo feeding regimes

- concepts from agriculture
  - (production animals – use production potential)
  - human consumption habits
Development of zoo feeding regimes

- concepts from agriculture
  (production animals – use production potential)
  human consumption habits

- copying natural diets
  avoid diseases – use adaptation potential – teaching biological knowledge
### Example: rabbit feeds

<table>
<thead>
<tr>
<th></th>
<th>Crude fibre</th>
<th>NDF (total fibre)</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% DM</td>
<td>% DM</td>
<td>% DM</td>
</tr>
<tr>
<td>meat production</td>
<td>15</td>
<td>38</td>
<td>16</td>
</tr>
<tr>
<td>pet animal</td>
<td>15</td>
<td>37</td>
<td>14</td>
</tr>
<tr>
<td>in the wild</td>
<td>30</td>
<td>55</td>
<td>20</td>
</tr>
</tbody>
</table>

...pet rabbits are fed like meat-production animals but not like rabbits in their natural habitat!
## Example: rabbit feeds

### Development of pet feeds

<table>
<thead>
<tr>
<th>Company A:</th>
<th>Year*</th>
<th>CF %DM</th>
<th>NDF %DM</th>
<th>Prot %DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbit (Standard)</td>
<td>1982</td>
<td>8</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Rabbit 4mm Pellet</td>
<td>1987</td>
<td>10</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>Supreme rabbit mix</td>
<td>2000</td>
<td>14</td>
<td>36</td>
<td>14</td>
</tr>
<tr>
<td>New Generation (Extrudate)</td>
<td>2006</td>
<td>21</td>
<td>47</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Company B:</th>
<th>Year</th>
<th>CF %DM</th>
<th>NDF %DM</th>
<th>Prot %DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menu Thyme (Mix)</td>
<td>ca.1980</td>
<td>10</td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>Rabbit Special Regular Pellet</td>
<td>2000</td>
<td>16</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>Emotion Beauty (Extrudate Mix)</td>
<td>2007</td>
<td>14</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>Emotion Sensitive (Extrudate Mix)</td>
<td>2007</td>
<td>17</td>
<td>40</td>
<td>14</td>
</tr>
</tbody>
</table>
Example: tortoises

Recommendations from successive editions of the same (German) textbook
Example: tortoises

Recommendations from successive editions of the same (German) textbook

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-1993</td>
<td>80% fruits, 19% meat, 1% minerals</td>
</tr>
<tr>
<td></td>
<td>Fruits: apple, pear, orange, banana, tomato, greens (grass, clover, salad)</td>
</tr>
<tr>
<td></td>
<td>Meat: muscle, heart – finely cut – also canned dog/cat food</td>
</tr>
<tr>
<td></td>
<td>If fruits not available: oat flakes, rice, dry dog food, cooked potato</td>
</tr>
</tbody>
</table>
Example: tortoises

Recommendations from successive editions of the same (German) textbook

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| 1980-1993| 80% fruits, 19% meat, 1% minerals  
Fruits: apple, pear, orange, banana, tomato, greens (grass, clover, salad)  
Meat: muscle, heart – finely cut – also canned dog/cat food  
If fruits not available: oat flakes, rice, dry dog food, cooked potato |
| 1999     | Leafy green vegetables, vegetables, fruits (apple, banana, pear, grapes, kiwi), sometimes canned dog/cat food, grain products |
| 2004-2009| Greens (herbs, low proportion of salad/vegetables), low amounts of fruits (lead to malfermentation and diarrhoea), canned dog/cat food should not be main component (cause gout), milk and grain products only in small amounts, hay always ad libitum, cuttlefish bone/egg shells |
Example: tortoises

