Nutritional Aspects of Non-Human Primate Care - Barbara Henry
Overview

• Know your animal
• Target nutrient values & BMR calculations
• Common challenges
Carnivore

Omnivore

Herbivore

Insectivorous

Tarsius sp. - Tarsiers

MOSTLY INSECTIVOROUS
Galagoides sp. - Bush babies
Loris tardigradus - Slow Loris

FRUIT = INSECT
Callithrix sp. - Marmosets

INSECT > FRUIT
Saimiri sp. - Squirrel monkeys

FRUIT > INSECT
Lenotopithecus sp. - Lion tamarin

Omnivore-Frugivore
Daubentonia madagascariensis - Aye-aye

FRUGIVORE
Ateles sp. - Spider Monkey

Insectivore
Carnivore Omnivore Herbivore

Gum Dominant

Plant/Fruit Dominant

Leaf/Plant Part Dominant

Insect Dominant

Fruit Dominant

Insectivorous Bamboo

Only

Overview

EXAMINE

Folivore Grivore

Frugivore
**Gum Dominant Leaf/Plant Part**

- *Euoticus elegantulus* - S. needle-clawed bush baby
- *Euoticus palludus* - N. needle-clawed bush baby
- *Galago senegalensis* - N. lesser bush baby
- *Galago moholi* - S. lesser bush baby
- *Otolemur crassicaudatus* - Thick-tailed greater bush baby
- *Phaner furcifer* - Fork-marked lemur

**Fruit Dominant**

- *Callithrix sp.* - marmoset
- *Lenotopithecus sp.* - Lion tamarin
- *Otolemur garnetti* - Garnett’s greater bush baby
- *Cheirogaleus major* - Greater dwarf lemur
- *Galago alleni* - Allen’s bush baby
- *Lemur catta* - Ring-tailed lemur

**Leaf/Plant Part Dominant**

- *Nycticebus pygmaeus* - Pygmy loris
- *Nycticebus coucang* - Slow loris
- *Hylobates sp.* - Gibbon/Siamang

**Omnivore**

- *Eulemur coronatus* - Crowned lemur
- *Perodicticus potto* - Potto
- *Varecia variegata* - Ruffed lemur
- *Microcebus sp.* - Mouse lemur
- *Pongo sp.* -- Orangutan
  - G.g. gorilla
  - W. Lowland gorilla
  - Pan
  -- Bonobo/Chimp
- *Nycticebus pygmaeus* - Pygmy loris
Jaw Structure

Generalized teeth, four kinds, many functions

Enclosed bony eye sockets
GI Tract Morphology

(adult human (*homo sapiens*) digestive tract, Stevens & Hume, 1999)

(chimpanzee (*Pan troglodytes*) digestive tract, Stevens & Hume, 1995)

Bushbaby

Baboon

Northern Douc Langur

Howler
The small intestine is about 17 feet or 5-6 meters long.

The large intestine is about 5 feet or (1.5 m) long.
Gut Health

- Gut health = fiber and carbohydrate (sugar/starch)?
- Fiber is ingested material that is resistant to vertebrate digestive enzymes
- Carbohydrate constitutes 50-80% of the dry matter in leaves, fruits, and seeds. Also ~40% of the metabolizable energy of the diet for most primates.
Sugar

Monosaccharides
- galactose
- fructose
- glucose

Disaccharides
- sucrose
- fructose
- lactose

Oligosaccharides
- verbascose
- raffinose
- stachyose

Polysaccharides
- Starch
- Starch-like

Non-starch
- Insoluble & soluble fiber

Grains, leguminous seeds, nuts, vegetables
Starch

- Starch digestion by endogenous mammals involving salivary and pancreatic α-amylase
- Problems may arise when high starch leads to excessive rapid fermentation may lead to digestive upset or stool quality.
- Serious issues may arise high starch/low fiber in foregut fermentators.
- Starch-like = glycogen and dextrins
Fiber (non starch)

- Cellulose and hemicellulose = insoluble fiber
  - Both can’t be broken down by endogenous enzymes
  - Symbiotic GI anaerobes = microbial fermentation = VFA
  - VFA = A, P, and B

- Soluble non-starch poly sacch = soluble fiber
  - Fermented by ruminal and intestinal bacteria
  - Pectic substances
  - Gums/mucilages
Fermentation

