Chapter 70

# Feeding Small Pet Mammals

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*"All the thoughts of a turtle are turtles, and of a rabbit, rabbits."*
*The Natural History of Intellect, 1893*

## CLINICAL IMPORTANCE

Ferrets, rabbits and rodents are popular pets that are often presented to veterinarians for advice about their care, including diet and feeding management and treatment of medical disorders. Each species presents nutritional challenges. Dietary management of ferrets, rabbits and rodents may be modified by lifestage, level of physical activity and state of health. Owners may need advice about feeding healthy pets to meet needs for maintenance, growth, reproduction or stress. Patients may present with disorders caused by an imbalanced diet or improper feeding practices. In addition, nutritional support is used for rehabilitation of debilitated animals. This chapter covers the nutritional needs of healthy pet ferrets, rabbits and rodents and those with common disease processes.

Dietary management begins with assessment of the animal, food and feeding method. A feeding plan is formulated based on the results of this assessment (Chapter 1). Although data are lacking for specific exotic species, assessment is similar to that for other mammals. It begins with a thorough history of the animal, including diet, husbandry and environment. Physical examination includes recording body weight and assessing body condition, using body condition scores. Details about body condition scoring systems are unavailable for most small mammals; however, a five-point system (where 1 = cachectic, 3 = optimal, and 5 = obese) can be applied to all species. Body condition scores qualitatively assess amounts of body fat and muscle. Excessive loss of body fat suggests starvation (due to husbandry, diet, or disease), whereas excessive loss of muscling suggests advanced starvation, forced inactivity or altered metabolic states (often due to disease).

Other factors may become part of overall nutritional assessment. Small mammals, for example, can also be evaluated for the condition of their skin and fur and their behavior and attitude. As for other species, serum biochemistry profiles are of limited use in nutritional assessment.

## DOMESTIC FERRETS

### Husbandry

The domestic or European ferret (*Mustela putorius furo*) is a member of the family Mustelidae, order Carnivora. Other mustelids include the mink (*Mustela vison*) and weasel (*Mustela* spp.). Pet ferrets were domesticated from the wild European polecat and were probably brought to North America by English settlers 300 years ago (Fox, 1988). Two variations are recognized, based on coloration: 1) the fitch ferret is pale yellow buff with black mask, legs and tail, and 2) the albino ferret is white with pink eyes.

Ferrets have become increasingly popular as companion animals due to their small size, ease of care and maintenance and inquisitive personality (Carpenter et al, 1994; Brown, 1993, 2004; Fox, 1988; Bernard et al, 1984; Ryland and Bernard, 1983; McLain et al, 1988).

## Key Nutritional Factors

Ferrets are strict carnivores that eat whole, small prey items in the wild. They have a very short, simple gastrointestinal (GI) tract lacking a cecum and ileocolic valve. Ingesta have a rapid intestinal transit time of approximately three to six hours (Bell, 1999; Brown, 2004). Because of the relatively inefficient GI tract, ferrets thrive on highly digestible foods containing large amounts of protein and fat, with minimal digestible (soluble) carbohydrate and fiber (Bell, 1999; Brown, 2004). In nature, the only significant sources of carbohydrates are those obtained from ingesting the gut contents of prey items (Bell, 1999). Although the most appropriate diet for a ferret is whole prey or a balanced fresh or freeze-dried carnivorous diet, this is impractical. Ferrets raised on ranches are often fed pelleted mink diets, which consist of 30 to 35% meat-based protein and 20% animal fat. However, diets for mink depend heavily on fish; mink diets are less palatable to ferrets because mink are naturally fond of fish whereas ferrets are not (Bell, 1999). Because the exact nutritional requirements of pet ferrets are unknown, recommendations for the best food for this species cannot be adequately determined. When evaluating a diet, review the list of ingredients on the package: the crude protein of a maintenance diet should be 30 to 35% and based on high quality meat, not grains; the fat content should be 15 to 20% (Bell, 1999; Brown, 2004). A comparison of constituent nutritional values of some North American commercial foods used for ferrets has been previously published (Bell, 1999; Lewington, 2000).

Commercial foods marketed specifically for ferrets mirror the formulations known to be successful in mink and cats (NRC, 2006, 1982; AAFCO, 2007). Guidelines for cat foods may be used when assessing the completeness and balance of foods intended for ferrets (AAFCO, 2007). Grocery store cat foods are very palatable because of their coating with animal fat and digest, but they are nutritionally inadequate for any stage of ferret's life. Minimally stressed ferrets may live on these foods for years, but nutritional deficiencies may occur especially in breeding animals (Bell, 1999). Pelleted ferret food is the preferred diet, although premium dry kitten food is generally acceptable for meeting the ferret's nutritional requirements for growth and reproduction (Kupersmith, 1998). Canned food should be avoided as the main diet because ferrets may be unable to consume enough protein and fat on a dry matter (DM) basis. Furthermore, periodontal disease may occur earlier if ferrets are fed a moist diet because of the lack of friction to help prevent plaque buildup on the teeth (Bell, 1999; Crossley and Aiken, 2004).

### *Protein and Amino Acids*

Ferrets require foods containing 30 to 35% protein on a DM and metabolizable energy (ME) basis. These levels correspond to label guaranteed analyses of about 27 to 32% for dry food and 6.5 to 8.0% for moist cat food (Bell, 1999; Brown, 2004). Protein quality is as important as quantity. Digestibility must be considered when determining the amount of protein. Poorly digestible protein will not satisfy the animal's nutrient requirements. Premium brands tend to have more digestible protein from meat sources rather than from cereal-based sources. Ferrets fed low-quality cat or dog food have a much higher incidence of struvite urolithiasis and may be susceptible to other complications such as GI diseases, respiratory infections, reproductive failure and poor growth (Bell, 1999; Orcutt, 2003).

