Minerals and Vitamins

- Inorganic and organic nutrients required by animals. How do we know they are required and how much is required?

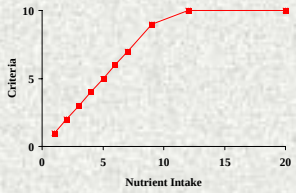

Fig. 5.1 Robbins

Calcium and Phosphorus

- 98% Ca and 80% P in bone
- Ca also involved in blood clotting, muscle function, acid-base balance, productive processes
- P in bone and in ATP and nucleic acids
- Ca:P ratios of 2:1 are best. Most problems when P becomes high relative to Ca
- Ca metabolism tied to a vitamin. Which one?

Minerals and Vitamins

- Expressing requirement as a concentration in the diet could be a problem:
  - A food with a higher concentration of digestible energy will require a higher concentration of other nutrients. Why?
  - Energy requirements change with conditions. If energy requirements high, more food will be eaten, and concentration of other nutrients can be lower
  - Larger animals require less energy/kg body mass than small animals. If requirements for a nutrient have a 1:1 relationship w/ body mass, than larger animals will need a higher concentration in diet.

Calcium and Phosphorus

- Deficiency symptoms
  - Reduced feed intake, abnormal eating habits, lethargy
  - Osteomalacia and rickets (chronic)
  - Tetany and paralysis (acute)
- Ca adequate in most forages; deficient in meat
  - Meat Ca:P ratio is bad. Also low in Cu, I, Vit. A
- Phosphorus low in browse and cactus
- When demand is high, eat bones, shells, etc…
- Huge Ca and P stores in bones. Mineral balance integrated over a long time scale.

Minerals

- 3 groups, based on amount required:
  - Macro elements - Ca, P, Na, K, Mg, Cl, S
  - Trace elements – Fe, Zn, Mn, Cu, Mo, I, Se, Co, F, Cr
  - Ultra trace elements – Some mentioned in text
- Minerals about 5% of the dry weight on animal's body. Most is Ca and P in bone. Many are co-factors in enzymes
- There are many complex interactions among minerals, particularly in absorption

Sodium

- Primary cation. Regulation body fluid volume, osmolarity, acid-base balance, and muscle and nerve function
- Abundant in nature, but plants do not require, so herbivores may be deficient
- Na deficient in areas of high rainfall
- To meet sodium requirements animals:
  - Strong Na drive – Salt licks often have high Na
  - Mechanisms to recover Na from feces & urine

Magnesium & Selenium

- Mg – Grass tetany or grass staggers.
  - Occurs in ruminants during spring on fertilized pastures. Poor Mg absorption or use. Most common in dairy cows but has been reported in wildlife.
- Se – In western U.S. toxic because substituted for sulfur in a.a.
  - Deficient in NW, Lake States, NE, Atlantic coast.
  - Co-enzyme to repair cell membrane oxidation
  - White muscle disease and capture myopathy

Vitamin A

- Functions in rods of the eye. Also affects respiratory, digestive and immune systems
- High in liver – predators do not have problem
- Plants have no vitamin A. Have carotenoids, vitamin A precursors which most animals can convert. Which species cannot?
- Expressed as International Units
  - 1 IU from 0.3 ug of retinol or 0.6 ug of B-carotene
- Eating livers of marine mammals can cause vitamin A toxicity

Vitamins

- Organic molecules required in small amounts
- 2 broad groups of vitamins
- Fat soluble
  - Absorbed and transported with lipids
  - Can be stored, often in the liver
  - Toxicities possible
  - Most not produced by gut microbes
  - Only contain C, H, and O
  - Vitamins A, D, E, and K.

Vitamin D

- Necessary to maintain plasma Ca
  - Promotes Ca absorption from small intestine
  - Increase rate of bone resorption
  - Increase Ca resorption in kidney
- Vit. D precursors in animal and plant tissue. Also made from cholesterol and UV light.
- Active form produced in response to low plasma Ca.
- Some plants contain the active form of Vit. D

Vitamins

- Water soluble vitamins
  - Not fat soluble
  - Absorption typically high
  - Readily excreted in urine
  - Cannot be stored
  - Continually required in the diet
  - Generally not toxic
  - Many produced by gut microbes in sufficient amts
  - Contain C, H, O, and N, S, or Co (Vit C is exception)

Vitamin E

- Antioxidant for lipids.
  - Lipids part of cell membrane. Oxidized lipids threaten integrity of cell membrane.
  - Discolored body fat, muscle lesions, anemia, in addition to general signs of deficiencies.
- Only produced by plants and microbes
  - Several forms. A-tocopherol most active form. Other forms 1-40% as active. Expressed as IU.
- High amounts in vegetable oils. Less in animal fats. Fish based diets may be deficient (High fat, storage, eviscerated)

Vitamin K

- Necessary for blood clotting
- Produced by plants and bacteria
- Widespread in nature, so deficiencies unlikely
- Gut microbes can meet a large portion of requirement. In humans about ½ of requirement met by gut microbes.

Essential Fatty Acids

- Discovered when animals fed fat free diets with adequate energy, protein, minerals, and vitamins. Symptoms disappeared with addition of fat.
- Animals cannot make some double bonds, so those fatty acids required in the diet.

Linolenic acid:

CH_3-CH_2-CH=CH-CH_2-CH=CH-CH_2-CH=CH-$(CH_2)_7$-COOH

Linoleic Acid has 2 instead of 3 double bonds

Arachidonic and Eicosapentaenoic acids produced from these. Some species not able to do these conversions. Guess which…

Essential Fatty Acids

- Deficiency Symptoms
  - Loss of hair, dermatitis, poor growth and repro, kidney problems, poor healing, dehydration, degeneration of liver, immune system failure
- Important in cell membranes and precursors for prostaglandins and leukotrienes
- Linoleic and linolenic – green plants, animal fats, seed oils
- Arachidonic – not found in plants. Cats get EFA deficiency on cereal-based dog foods
- EFAs oxidize easily. Storage & heat problem