Recommendations from successive editions of the same (German) textbook

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| 1980-1993 | 80% fruits, 19% meat, 1% minerals  
Fruits: apple, pear, orange, banana, tomato, greens (grass, clover, salad)  
Meat: muscle, heart – finely cut – also canned dog/cat food  
If fruits not available: oat flakes, rice, dry dog food, cooked potato |
| 1999      | Leafy green vegetables, vegetables, fruits (apple, banana, pear, grapes, kiwi), sometimes canned dog/cat food, grain products |
| 2004-2009 | Greens (herbs, low proportion of salad/vegetables),  
low amounts of fruits (lead to malfermentation and diarrhoea),  
canned dog/cat food should not be main component (cause gout),  
milk and grain products only in small amounts,  
hay always ad libitum,  
cuttlefish bone/egg shells |
Example: tortoises

Recommendations from successive editions of the same (German) textbook

<table>
<thead>
<tr>
<th>Year</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| 1980-1993| 80% fruits, 19% meat, 1% minerals  
Fruits: apple, pear, orange, banana, tomato, greens (grass, clover, salad)  
Meat: muscle, heart – finely cut – also canned dog/cat food  
If fruits not available: oat flakes, rice, dry dog food, cooked potato |
| 1999     | Leafy green vegetables, vegetables, fruits (apple, banana, pear, grapes, kiwi), sometimes canned dog/cat food, grain products |
| 2004-2009| Greens (herbs, low proportion of salad/vegetables),  
low amounts of fruits (lead to malfermentation and diarrhoea),  
canned dog/cat food should not be main component (cause gout),  
milk and grain products only in small amounts,  
hay always ad libitum,  
cuttlefish bone/egg shells |
Feeding herbivores from Stevens und Hume (1995)
Feeding herbivores

Major goal of herbivore feeding:

Do not disturb the balance of the ‘fermentation chamber’!

from Stevens und Hume (1995)
Feeding herbivores

This happens if, instead of plant fibre, larger amounts of starches or sugars enter into the fermentation chamber!

from Stevens und Hume (1995)
Bacteria ferment all carbohydrates into volatile fatty acids (VFA)
Bacteria ferment all carbohydrates into volatile fatty acids (VFA)

- plant fibres (cellulose, hemicellulose) are fermented slowly
  - the VFA can be absorbed as they come
  - the pH in the fermentation chamber remains stable
Bacteria ferment all carbohydrates into volatile fatty acids (VFA)

- plant fibres (cellulose, hemicellulose) are fermented slowly
  - the VFA can be absorbed as they come
  - the pH in the fermentation chamber remains stable

- sugars/starch are fermented rapidly (some even "explosively")
  - more VFA produced than can be absorbed
  - the pH in the fermentation chamber drops
Bacteria ferment all carbohydrates into volatile fatty acids (VFA)

- Plant fibres (cellulose, hemicellulose) are fermented slowly
  - The VFA can be absorbed as they come
  - The pH in the fermentation chamber remains stable

- Sugars/starch are fermented rapidly (some even "explosively")
  - More VFA produced than can be absorbed
  - The pH in the fermentation chamber drops

▶▶▶▶ ACIDOSIs!
Man-made diets: too little fibre

- Human nutrition
- Pigs
- Beef cattle/ Dairy cattle
- Riding horses
- Dogs/ Cats
- Zoo animals
Man-made diets: too little fibre

- Human nutrition → gut health
- Pigs → piglet diarrhoea
- Beef cattle/ Dairy cattle
- Riding horses → crib biting
- Dogs/ Cats → faeces consistency
- Zoo animals → obesity
Man-made diets: too little fibre

- Human nutrition → gut health
- Pigs → piglet diarrhoea
- Beef cattle/ Dairy cattle
- Riding horses → crib biting
- Dogs/ Cats → faeces consistency
- Zoo animals → obesity
Fibre content depends on intended use

<table>
<thead>
<tr>
<th>Use</th>
<th>Fibre content*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle</td>
<td>12 %DM</td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>18 %DM</td>
</tr>
<tr>
<td>Feral cattle</td>
<td>30 %DM</td>
</tr>
</tbody>
</table>

*historical recommendations for ration design
## Fibre content depends on intended use