Specific amino acid requirements are unknown for ferrets, but are assumed to be similar to requirements for cats. For example, young ferrets fed a single meal of an arginine-free food developed hyperammonemia, as do young cats (Deshmukh and Rusk, 1989). Likewise, cats and other strict carnivores need the high biologic value of proteins found in meat. To ensure high biologic value and maintain high food digestibility, dietary protein for ferrets should originate primarily from animal-based ingredients (poultry meal, meat by-products, eggs).

### *Fat and Fatty Acids*

Ferrets thrive when fed commercial foods containing 15 to 20% DM fat (Bell, 1999; Brown, 2004). These levels correspond to label guaranteed analyses of about 14 to 18% for dry and 3 to 5% for moist cat food.

Specific fatty acid requirements are unknown, but it is assumed that ferrets require linoleic and arachidonic acids. The former is abundant in vegetable oils, whereas the latter is abundant in animal-based ingredients (especially nerve tissue). Fatty acid requirements should be met by providing meat-based commercial cat or mink foods.

### *Digestible Carbohydrates and Fiber*

Other strictly carnivorous species, such as cats and mink, have no dietary requirement for carbohydrates, including fiber. Glucose is provided by hepatic gluconeogenesis, using amino acids. Dietary fiber may play a role in weight control and reduction, and in certain specific GI disorders.

The simple, short digestive tract of strict carnivores dictates hydrolysis of most dietary fuels, with little or no hindgut fermentation of fiber. The ferret intestinal tract is comparatively deficient in brush-border enzymes, thus ferrets are less able to absorb calories from carbohydrates (Bell, 1999). Generally, foods with added fiber should not be fed to healthy ferrets and those in above-maintenance physiologic states, such as growth and lactation, but may be considered for patients with fiber-responsive disorders.

### *Energy*

Metabolic rates for mustelids vary, but generally those with a long thin body shape, short fur, strict carnivorous behavior and high activity (e.g., ferrets and mink) have high metabolic rates, hence high caloric needs, relative to cats and other mustelids with different body shapes and activity levels (Knudsen and Kilgore, 1990). Seasonal metabolic cycles complicate predic-

tions of energy needs. Generally, autumn (shortening daylight) signals fat deposition and weight gain, whereas spring (lengthening daylight) signals fat mobilization and weight loss (Robbins, 1993). Pet ferrets that aren't exposed to variations in photoperiod may not undergo physiologic fluctuations in weight (Bell, 1999).

Ferrets reportedly consume 200 to 300 kcal (837 to 1,255 kJ) ME/kg body weight daily for adult maintenance (**Table 70-1**) (McLain et al, 1988). This amount equals about one-half to three-quarters cup of dry cat food containing about 400 kcal (1,674 kJ) ME per cup (standard eight-oz. measuring cup). This is about three times greater than the food intake of an average cat.

Energy needs increase for growth and reproduction (**Table 70-1**). Caloric requirements may be met by increased intake of an adult maintenance food or by consumption of a diet with increased caloric density. Increasing food intake works to a point, but foods with higher caloric density should be offered in demanding situations. Thus, growing and lactating ferrets should be fed cat foods formulated for growth and reproduction.

A ration with a caloric density of about 5.0 kcal/g (20.9 kJ/g) DM has been recommended for ferrets (McLain et al, 1988). Generally, dry cat foods contain 4.0 to 5.0 kcal ME/g (16.7 to 20.9 kJ ME/g) DM, or about 360 to 450 kcal ME/100 g (1,506 to 1,883 kJ ME/100 g) (about 1 cup). Moist cat foods usually contain 4.0 to 5.0 kcal ME/g (16.7 to 20.9 kJ ME/g) DM, or about 360 to 450 kcal ME/400 g (1,506 to 1,883 kJ ME/400 g) (about one 13-oz. can). Dry foods are generally preferred for ferrets because their texture may help prevent periodontal disease. Furthermore, although moist food may contain more DM protein and fat, ferrets may be unable to consume enough of this formulation to meet their requirements, because the bulk of the high moisture content in the food limits consumption (Bell, 1999).

Obesity is uncommon in ferrets, but may occur in later years as activity decreases. Most ferrets, therefore, are fed successfully by free-choice access to a high quality commercial ferret (or kitten) food. Although ferrets do not need treats, an occasional, judicious addition of natural treats (selected fruits and even vegetables) may be used. Food intake should be regulated for overweight ferrets.

**Table 70-1.** Average daily metabolizable energy (ME) intakes for ferrets at maintenance (M) and above-maintenance states, based on the recommendation of 200 to 300 kcal ME/kg body weight. For this table, 250 kcal/kg was used. Much variation between individuals should be expected.*

| Body weight | Daily energy intake (kcal ME) | | | | |
|---|---|---|---|---|---|
| (g) | M | 1.5M | 2M | 2.5M | 3M |
| 200 | 50 | 75 | 100 | 125 | 150 |
| 300 | 75 | 112 | 150 | 188 | 225 |
| 400 | 100 | 150 | 200 | 250 | 300 |
| 500 | 125 | 188 | 250 | 312 | 375 |
| 600 | 150 | 225 | 300 | 375 | 450 |
| 700 | 175 | 262 | 350 | 438 | 525 |
| 800 | 200 | 300 | 400 | 500 | 600 |
| 900 | 225 | 338 | 450 | 562 | 675 |
| 1,000 | 250 | 375 | 500 | 625 | 750 |
| 1,200 | 300 | 450 | 600 | 750 | 900 |
| 1,400 | 350 | 525 | 700 | 875 | 1,050 |
| 1,600 | 400 | 600 | 800 | 1,000 | 1,200 |
| 1,800 | 450 | 675 | 900 | 1,125 | 1,350 |
| 2,000 | 500 | 750 | 1,000 | 1,250 | 1,500 |
| 2,200 | 550 | 825 | 1,100 | 1,375 | 1,650 |

*To convert to kJ, multiply kcal by 4.184.