• Meeting the energy needs of herbivorous primates (colobus or howlers)
• Colon and cecum
• Marmosets and tamarins
• *Cebuella pygmaea* and *Callithrix spp.*
• *Saguinus spp.* And *Leontopithecus spp.*
• Microbial fermentation – protein from urea and vitamins?
Fiber (non starch)

- Cellulose and hemicellulose = insoluble fiber
  - Cellulose can't be broken down by endogenous enzymes
- Constituents of plant cell walls (NDF and ADF)
- How to measure? Crude fiber, ADF, NDF, Lignin
- Fermentation and its products
- Wild fruits vs our fruits
Fecal & Body Condition Scoring

• Not aware of a gold standard for primates
• Fecal score charts are nice to have to monitor any changes
• Tough to develop visual scoring on primates
• Essential to weigh animals and during PE get hands on
• Perhaps focal points
• Standard pose
Target Nutrient Values

• Physiological state and body condition
  – reproduction increased energy need
• Age, health status, environment, group dynamics
• Sources of information on nutrient requirements
  – NRC - actual
  – AZA Husbandry manuals/nutrition recommendations
• Vitamin D
Metabolism

• Individuals are different
• Life stages – different requirements
• Nutrient targets depend on both internal and external
• Nutrients interact
• Vitamin D needs
• Deficiency and toxicity
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Target Nutrients^a</th>
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<tbody>
<tr>
<td>Protein, %</td>
<td>15-22^b</td>
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<tr>
<td>Essential n-3 Fatty Acids, %</td>
<td>0.5</td>
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<tr>
<td>Essential n-6 Fatty Acids, %</td>
<td>2</td>
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<tr>
<td>NDF, %</td>
<td>10-30^c</td>
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<tr>
<td>ADF, %</td>
<td>5-15^c</td>
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<tr>
<td>Vitamin A, IU/g</td>
<td>8</td>
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<tr>
<td>Vitamin D, IU/g</td>
<td>2.5^d</td>
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<tr>
<td>Vitamin E, mg/kg</td>
<td>50-100</td>
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<tr>
<td>Thiamin, mg/kg</td>
<td>3</td>
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<tr>
<td>Riboflavin, mg/kg</td>
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<tr>
<td>Niacin, mg/kg</td>
<td>25</td>
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<tr>
<td>Pyridoxine, mg/kg</td>
<td>4</td>
</tr>
<tr>
<td>Folacin, mg/kg</td>
<td>4</td>
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<tr>
<td>Biotin, mg/kg</td>
<td>0.11-0.2</td>
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<tr>
<td>Vitamin B12, mg/kg</td>
<td>0.01-0.03</td>
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<td>Pantothenic acid, mg/kg</td>
<td>12</td>
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<tr>
<td>Choline, mg/kg</td>
<td>750</td>
</tr>
<tr>
<td>Vitamin C, mg/kg</td>
<td>200^e</td>
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<tr>
<td>Calcium, %</td>
<td>0.5-0.8</td>
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<tr>
<td>Phosphorus, %</td>
<td>0.4-0.6^f</td>
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<tr>
<td>Magnesium, %</td>
<td>0.08</td>
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<tr>
<td>Potassium, %</td>
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<tr>
<td>Sodium, %</td>
<td>0.2</td>
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<tr>
<td>Iron, mg/kg</td>
<td>100</td>
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<tr>
<td>Zinc, mg/kg</td>
<td>20-100</td>
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<tr>
<td>Copper, mg/kg</td>
<td>12-20</td>
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<td>Manganese, mg/kg</td>
<td>20</td>
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<tr>
<td>Iodine, mg/kg</td>
<td>0.35</td>
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<tr>
<td>Selenium, mg/kg</td>
<td>0.11-0.3</td>
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</table>
What is a target nutrient?

• Minimal amount of nutrient to achieve some measurable outcome
  – Basic health
  – Normal growth
  – Reproduction
  – Slow senescence
Energy

Energy is measured in calories and is the amount of energy required at 1 atmosphere of pressure to raise the temperature of 1 gram of water from 14.5°C to 15.5°C.

BMR calculations base

• Kleiber
  – 70(healthy BW [kg])^{0.75}
  – That 70 will change based on species and activity
  – Energy requirement of small primates is twice BMR
  – Factors for maintenance, growth, pregnancy/lactation
  – Just a baseline - variance
Practical Diet Formulation

• Free ranging diet information
• GI tract
• Specific to species/closest domestic
• Season
• Physiological state
• Health Status
• Management
• Foods Available
• Presentation
How do you classify produce?