<table>
<thead>
<tr>
<th>Use</th>
<th>Fibre content*</th>
<th>Longevity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle</td>
<td>12 %DM</td>
<td>app. 2 years</td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>18 %DM</td>
<td>app. 4 years</td>
</tr>
<tr>
<td>Feral cattle</td>
<td>30 %DM</td>
<td>app. 25 years</td>
</tr>
</tbody>
</table>

*historical recommendations for ration design
There are no secret, species-specific ingredients!
A simple way to pretend specialized nutritional knowledge is to produce a pellet, put it in bags of different colours and label (and price) these differently.
Complete feed for rabbits
- maintenance -

Protein 12 %
Fibre 18 %
Calcium 1.2 %

Ingredients: Lucerne meal, soy meal, wheat bran, oats, Calciummonophosphate
Complete feed for rabbits
- maintenance -

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>12 %</td>
</tr>
<tr>
<td>Fibre</td>
<td>18 %</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.2 %</td>
</tr>
</tbody>
</table>

**Ingredients:** Lucerne meal, soy meal, wheat bran, oats, Calciummonophosphate

Mandrill Special®
Supplement for Mandrills

Years of zoo experience!

Especially balanced nutrient composition for this critical species

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>12 %</td>
</tr>
<tr>
<td>Fibre</td>
<td>18 %</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.2 %</td>
</tr>
</tbody>
</table>
Don’t believe names, think for yourself

• ‘Frugivores’ are adapted to wild fruits but not to commercial produce that has been bred for centuries to please the human palate!

<table>
<thead>
<tr>
<th>Species</th>
<th>Crude fiber (% dry matter)</th>
<th>NDF (% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duikers (various spp.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage</td>
<td>–</td>
<td>25–70</td>
</tr>
<tr>
<td>Fruits</td>
<td>–</td>
<td>30–60</td>
</tr>
<tr>
<td>Colobus monkeys (different species)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forages</td>
<td>–</td>
<td>30–70</td>
</tr>
<tr>
<td>Fruits</td>
<td>–</td>
<td>50–70</td>
</tr>
<tr>
<td>Howler monkey (Alouatta alouatta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forages</td>
<td>–</td>
<td>20–80</td>
</tr>
<tr>
<td>Fruits</td>
<td>–</td>
<td>20–70</td>
</tr>
</tbody>
</table>

data collected in Clauss & Dierenfeld (2008)
Don’t believe names, think for yourself

• A large number of nutritional analyses document that ‘wild fruit’ contain more fibre and less sugar than commercially available fruit (that is the product of selective breeding to please human taste).
What is in an apple?
What is in an apple?

- 85% water
- 10% sugar
What's in an apple?