## *Vitamins and Minerals*

Dietary guidelines for cats and mink have been established by controlled comparative trials and thus are followed for pet ferrets because of limited research data in this species. Most published reports suggest that ferrets require vitamins and minerals in amounts similar to other carnivores. For example, research suggests that ferrets grow well when fed calcium (0.6 to 0.8% DM) and phosphorus (0.4 to 1.0% DM) in ranges fed to other mammalian carnivores (Edfors et al, 1990). Unlike cats, however, ferrets absorb β-carotene (the plant-based precursor of vitamin A) (Ribaya-Mercado et al, 1989). Despite this interesting finding, the conversion process is inefficient in ferrets: therefore, foods for pet ferrets should contain preformed vitamin A (e.g., retinyl palmitate) and not rely on carotenoids (Lederman et al, 1998).

Generally, deficiencies of specific vitamins and minerals are unlikely to occur in ferrets fed commercial foods formulated for cats, ferrets or mink. Deficiencies are more likely to occur in ferrets fed poorly formulated homemade foods. Imbalanced homemade foods for carnivores are most likely to be deficient in calcium and iodine. Both nutrients are deficient in common ingredients such as meats, most dairy products, rice and vegetables. Homemade foods should contain sources of calcium (bone meal, calcium carbonate) and iodine (iodized salt, kelp). Chapter 10 contains recipes for balanced homemade foods for cats that may be given to owners who insist on cooking for their ferrets (Donoghue and Kronfeld, 1994).

Deficiencies may also occur when excessive amounts of table foods or supplements are added to commercial ferret, cat or mink foods. Supplementation with table foods or single ingredients above about 10% of DM may imbalance previously balanced foods. For example, adding large amounts of corn oil reduces protein and other essential nutrients to deficient levels (on an energy basis). Deficiencies may also arise when large amounts of calcium are added to balanced foods because excess calcium interferes with absorption of trace minerals such as zinc and copper.

Vitamin and mineral toxicities may occur in ferrets overdosed with commercial supplements (e.g., chewable vitamin-mineral preparations given as treats) or with specific ingredients (e.g., vitamin A intoxication from an all-liver diet).

## Special Nutritional Needs

Kits from six weeks (weaning) to about 14 weeks of age require a soft, moist food. Growing kits require 35% protein and 20%

fat (Bell, 1999; Brown, 2004). Although a ferret kibble may be most appropriate, a premium quality cat food (formulated for all lifestages or for growth and reproduction) soaked with water may also be adequate for growth. Goat's milk added to softened cat food has been recommended for slow-growing kits (Morton and Morton, 1985). Ferrets achieve 90% of their adult size by 14 weeks of age, thus food consumption is very high.

Providing protein at levels greater than 35% improves the conception rate in jills (Bell, 1999). Pregnant and lactating ferrets also require above-maintenance levels of food. Generally, pregnant animals need about twice the maintenance level, whereas animals at peak lactation need three to four times maintenance amounts. Unrestricted access to premium quality food and a constant supply of water are required during these periods of high metabolic demand.

Food intake varies seasonally. Under natural lighting conditions, ferrets eat more and gain weight in the fall in preparation for the cold winter months (Morton and Morton, 1985). As the photoperiod increases in the spring, ferrets tend to lose most of their body fat, thereby preparing them for summer heat. Weight cycling may occur at other times as a result of unnatural photoperiods (Morton and Morton, 1985). Pet ferrets may not experience these fluctuations if they are not exposed to natural photoperiods.

## Selected Nutritional Diseases

Although the prevalence of nutrient deficiencies and toxicities in ferrets is largely unknown, specific diet-related problems are rarely seen in practice. Like dogs and cats, some ferrets with dermatologic problems respond to dietary supplementation with fatty acids (Chapter 32), but direct causal links between diet and disease remain to be established.

Anecdotal reports suggest that some, but not all, ferrets with dermatologic problems may respond to adding meat or liver to their usual diet of commercial cat food. This finding suggests that ferrets may be responding to arachidonic acid in meat or perhaps additional protein. When feeding liver, care must be taken to avoid inducing vitamin A intoxication. Generally, no more than 30 g of liver should be added per 800 kcal (3,347 kJ).

Ferrets fed excessive dietary fat risk protein deficiency. Protein deficiency manifests as slow growth in the young, low conception rates and failed lactation in breeding females and impaired immunity and generalized unthriftiness in ferrets of all ages. The problem may be corrected by feeding a commercial ferret chow or premium kitten chow.

Quality commercial ferret, kitten or cat foods appear to provide adequate levels of vitamins and minerals for ferrets. Most published reports of clinical problems have occurred in large breeding operations or under laboratory conditions.

Vitamin E deficiency results in yellow discoloration of body fat, hemolytic anemia, anorexia and a progressively impaired gait leading to paralysis (McLain et al, 1988). Affected young growing kits are found dead or depressed, cry when handled and are reluctant to move. Diffuse firm swellings under the skin and prominent subcutaneous lumps in the inguinal areas are clinical manifestations of the deficiency (McLain et al, 1988). This disease has been termed yellow fat disease, fatty degeneration of the liver and steatitis. It results from feeding foods containing high levels of polyunsaturated fatty acids with inadequate dietary vitamin E (McLain et al, 1988). Diagnosis is based on clinical signs and a history of feeding a food containing high levels of polyunsaturated fatty acids, deficient levels of vitamin E or both.

Thiamin deficiency resulting from feeding fish containing thiaminase has been reported to occur on ferret farms in New Zealand (McLain et al, 1988). The disease was seen in weanling animals and adults. Clinical signs included anorexia and lethargy followed by dyspnea, prostration and convulsions.