• Trained to fit into categories
  – Fruit
  – Vegetable
  – Leafy Green
  – Starch

• Some overlap between categories

• Not enough emphasis on sugar and fiber

• Earlier information on sugar, fiber, starch etc. now evaluated on how body breaks down and utilized
Fruit

• Fruit = any seed bearing structure in a flowering plant formed from the ovary after flowering. Eating ovaries.....
  – Apples
  – Oranges
  – All beans
  – Tomato
  – Corn
  – Wheat Grains

• Domestic vs. wild
Primates and Sweet Foods

• Love sweet foods
• Sweet foods high in sugar
• Glucose = most readily available source of energy
• Glucose present = choice for energy
• \( \uparrow \text{glucose} \rightarrow \uparrow \text{insulin} \rightarrow \text{ENERGY} \)
  \( (\downarrow \text{blood glucose} + \uparrow \text{intracellular glucose}) \)
Vegetable

- Vegetable = any vegetative part of a plant that is not a fruit, nut, tuber, or grain.
  - Broccoli/cauliflower
  - Brussel sprouts
  - Radishes
  - Onions
  - Turnips
  - Beets
  - Artichoke
Leafy Greens

• Leafy Greens = leaves, petioles, or shoots of vegetable plants.
  – Romaine
  – Spinach
  – Escarole
  – Kale
  – Cabbage
  – Celery
  – Endive
  – Collards
Starchy Vegetable

• Starch vegetable = structure for energy storage for plant re-growth the following season. Readily broken down by the body or cooking into simple sugars
  – Sweet/white potato
  – Carrot
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Biscuit 1</th>
<th>Biscuit 2</th>
<th>Biscuit 3</th>
<th>Biscuit 4</th>
<th>Biscuit 5</th>
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<tr>
<td>Protein, %</td>
<td>26</td>
<td>18</td>
<td>21</td>
<td>21</td>
<td>23</td>
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<tr>
<td>Fat, %</td>
<td>6.2</td>
<td>3</td>
<td>5.0</td>
<td>6.4</td>
<td>6.5</td>
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<tr>
<td>NDF, %</td>
<td>17</td>
<td>26</td>
<td>33</td>
<td>-</td>
<td>21</td>
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<tr>
<td>ADF, %</td>
<td>6.8</td>
<td>18</td>
<td>22</td>
<td>-</td>
<td>13</td>
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<td>Sugar, %</td>
<td>2.8</td>
<td>17.3</td>
<td>5.5</td>
<td>1.9</td>
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<tr>
<td>Starch, %</td>
<td>32.2</td>
<td>16</td>
<td>6.0</td>
<td>-</td>
<td>-</td>
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<td>Energy, kcal/g</td>
<td>3.15</td>
<td>2.73</td>
<td>2.65</td>
<td>3.9</td>
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<td>Vitamin D3, IU/g</td>
<td>6.6</td>
<td>3.3</td>
<td>4.2</td>
<td>2.1</td>
<td>3.5</td>
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<td>Vitamin A, IU/g</td>
<td>43</td>
<td>25</td>
<td>23</td>
<td>14</td>
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<td>Vitamin C, mg/kg</td>
<td>500</td>
<td>475</td>
<td>795</td>
<td>605</td>
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<tr>
<td>Calcium, %</td>
<td>1.0</td>
<td>1.2</td>
<td>1.0</td>
<td>0.6</td>
<td>1.0</td>
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<tr>
<td>Phosphorus, %</td>
<td>0.6</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
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<td>Iron, mg/kg</td>
<td>440</td>
<td>385</td>
<td>225</td>
<td>86</td>
<td>100</td>
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<tr>
<td>Zinc, mg/kg</td>
<td>160</td>
<td>165</td>
<td>160</td>
<td>62</td>
<td>-</td>
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<tr>
<td>Selenium, mg/kg</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Balancing primate diets

• Consistent plane of nutrition
• Be cognizant of the sugar in the diet
• Know which food items contribute sugar
• Not too much sugar
• Balance sugar with fiber (type)
Dental Health

- Dry biscuits/pellets
- Whole vegetables
- Browse
Common Nutrition Challenges

• Seasonal changes or not?
• Weight gain vs weight loss
• Vitamin D
• Obesity
Common Diet Related Issues

- Periodontal Disease
- Dental Caries
- Cardiovascular Disease
- Diabetes
- Microbiome Shift

Obesity