- 85% water
- 10% sugar
### Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Water %</th>
<th>Residual %</th>
<th>Protein %</th>
<th>Available carbohydrates %</th>
<th>Calcium %</th>
<th>Phosphorus %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>83.7</td>
<td>14.7</td>
<td>1.7</td>
<td>1.3 (should be kept - fat content)</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Black currant</td>
<td>81.7</td>
<td>14.7</td>
<td>4.8</td>
<td>3.5</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Blueberry</td>
<td>84.0</td>
<td>10.5</td>
<td>7.8</td>
<td>6.4</td>
<td>2.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Black currant</td>
<td>81.7</td>
<td>14.7</td>
<td>4.8</td>
<td>3.5</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Raspberry</td>
<td>84.5</td>
<td>13.5</td>
<td>8.4</td>
<td>6.4</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Grapes</td>
<td>85.5</td>
<td>16.5</td>
<td>5.5</td>
<td>4.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Peaches</td>
<td>87.5</td>
<td>12.5</td>
<td>6.1</td>
<td>5.0</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Mango</td>
<td>82.0</td>
<td>18.0</td>
<td>3.3</td>
<td>2.0</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Prune</td>
<td>83.7</td>
<td>18.3</td>
<td>3.7</td>
<td>3.0</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Apricot</td>
<td>85.5</td>
<td>14.7</td>
<td>6.1</td>
<td>4.5</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Currants</td>
<td>87.5</td>
<td>12.7</td>
<td>6.1</td>
<td>4.5</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Dates</td>
<td>85.8</td>
<td>16.2</td>
<td>6.2</td>
<td>5.0</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Fig</td>
<td>80.2</td>
<td>19.8</td>
<td>8.6</td>
<td>6.5</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Orange</td>
<td>85.7</td>
<td>14.3</td>
<td>7.0</td>
<td>6.4</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Strawberries</td>
<td>85.5</td>
<td>10.5</td>
<td>7.8</td>
<td>6.4</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Black currant</td>
<td>81.7</td>
<td>14.7</td>
<td>4.8</td>
<td>3.5</td>
<td>2.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Red currant</td>
<td>84.7</td>
<td>15.3</td>
<td>7.4</td>
<td>4.8</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Blueberry</td>
<td>84.6</td>
<td>15.4</td>
<td>3.5</td>
<td>4.7</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Blackcurrant</td>
<td>88.7</td>
<td>13.3</td>
<td>7.8</td>
<td>4.6</td>
<td>2.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Raspberry</td>
<td>84.5</td>
<td>13.5</td>
<td>8.4</td>
<td>6.4</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Grapes</td>
<td>85.5</td>
<td>16.5</td>
<td>5.5</td>
<td>4.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Peaches</td>
<td>87.9</td>
<td>12.1</td>
<td>4.3</td>
<td>2.0</td>
<td>1.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Apple</td>
<td>84.0</td>
<td>32.0</td>
<td>5.9</td>
<td>2.9</td>
<td>1.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*minimum


### Vegetables

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Water %</th>
<th>Residual %</th>
<th>Protein %</th>
<th>Available carbohydrates %</th>
<th>Calcium %</th>
<th>Phosphorus %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beetroots</td>
<td>88.8</td>
<td>11.2</td>
<td>13.7</td>
<td>7.6</td>
<td>2.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Green beans</td>
<td>77.8</td>
<td>22.2</td>
<td>9.2</td>
<td>10.4</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Carrots</td>
<td>90.8</td>
<td>9.2</td>
<td>1.2</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Beetroot</td>
<td>88.8</td>
<td>11.2</td>
<td>13.7</td>
<td>7.6</td>
<td>2.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Green beans</td>
<td>77.8</td>
<td>22.2</td>
<td>9.2</td>
<td>10.4</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Carrots</td>
<td>90.8</td>
<td>9.2</td>
<td>1.2</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

*minimum

... ist gesünder als ...

... is healthy?
... is healthier than ...
... is healthier than ...

... is healthier than ...

... is healthier than ...
Variety

Variety
Variety
Variety
There are no studies to date corroborating a positive effect of dietary variety on animal welfare!
There are no studies to date corroborating a positive effect of dietary variety on animal welfare!
Feeding high-sugar/starch diets
Feeding high-sugar/starch diets
Feeding high-sugar/starch diets

Easily digestible nutrients absorbed in small intestine => obesity
Free-range vs. zoo

from Hatt & Clauss (2006)
A survey of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephant diets and measured body dimensions compared to their estimated nutrient requirements

K. Ange, S.D. Crissey, C. Doyle, K. Lance, H. Hintz
Proceedings of the 2001 Conference of the AZA Nutrition Advisory Group 4:5-14

Mean adult female body mass (kg)

<table>
<thead>
<tr>
<th></th>
<th>Free-range</th>
<th></th>
<th>Zoo</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2720</td>
<td>2800</td>
<td>3453</td>
</tr>
</tbody>
</table>
Fecundity and population viability in female zoo elephants: problems and possible solutions