Zinc toxicity has also been reported to occur in ferrets on farms in New Zealand (McLain et al, 1988). The toxicosis resulted from excessive intake of dietary zinc that had leached from galvanized feeding pans and water dishes. Presumptive zinc toxicity was based on clinical signs (anemia, posterior weakness and lethargy), gross pathology and histologic examination of kidney and liver specimens and demonstration of elevated levels of zinc in these tissues.

Copper toxicosis has been reported to occur in sibling pet ferrets (Fox et al, 1994). Signs referred to liver disease; tissue copper concentrations confirmed the diagnosis. A genetic predisposition to copper intoxication was proposed.

Ferrets also can develop lower urinary tract disease similar to that seen in domestic cats. Diet is thought to play an important role. Ferrets fed a diet containing poor quality protein have a higher incidence of struvite urolithiasis (Orcutt, 2003). Metabolism of plant protein creates more alkaline urine, which enhances formation of struvite crystals. Suggestions for prevention mirror recommendations for feline lower urinary tract disease (Chapter 46); however, the disease in ferrets is not well documented.

## Feeding Plan

Ferrets require a high-protein, high-fat, low-carbohydrate diet. Foods for ferrets should be a premium quality kibble or chow and should be formulated for strict carnivores–ferrets or kittens (and possibly even adult cats). The diet must contain a high quality animal-source, not plant-source protein, to ensure high digestibility, palatability and protein quality. Protein and fat levels should preferably be 30 to 35% and 20% DM, respectively (Bell, 1999).

Foods may be fed free choice unless the ferret is overweight. Because of their high metabolic rate, ferrets consume more calories, hence more food, than cats.

Healthy ferrets should not be fed high-fiber foods. Dietary fiber, though, may play a role in weight control and in fiber-responsive disorders.

Other dietary recommendations for ferrets include:

- Vitamin-mineral supplements are generally unnecessary for healthy ferrets fed well-formulated commercial ferret or kitten/cat foods. Supplementing foods that are already balanced increases the risk of creating an imbalance and subsequent deficiencies or intoxications.
- Although it was a common practice to supplement a ferret's

diet with table foods such as cooked meat, fish, poultry, and eggs or fresh liver (Bernard et al, 1984; Ryland and Bernard, 1983), this practice is seldom indicated. Foods containing lactose or simple sugars should be avoided to prevent digestive upsets. Fruits and vegetables have also been offered in limited quantities; however, ferrets do not digest the fiber in these foods; therefore, they are generally not required. If a client insists on supplementing a ferret's diet, selected supplements should be used judiciously. Supplements should be limited to no more than 10% of the daily caloric intake. One ml of Linotone[a] or Ferretone[a] is acceptable, and soft-moist meat or liver snacks manufactured for ferrets or cats make good treats (Bell, 1999). Other acceptable snacks include baby food meats that contain no carbohydrates, egg yolk or whole cooked egg or small amounts of raw meat or liver. Pureed raw liver or hamburger mixed with egg yolk is especially appealing to kits and contains amino and fatty acids that may correct deficiencies associated with inadequate diets (Bell, 1999). Ferrets should not be offered carrots or nuts (may rarely cause intestinal obstruction), raisins (high sugar content) and bananas in amounts larger than 1 tsp (Purcell and Brown, 1999).

- Dry foods are generally recommended for ferrets because they may help keep the animal's teeth and gums in good condition, are more energy efficient, cost less and are easier to store and feed than moist foods.
- Ferrets do not need to eat mice or other rodents.
- Because hairballs occasionally occur in ferrets, feline hairball laxatives may be given every other day, following label dosage recommendations for cats (Brown, 1993).
- Bones should be avoided to prevent obstructions in the oral cavity and GI tract.
- Fresh water, in either a heavy crock-type bowl or drinking bottle, should be available free choice.
- Because ferrets are finicky, any food changes should be made gradually.
- Ferrets with insulinomas need constant access to a high-quality protein-based food. If a sugar-based syrup is used for emergency treatment of a hypoglycemic episode, it should be followed by a meat-based supplement after the patient is able to swallow to prevent dramatic fluctuations in glucose concentrations.
- Sick ferrets may be reluctant to eat and often require frequent hand feedings of warmed, moist, highly palatable foods. Examples include meat baby foods or a mixture of meat baby food, premium-quality moist cat food and a high-calorie supplement (e.g., Ensure Plus[b]) blended with the preferred dry diet (ground into a powder) and made into a warm gruel (Bell, 1999).

## RABBITS

### Husbandry

The domestic rabbit (*Oryctolagus cuniculus*) (Order Lagomorpha) is a descendent of the old world rabbit of western Europe and northwestern Africa (Fox, 1994; Donnelly, 2004a). It has become a popular pet, resulting in an increased demand for veterinary care for this species. Although domestic rabbits are used for commercial meat and fur production, teaching and biomedical research, exhibition by rabbit fanciers and as outdoor pets, most now are probably household pets. As pets, rabbits are small, relatively easy to care for, fastidious, quiet mannered and can be litter-box trained.

**Figure 70-1.** Overgrown, malocclusion incisor teeth frequently result in malnutrition or anorexia in rabbits.

As noted by their dental formula (I2/1, C0/0, P3/2, M3/3), lagomorphs can be distinguished from rodents by the presence of two pairs of upper incisor teeth. The smaller, second upper incisors, known as peg teeth, are located directly behind the first and lack a cutting edge. Rabbit teeth are hypsodont or open-rooted (continuously growing). Malocclusion and overgrowth are most likely to occur with the incisor teeth (**Figure 70-1**), which grow 10 to 12 cm a year throughout life, although malocclusion and overgrowth of the molar teeth may also occur (Harkness and Wagner, 1989). Rabbit teeth are developed for a high-fiber, herbivorous diet (Davies and Davies, 2003; Brooks, 2004). Chewing is characterized by up to 120 jaw movements per minute, with a lateral motion, which helps wear the teeth down to the proper occlusal surfaces.

As herbivorous hindgut fermenters, rabbits have a GI system resembling that of horses (Cheeke, 1994). Both species possess a non-compartmentalized stomach and a large cecum. The simple stomach has thin walls and indistinctly separated glandular and nonglandular areas. Rabbits are unable to vomit because of a well-developed cardiac sphincter (Davies and Davies, 2003; Brooks, 2004). The stomach is normally never fully devoid of food and fecal pellets. The terminal ileum expands and forms a thin-walled structure unique to lagomorphs known as the sacculus rotundus. Large amounts of lymphatic tissue are located in the wall of the sacculus, giving it a "honeycomb" external appearance. The thin-walled cecum is

**Figure 70-2.** A ventrodorsal radiograph of the abdomen of a rabbit with a gastric trichobezoar. Note the tubular distention of the stomach. (Reprinted with permission from Veterinary Medicine 1995; 90: 365-372.)

**Figure 70-3.** A ventrodorsal radiograph of the abdomen of the rabbit in **Figure 70-2** following a barium swallow. Note the contrast medium outlining the mass filling the gastric lumen. (Reprinted with permission from Veterinary Medicine 1995; 90: 365-372.)

a spiral structure and the largest and most prominent organ in the abdominal cavity of rabbits. The cecum has approximately 10-fold the stomach capacity and makes up 40 to 60% of the total volume of the GI tract (Jenkins, 1999). Antiperistaltic action moves small particles and solubles into the cecum, where cellulose is digested and fermented. The GI transit time for fiber is approximately four to five hours.

Instead of chewing cud for improved digestion, as would ruminants, rabbits use cecotrophy or pseudorumination (Brooks, 2004). Muscular contractions in the colon cause indigestible fiber particles to separate from nonfiber components of the gut contents. The fusus coli, another structure unique to lagomorphs, separates the proximal from the distal colon. The fusus coli functions as a pacemaker to control colonic contractions. Peristaltic contractions move fiber through the colon for excretion in hard feces. Antiperistaltic contractions move fluids and particles retrograde through the colon into the cecum for fermentation. After fermentation, the cecal contents are expelled through the colon (Brooks, 2004; Cheeke, 1994; Jenkins, 1999; Irelbeck, 2001). The fermented pellets produced in the cecum are called cecotrophs. Cecotrophs are excreted during the night and early morning, approximately eight hours after consumption of the original food item, as clusters of grapelike material and are consumed (cecotrophy) directly from the anus. Cecotrophs contain twice the protein (25 to 30% DM) of usual fecal pellets, more B vitamins and much less fiber (Tobin, 1996; Lowe, 1998; Brooks, 2004; Davies and Davies, 2003). Cecotrophy is particularly important for efficient digestion of forage proteins. The process also provides the rabbit with microbially synthesized B-complex vitamins, microbial protein and small quantities of volatile fatty acids. The pH of the rabbit's stomach is extremely acidic (<2.0), which may neutralize large num-

bers of bacteria ingested with cecotrophs.

The most clinically relevant feature, however, of the rabbit's GI system may be that the myoelectrical initiation of peristalsis occurs distal to the stomach. This feature allows hair to accumulate in the stomach and may account for the common occurrence of gastric trichobezoars in rabbits (**Figures 70-2** through **70-4**) (Gentz et al, 1995).

## Key Nutritional Factors

### *Energy*

Daily caloric needs for maintenance of healthy adult rabbits are estimated to be $100(BW_{kg})^{0.75}$ (**Table 70-2**) (Tobin, 1996). Thus, a healthy adult rabbit weighing 4 kg consumes almost 300 kcal/day (1,255 kJ). Because energy needs relate to metabolic body size, smaller breeds require a higher caloric intake per unit of body weight.

Daily energy needs increase for growth (190 to $210[BW_{kg}]^{0.75}$), early gestation ($135[BW_{kg}]^{0.75}$), late gestation ($200[BW_{kg}]^{0.75}$) and lactation ($300[BW_{kg}]^{0.75}$) (**Table 70-2**) (Tobin, 1996). Thus, there are two- to threefold increases in energy needs; therefore, food consumption correspondingly increases during growth and lactation (Harkness, 1987; Collins, 1988). Energy needs also increase in cold environmental temperatures.

Production rabbits often adjust feed intake to meet energy needs, when appropriate feed is available. Pet rabbits, however, occasionally overeat and risk obesity.

### *Protein and Fat*

Rabbits require 13 to 18% DM dietary crude protein (**Table 70-3**). Research suggests that 13% is adequate for maintenance, 15 to 16% for maximum growth and 18% for gestating or lactating does. These levels are allowable minimums determined for laboratory and production rabbits. Protein levels of 12 to 16% should be adequate for healthy household rabbits. Protein provided at levels used for production may be excessive for pet rabbits and may lead to reduced appetite for cecotrophs (Harcourt-Brown, 2002).

Rabbits require adequate amounts of relatively high-protein, high-quality foods, which is achieved by efficient use of plant proteins, such as those found in alfalfa and clover (**Table 70-4**). Low-protein foods and nonprotein nitrogen are used poorly. Bacterial protein from the lower bowel contributes little to the amino acid needs of growing rabbits, but may benefit adults fed poor-quality protein at maintenance. Excess dietary protein may allow the proliferation of *Clostridium* spp., which could lead to enteritis (Lebas et al, 1998).

Rabbits require no added dietary fat. Most foods contain 2 to 5% fat, which is sufficient (**Table 70-3**). Excess dietary fat may increase the incidence of arteriosclerosis, although some strains of rabbits may develop arteriosclerotic plaques even on a fat-free diet (Brooks, 2004).