R Clubb†, M Rowcliffe‡, P Lee§#, KU Mar¶, C Moss# and GJ Mason*#


<table>
<thead>
<tr>
<th>Group/measure</th>
<th>Population</th>
<th>Population difference</th>
<th>Data source/notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In situ</td>
<td>Zoo</td>
<td></td>
</tr>
<tr>
<td>Birth weight</td>
<td>89.5 (± 6.3) kg (n = 5)</td>
<td>102.1 (± 9.6) kg (n = 63)</td>
<td>$F_{1, 66} = 8.32, P = 0.005$</td>
</tr>
<tr>
<td></td>
<td>74.0 kg (n = 6)</td>
<td>105.6 kg (n = 40)</td>
<td>Reported in paper as significant</td>
</tr>
<tr>
<td></td>
<td>–</td>
<td>118.8 kg (n = 7)</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Free-range vs. zoo

from various internet sources and own photo
Free-range vs. zoo

from Clauss & Hatt (2006)
Gabrisch & Zwart (2005)
Feeding high-sugar/starch diets

Easily digestible nutrients absorbed in small intestine => obesity

Only at very excessive amounts: ‘caecum acidosis’, diarrhoea, laminitis
Tapir faeces

Free range

Photo: Patricia Medici
Tapir faeces

Free range

‘traditional’ zoo diets

Photos: Patricia Medici, Stefanie Lang-Deuerliein, J.-M. Hatt, M. Clauss
Faecal scores in tapirs

Photos: Tamsin Wilkins

from Clauss et al. (2008)
Faecal scores in tapirs

from Clauss et al. (2008)
Polymerase chain reaction detection of *Clostridium perfringens* in feces from captive and wild chimpanzees, *Pan troglodytes*

Shiho Fujita¹ & Takashi Kageyama²

Table 2 Detection of *Clostridium perfringens* in feces of captive chimpanzees

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Age</th>
<th>Birth</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Not detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ai¹</td>
<td>Female</td>
<td>24 years</td>
<td>Wild</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pendesa</td>
<td>Female</td>
<td>23 years</td>
<td>Captive²</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chloé</td>
<td>Female</td>
<td>19 years</td>
<td>Captive⁴</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Reo</td>
<td>Male</td>
<td>18 years</td>
<td>Captive³</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ayumu¹</td>
<td>Male</td>
<td>5 months</td>
<td>Captive³</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total (%)</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>5 (50)</td>
<td>3 (30)</td>
<td>2 (20)</td>
</tr>
</tbody>
</table>

¹Ai and Ayumu are a mother–infant pair.
²Japan Monkey Center.
³Primate Research Institute.
⁴Parc Zoologique de Paris.

Table 3 Detection of *Clostridium perfringens* in feces of wild chimpanzees

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Not detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahale</td>
<td>Dry</td>
<td>16</td>
<td>0 (0.0)¹</td>
<td>1 (6.3)</td>
<td>15 (93.7)</td>
</tr>
<tr>
<td></td>
<td>Wet (I and II)</td>
<td>65</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>65 (100.0)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>81</td>
<td>0 (0.0)</td>
<td>1 (1.3)</td>
<td>80 (98.7)</td>
</tr>
<tr>
<td>Bossou</td>
<td>Dry</td>
<td>23</td>
<td>1 (4.3)</td>
<td>2 (8.7)</td>
<td>20 (87.0)</td>
</tr>
<tr>
<td></td>
<td>Wet</td>
<td>30</td>
<td>5 (16.7)</td>
<td>4 (13.3)</td>
<td>21 (70.0)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>53</td>
<td>6 (11.3)</td>
<td>6 (11.3)</td>
<td>41 (77.4)</td>
</tr>
</tbody>
</table>

¹The values in parentheses show percentages.
Polymerase chain reaction detection of *Clostridium perfringens* in feces from captive and wild chimpanzees, *Pan troglodytes*