### *Fiber*

Dietary fiber can be divided into indigestible fiber (passes through the digestive tract without entering the cecum) and fermentable fiber (enters the cecum for fermentation). Both indigestible and fermentable fiber are critical to optimal rabbit nutrition. The indigestible fiber stimulates gut motility, provides optimal dental wear and stimulates ingestion of cecotrophs. Fermentable fiber provides a substrate for cecal microflora, allows for volatile fatty acid production and prevents proliferation of pathogenic bacteria in the cecum (Harcourt-Brown, 2002; Brooks, 2004). Rabbits need a minimum of about 12 to 16% dietary crude fiber. The low end of the range, 12%,

**Figure 70-4.** The gastric trichobezoar removed in pieces from the rabbit in **Figures 70-2** and **70-3** weighed 102 g. Trichobezoars are frequently associated with a low-fiber diet. (Reprinted with permission from Veterinary Medicine 1995; 90: 365-372.)

**Table 70-2.** Average daily metabolizable energy (ME) intakes for rabbits at maintenance (M) and above-maintenance states.* Much variation between individuals should be expected.

| Body weight (kg) | Daily energy intake (kcal ME)** | | | | |
|---|---|---|---|---|---|
| | M | Growth | Early gestation | Late gestation | Lactation |
| 1.4 | 129 | 258 | 174 | 258 | 387 |
| 1.6 | 142 | 284 | 192 | 284 | 426 |
| 1.8 | 156 | 312 | 211 | 312 | 468 |
| 2.0 | 168 | 336 | 227 | 336 | 504 |
| 2.3 | 187 | 374 | 252 | 374 | 561 |
| 2.5 | 199 | 398 | 269 | 398 | 597 |
| 2.7 | 211 | 422 | 285 | 422 | 633 |
| 3.0 | 228 | 456 | 308 | 456 | 684 |
| 3.2 | 239 | 478 | 323 | 478 | 717 |
| 3.4 | 250 | 500 | 338 | 500 | 750 |
| 3.6 | 261 | 522 | 352 | 522 | 783 |
| 4.1 | 288 | 576 | 389 | 576 | 864 |
| 4.5 | 309 | 618 | 417 | 618 | 927 |
| 5.4 | 354 | 708 | 478 | 708 | 1,062 |
| 6.4 | 402 | 804 | 543 | 804 | 1,206 |
| 7.3 | 444 | 888 | 599 | 888 | 1,332 |

*Adapted from Tobin G. Small pets–food types, nutrient requirements and nutritional disorders. Manual of Companion Animal Nutrition & Feeding. London, UK: British Small Animal Veterinary Association, 1996: 208-225.
**To convert to kJ, multiply kcal by 4.184.

**Table 70-3.** Requirements of selected nutrients for rabbits.*

| Nutrients (DM) | Growth (4-12 wks) | Lactation | Gestation | Maintenance | Does and litters fed one food |
|---|---|---|---|---|---|
| **Crude protein (%)** | **15** | **18** | **18** | **13** | **17** |
| **Amino acids** | | | | | |
| Methionine + cystine | 0.5 | 0.6 | - | - | 0.55 |
| Lysine | 0.6 | 0.75 | - | - | 0.7 |
| **Crude fiber (%)** | 14 | 12 | 14 | 15-16 | 14 |
| **Digestible energy (kcal/kg)**** | 2,500 | 2,700 | 2,500 | 2,200 | 2,500 |
| **Fat (%)** | 3 | 5 | 3 | 3 | 3 |
| **Minerals** | | | | | |
| Calcium (%) | 0.5 | 1.1 | 0.8 | 0.6 | 1.1 |
| Phosphorus (%) | 0.3 | 0.8 | 0.5 | 0.4 | 0.8 |
| **Vitamins** | | | | | |
| A (IU/kg) | 6,000 | 12,000 | 12,000 | - | 10,000 |
| D (IU/kg) | 900 | 900 | 900 | - | 900 |
| E (ppm) | 50 | 50 | 50 | 50 | 50 |

Key: DM = dry matter.
*Adapted from Cheeke PR. Rabbits. In: Pond WG, Church DC, Pond KR, eds. Basic Animal Nutrition and Feeding. New York, NY: John Wiley & Sons, 1995; 451-459.
**To convert to kJ, multiply kcal by 4.184.

has been recommended for lactating does, 14% for growth and gestation and 15 to 16% for maintenance (**Table 70-3**) (Cheeke, 1995). These levels are minimums established for production rabbits; higher fiber levels may benefit pets. Dietary fiber levels of 18 to 25% have been recommended to maintain optimal GI health and help prevent obesity in pet rabbits (Lowe, 1998; Irlbeck, 2001; Brooks, 2004).

Adequate insoluble dietary fiber is important for rabbit health. In studies, growth rates were reduced in young rabbits fed low-fiber foods. Growth rates of production rabbits are optimal when foods containing 10 to 15% DM crude fiber are fed. Enteritis is more common in rabbits fed less than 10% crude fiber (Cheeke, 1994). Dietary fiber primarily stimulates gut motility rather than serves as a source of nutrition. Fiber promotes intestinal motility, provides nutrition for intestinal microorganisms and minimizes susceptibility to enteritis. Cecal fermentation of fiber produces volatile fatty acids (acetate, butyrate, and propionate), which are absorbed and used for energy. Volatile fatty acids aid in the control of pathogenic organisms by helping to maintain a low cecal pH. Foods with adequate fiber help to prevent obesity and hair chewing (**Table 70-4**) (Harkness, 1987). Diets low in indigestible fiber can lead to decreased GI motility and retention of food and hair in the stomach. Slowed gut motility and increased retention time of food can lead to alterations in the gut flora and development of enterotoxemia (Harcourt-Brown, 2002; Brooks, 2004).