Shiho Fujita¹ & Takashi Kageyama²

**Table 2** Detection of *Clostridium perfringens* in feces of captive chimpanzees

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Age</th>
<th>Birth</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Not detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ai¹</td>
<td>Female</td>
<td>24 years</td>
<td>Wild</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pendesa</td>
<td>Female</td>
<td>23 years</td>
<td>Captive²</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chloé</td>
<td>Female</td>
<td>19 years</td>
<td>Captive⁴</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Reo</td>
<td>Male</td>
<td>18 years</td>
<td>Captive³</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ayumu¹</td>
<td>Male</td>
<td>5 months</td>
<td>Captive³</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total (%)</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>5 (50)</td>
<td>3 (30)</td>
<td>2 (20)</td>
</tr>
</tbody>
</table>

¹Ai and Ayumu are a mother–infant pair.
²Japan Monkey Center.
³Primate Research Institute.
⁴Parc Zoologique de Paris.

**Table 3** Detection of *Clostridium perfringens* in feces of wild chimpanzees

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Not detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahale</td>
<td>Dry</td>
<td>16</td>
<td>0 (0.0)¹</td>
<td>1 (6.3)</td>
<td>15 (93.7)</td>
</tr>
<tr>
<td></td>
<td>Wet (I and II)</td>
<td>65</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>65 (100.0)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>81</td>
<td>0 (0.0)</td>
<td>1 (1.3)</td>
<td>80 (98.7)</td>
</tr>
<tr>
<td>Bossou</td>
<td>Dry</td>
<td>23</td>
<td>1 (4.3)</td>
<td>2 (8.7)</td>
<td>20 (87.0)</td>
</tr>
<tr>
<td></td>
<td>Wet</td>
<td>30</td>
<td>5 (16.7)</td>
<td>4 (13.3)</td>
<td>21 (70.0)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>53</td>
<td>6 (11.3)</td>
<td>6 (11.3)</td>
<td>41 (77.4)</td>
</tr>
</tbody>
</table>

¹The values in parentheses show percentages.
Polymerase chain reaction detection of *Clostridium perfringens* in feces from captive and wild chimpanzees, *Pan troglodytes*

Shiho Fujita¹ & Takashi Kageyama²


**Table 2** Detection of *Clostridium perfringens* in feces of captive chimpanzees

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Age</th>
<th>Birth</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ai¹</td>
<td>Female</td>
<td>24 years</td>
<td>Wild</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pendesa</td>
<td>Female</td>
<td>23 years</td>
<td>Captive²</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chloé</td>
<td>Female</td>
<td>19 years</td>
<td>Captive⁴</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Reo</td>
<td>Male</td>
<td>18 years</td>
<td>Captive³</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ayumu¹</td>
<td>Male</td>
<td>5 months</td>
<td>Captive³</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>5 (50)</td>
<td>3 (30)</td>
<td>2 (20)</td>
</tr>
</tbody>
</table>

¹Ai and Ayumu are a mother–infant pair.
²Japan Monkey Center.
³Primate Research Institute.
⁴Parc Zoologique de Paris.

**Table 3** Detection of *Clostridium perfringens* in feces of wild chimpanzees

<table>
<thead>
<tr>
<th>Site</th>
<th>Season</th>
<th>No. of samples tested</th>
<th>First PCR</th>
<th>Nested PCR</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahale</td>
<td>Dry</td>
<td>16</td>
<td>0 (0.0)¹</td>
<td>1 (6.3)</td>
<td>15 (93.7)</td>
</tr>
<tr>
<td></td>
<td>Wet (I and II)</td>
<td>65</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>65 (100.0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>81</td>
<td>0 (0.0)</td>
<td>1 (1.3)</td>
<td>80 (98.7)</td>
</tr>
<tr>
<td>Bossou</td>
<td>Dry</td>
<td>23</td>
<td>1 (4.3)</td>
<td>2 (8.7)</td>
<td>20 (87.0)</td>
</tr>
<tr>
<td></td>
<td>Wet</td>
<td>30</td>
<td>5 (16.7)</td>
<td>4 (13.3)</td>
<td>21 (70.0)</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>53</td>
<td>6 (11.3)</td>
<td>6 (11.3)</td>
<td>41 (77.4)</td>
</tr>
</tbody>
</table>