## *Vitamins*

A dietary supply of vitamins A, D and E is an integral part of rabbit nutrition. Bacteria in the gut synthesize B vitamins in adequate quantities. Thus, addition of B vitamins to commercial foods may be unnecessary, although it often occurs. The adequacy of vitamin K synthesis in the gut is questionable; therefore, manufacturers often add this fat-soluble vitamin to commercial foods.

Because vitamins A and E are readily destroyed by oxidation, food preparation and storage methods should prevent losses from excess light or heat. Optimally, feed should be stored at 15°C (60°F) in a vermin proof area and fed within 90 days of milling (Brooks, 2004). Foods containing more than 30% alfalfa meal may provide sufficient vitamin A in the form of the precursor β-carotene (Fraser, 1991). Deficiency may occur, however, if old (more than one year postharvest) alfalfa is fed.

**Table 70-3** lists recommended levels of dietary vitamin A for production rabbits. Recommendations for pet rabbits include 7,000 to 18,000 IU vitamin A/kg food, 40 to 70 mg vitamin E/kg food and 2 mg vitamin K/kg food (Tobin, 1996; Lowe, 1998; Harcourt-Brown, 2002). The role of vitamin D in calcium regulation in rabbits differs from that in other species. Intestinal absorption of calcium does not require the presence of vitamin D. In rabbits, vitamin D is important for phosphorus metabolism and deficiencies can lead to hypophosphatemia and osteomalacia (Harcourt-Brown, 2002). Sunlight is necessary for endogenous synthesis of vitamin D in rabbits. Commercial rabbit pellets are also supplemented with vitamin D. A level of 800 to 1,200 IU/kg is recommended for pet rabbits (Lowe, 1998; Harcourt-Brown, 2002).

## *Minerals*

Calcium requirements for rabbits appear to be similar to those for other species (i.e., 0.5 to 1.0 % DM [**Table 70-3**]). Rabbits absorb calcium very efficiently and the excess is excreted in urine, rather than in bile as typically occurs in other species (Cheeke, 1994; Norris, 2001). Normal rabbit urine may have a thick milky appearance due to the excretion of calcium carbonate. Interestingly, rabbits have a higher than normal serum calcium level (12 to 13 mg/dl) compared to that of other mammals. Excess calcium supplementation with certain types of greens or vitamin-mineral mixes may cause urolithiasis or excessive calciuria in some pet rabbits (Irlbeck, 2001; Harcourt-Brown, 2002; Brooks, 2004). Urinary calculi can form in the kidneys, ureters and urinary bladder. **Table 70-5** lists calcium

**Table 70-4.** Protein and fiber contents (dry matter basis) of forages commonly fed to rabbits.*

| Forages | Crude protein (%) | Cellulose (%) | Hemicellulose (%) | Lignin (%) | ADF (%) | Crude fiber (%) |
|---|---|---|---|---|---|---|
| Alfalfa hay | 14 | 26 | 12 | 12 | 39 | 32 |
| Alfalfa meal | 18 | 24 | - | 11 | 35 | 26 |
| Clover hay | 16 | 26 | 9 | 10 | - | 29 |
| Orchard grass hay | 8 | 39 | 27 | 9 | 45 | 37 |
| Timothy hay | 9 | 33 | 31 | 5 | 36 | 31 |

Key: ADF = acid detergent fiber.
*Adapted from United States–Canadian Tables of Feed Composition, 3rd revision. Washington, DC: National Academy Press, 1982.

and phosphorus contents of commonly fed forages.

Most rabbit foods contain adequate calcium because the formulations include alfalfa meal, which averages about 1.4% calcium, 0.2% phosphorus and at least 300 IU vitamin $D_2$ (ergocalciferol) per g (DM) (United States–Canadian Tables of Feed Composition, 1982). Prolonged intake of high-calcium foods (4% DM) may cause calcification of soft tissues such as the aorta and kidneys; hypervitaminosis D most likely exacerbates the effect because it aids calcium absorption (Cheeke, 1994). Feeding a food (e.g., possibly a diet lower in alfalfa or alfalfa meal) containing 0.5% calcium prevents soft-tissue calcification.

**Table 70-5.** Calcium, phosphorus and vitamin $D_2$ contents (dry matter basis) of forages commonly fed to rabbits.*

| Forages | Calcium (%) | Phosphorus (%) | Vitamin $D_2$ (IU/g) |
|---|---|---|---|
| Alfalfa hay | 1.3 | 0.2 | 1,411 |
| Alfalfa meal | 1.4 | 0.2 | - |
| Clover hay | 1.5 | 0.3 | 1,914 |
| Orchard grass hay | 0.4 | 0.4 | - |
| Timothy hay | 0.5 | 0.2 | 1,930 |

*Adapted from United States–Canadian Tables of Feed Composition, 3rd revision. Washington, DC: National Academy Press, 1982.

## Special Nutritional Needs

The energy requirements of production rabbits fed free choice have been met by feeding dry foods containing 2.2 kcal/g (9.2 kJ/g) of food during maintenance, 2.5 kcal/g (10.5 kJ/g) of food during growth and gestation and 2.7 kcal/g (11.3 kJ/g) during lactation (Cheeke, 1995). Alternatively, feeding a single pelleted commercial rabbit food (hence a single energy density, often about 2.5 kcal/g [10.5 kJ/g] DM) and varying food intake, instead of the food itself, can be used to meet energy goals above maintenance needs.

Ideally, specific foods could be used for different functions: creep, starter, grower, finisher, lactation and maintenance (Cheeke, 1994). In most instances, however, commercial rabbit producers find it impractical to use more than one food. Thus, a single commercial pellet is typically fed to the entire rabbit colony. Adjustments for increased consumption of food above normal must be made for pregnant and lactating animals. Similar techniques may be used for pet rabbits.