¹The values in parentheses show percentages.
Feeding high-sugar/starch diets

Easily digestible nutrients absorbed in small intestine => obesity

Only at very excessive amounts: ‘caecum acidosis’, diarrhoea, laminitis
Free-range vs. zoo

from Collen et al. (2011)  
from Taylor et al. (2013)
Feeding high-sugar/starch diets

Easily digestible nutrients absorbed in small intestine => obesity

Only at very excessive amounts: ‘caecum acidosis’, diarrhoea, laminitis

Easily digestible nutrients enter the fermentation chamber ⇒ ‘malfermentation’
Feeding high-sugar/starch diets

Easily digestible nutrients absorbed in small intestine => obesity

Easily digestible nutrients enter the fermentation chamber ⇒ ‘malfermentation’

Low food intake
Laminitis
Liver abscess
Reduced lifespan?
Diarrhoea
Oral stereotypies

Only at very excessive amounts: ‘caecum acidosis’, diarrhoea, laminitis
Oral Stereotypies in Giraffe

Photo: Daniela Schaub
Laminitis from Nocek (1997)
Photos: M. Clauss, W. Zenker
Feeding-related problems - rule of thumb for high-energy feeds

Digestive upset/wasting
- langurs
- sloths
- small ruminants
- browsing ruminants

Obesity
- elephants
- rhinos
- tapirs
- lemurs
- great apes

- large grazing ruminants
- hippos
Primates as a prime example

Easily digestible nutrients enter the fermentation chamber ⇒ ‘malfermentation’

(Obesity)

Low food intake
Laminitis
Liver abscess
Reduced lifespan?
Diarrhoea
Oral stereotypies
 Obesity in primates

- Gorillas (Cousins 1972, Leigh 1992)
- Orangutans: wild ♀ 38.7 kg, ♂ 86.3 kg
  zoo ♀ up to 81 kg, ♂ up to 189 kg; (Schmidt 2004)
- Chimpanzees: 10.5% ♀♀ obese
  (Videan et al. 2007)
- Macaques: 7-23% obese
  (Walike et al. 1977, Schwartz et al. 1993, Chen at al. 2002)
- Marmosets
Primates as a prime example

- Colobus Monkey
  - (Colobus abyssinicus)
  - Body Length: 50 cm
- Orangutan
  - (Pongo pygmaeus)
  - Body Length: 84 cm

Obese lemurs
Primates as a prime example

langurs with bad condition, diarrhoea, short lifespan

obese lemurs
Primates as a prime example
Indigestion / Unthriftiness - Wasting

Obesity

Elephant/ Rhino/ Tapir

Lemurs

Rodents (Carnivores, Bears)

Small ruminants/ Browsing ruminants

(large ruminants/ grazing ruminants/ hippos)
Does it matter?

Health problems

Indigestion / Unthriftiness - Wasting

Langurs
Sloths
Small ruminants/
Browsing ruminants

Obesity

Elephant/ Rhino/ Tapir
Lemurs
Rodents
(Carnivores, Bears)

(large ruminants/
grazing ruminants/
hippos)
<table>
<thead>
<tr>
<th>Indigestion / Unthriftiness - Wasting</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langurs</td>
<td>Elephant/ Rhino/ Tapir</td>
</tr>
<tr>
<td>Sloths</td>
<td>Lemurs</td>
</tr>
<tr>
<td>Small ruminants/ Browsing ruminants</td>
<td>Rodents (Carnivores, Bears)</td>
</tr>
<tr>
<td><strong>Health problems</strong></td>
<td>(large ruminants/ grazing ruminants/ hippos)</td>
</tr>
</tbody>
</table>
Obesity in orangutans

Factors Influencing the Well-Being and Longevity of Captive Female Orangutans

Leif Cocks

Fig. 12 Survival vs. female weight.
A Survey of Diabetes Prevalence in Zoo-housed Primates

C. W. Kuhar,* G. A. Fuller, and P. M. Dennis

Nearly 30% of responding institutions reported at least one diabetic primate in their current collection. Although the majority of reported cases were in Old World Monkeys (51%), all major taxonomic groups were represented. Females represented nearly 80% of the diagnosed cases. A wide variety of diagnosing, monitoring, and treatment techniques were reported. It is clear from these results diabetes should be considered prominently in decisions relating to diet, weight and activity levels in zoo-housed primates, as well as discussions surrounding animal health and welfare.

Hypertension Increases With Aging and Obesity in Chimpanzees (*Pan troglodytes*)

John J. Ely,* Tony Zavaskis, and Michael L. Lamme
Zoo Biology 32: 79–87 (2013)

Cardiovascular disease is a primary cause of morbidity and mortality in captive chimpanzees. For females, obesity was a significant determinant of BP.
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


to ovarian acyclicity. 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.
let's show what they evolved to cope with
(not what they can stand)

from Stevens und Hume (1995)
Feeding captive herbivores

• no commercial fruits (they resemble nothing in the wild!)
• wild fruits = green leafy vegetables!
• starch(grain)-based pellets only very limited amounts (better: beet pulp and lucerne meal-based)

• roughage or a variety of roughages (grass hay, lucerne hay, browse, fresh grass, fresh lucerne, silages incl. browse silage)

• minerals (mineralised pelleted feed)

• weight control (scales, body condition score)
Check weight / body condition

Body Condition Index Scores

Photographic scale.

1. All ribs (shoulder to pelvis) visible, some ribs prominent (spaces in between sunken in), shoulder and pelvic girdles prominent
2. Ribs not visible, shoulder and pelvic girdles visible
3. Backbone visible as a ridge, shoulder and pelvic girdles not visible
4. 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.
Feeding captive herbivores

- Roughages of medium or low feeding value (i.e. ‘rough cuts’) are suitable for many large zoo herbivores

- Hygienic status has to be impeccable

  (feeding value ≠ hygienic status)
Feeding herbivores

- If variety is an aim, achieve it by offering different roughages
Feeding herbivores

• in situations of increasing energy/nutrient requirements (e.g. lactation)?
Feeding herbivores

- in situations of increasing energy/nutrient requirements (e.g. lactation)?

‘concentrates’?
Feeding herbivores

• in situations of increasing energy/nutrient requirements (e.g. lactation)?

‘concentrates’? roughage of a higher feeding value
Feeding by weight

- visually estimating amounts often leads to errors
Not every herbivore likes grass hay

from Foose (1982)
Changing a tapir diet I

- strawberries
- mangos
- plums (w/o stones)
- apricots/peaches (w/o stones)
- apples
- pears
- ananas
- leek
- lettuce
- tomatoes
- cooked pasta/cooked rice with raisins
- oat flakes
- dry bread
- yoghurt
- minced meat (1x/week)
- ... and grass hay ad libitum (is hardly eaten)
Changing a tapir diet II

- **morning:**
  Lucerne hay *ad libitum* (for the whole day)
  and one lettuce, one bunch of leek, one bunch of celery stalks
  handful of pelleted feed (for minerals)

- **afternoon (alterating):**
  20 carrots or
  2 pieces of barley sprouts or
  2 cucumbers

- always fresh browse (twigs with leaves)

from Clauss et al. (2008)
Changing a tapir diet III

- Alfred Brehm (1864):
  „It always costs them quite an effort to rise up from their inactivity and phlegm. “
Changing a tapir diet III

- Alfred Brehm (1864):
  "It always costs them quite an effort to rise up from their inactivity and phlegm."

- One year after the diet change:
  Animals did not starve!
  Animals are more active, alert, lively, ingest food (lucerne hay) throughout the day, easier to handle for keepers (more responsive)

  Animals are less obsese

  From Clauss et al. (2008)