Compared with many other mammals, rabbits have a high water intake. Rabbits drink about 120 ml/kg body weight daily (Cheeke, 1994), and even more during lactation and hot weather.

## Selected Nutritional Diseases

Although nutrient requirements of rabbits have been summarized in numerous studies (Cheeke, 1987, 1994, 1995; Cheeke et al, 1987; Lebas, 1987; Fraser, 1991), data about specific requirements are limited. However, the major nutritional problems of rabbits are not specific nutrient deficiencies or imbalances, but rather disturbances in digestive tract function (enteric disease) associated with dietary factors (Cheeke, 1994; Harcourt-Brown, 2002; Brooks, 2004) or with malocclusion of teeth.

### *Malocclusion*

Anorexia is a common clinical presentation of pet rabbits. Malocclusion of the teeth is a likely cause. Because rabbit incisor teeth are open-rooted, a developmental defect in the normal appositional anatomy precludes normal wear; thus, overgrowth of the teeth occurs (**Figure 70-1**). Overgrown incisor teeth may limit or prevent prehension of food and can traumatize the oral mucosa. A complete physical examination of rabbits should always include an evaluation of the oral cavity, including the molar teeth. Maloccluded incisor teeth need to be trimmed using either a high- or low-speed dental handpiece every four to six weeks or may need to be extracted (Crossley and Aiken, 2004). Specialized dental equipment, including speculums, mouth gags and long-shank dental burrs are available for use in rabbits. Endoscopic equipment can also be used to examine the oral cavity and teeth (Crossley and Aiken, 2004).

Rabbit molar and premolar teeth may also be maloccluded. Although maloccluded molar teeth are often floated with a fine file or their sharp points clipped off with a rongeur, ideally dental drills (low speed) should be used to remove the points (Crossley, 2003).

### *Trichobezoars*

Gastric obstruction by a trichobezoar is another common cause of anorexia in rabbits (**Figures 70-2** through **70-4**). Hairballs are common incidental findings in rabbit necropsies, even among shorthaired breeds. The rabbit's inability to vomit and the small pyloric lumen predispose to hair accumulation in the stomach. The primary inciting factor for development of trichobezoars is intestinal hypomotility. Diets low in indigestible

fiber and high in carbohydrates predispose to GI hypomotility and retention of hair and food in the stomach (Harcourt-Brown, 2002; Jenkins, 2004). A definitive diagnosis can be difficult. Occasionally, the stomach can be palpated in the cranial abdomen as a large, doughy mass. Fecal pellet production is frequently reduced or absent, and those that are passed are smaller than normal. Survey radiography may reveal an enlarged stomach with displaced intestines. Contrast radiography may aid the diagnosis. A large, ingesta-filled stomach in a rabbit that has been anorectic for four to seven days suggests gastric stasis. A definitive diagnosis requires exploratory laparotomy; however, given the risk of surgery in these compromised patients, a presumptive diagnosis is often made based on response to treatment (Jenkins, 2004).

Medical treatment strategies emphasizing rehydration of the patient and stimulation of gastric motility have been developed with very good results (Hernandez-Divers, 2005). Force-feeding fluids, vegetable purees or commercial products (Critical Care for Herbivores[c]) is often indicated, as is administration of subcutaneous fluids, or if the patient is hospitalized, intravenous fluids (Jenkins, 2004). Additional treatments may include administration of an appropriate systemic antibiotic, gastric motility stimulants and surgery if the rabbit fails to respond to medical management. Although feeding fresh pineapple juice (10 ml/day) (which contains the enzyme bromelain), papaya tablets (which contain papain) or proteolytic enzymes have been reported to aid breakdown and passage of trichobezoars, the response to such treatments is equivocal (Jenkins, 2004) and no longer recommended as a treatment strategy. Hairballs or gastric stasis in rabbits can generally be prevented by feeding foods with adequate fiber (>14% DM crude fiber), minimizing stress and boredom, frequent grooming and providing adequate exercise (Carpenter et al, 1995).

## Mucoid Enteropathy

Pet rabbits are also commonly presented with diarrhea, for which there are several differential diagnoses. Mucoid enteropathy is a GI disorder that is paradoxically characterized by constipation and diarrhea (Gentz et al, 1995; Jenkins, 2004), and by anorexia, lethargy, weight loss, cecal impaction and excessive production of mucus in the digestive tract (Lelkes and Chang, 1987). The cause of mucoid enteropathy is still under investigation, but the disease appears to be caused by changes in cecal pH that result from disruptions in the normal cecal flora (Lelkes and Chang, 1987; Jenkins, 1993). It likely occurs secondary to microbial alterations caused by hyperacidic cecal pH (Lelkes and Chang, 1987). A food containing about 20% crude fiber seems to maintain an optimal cecal pH to prevent changes in the normal microbial flora.

Mucoid enteropathy generally occurs in young rabbits, typically those just beyond weaning age (seven to 14 weeks) (Jenkins, 1993, 2004). It is rarely encountered in rabbitries that feed a high-fiber ration and avoid grains, simple carbohydrates and excesses of proteins or fats. Treatment includes feeding a high-fiber food (alfalfa hay) or syringe feeding a vegetable baby food (Jenkins, 1993) containing no additional sugars. In some cases, metoclopramide stimulates gastric emptying and apparently improves cecal activity. Fluid therapy to correct fluid and electrolyte imbalances is a priority to counteract losses that accompany the diarrhea (Gentz et al, 1995). Other treatment recommendations have been previously reported (Gentz et al, 1995; Jenkins, 2004).

## Enterotoxemia

Enterotoxemia is one of the most common diseases of rabbits seen in clinical practice. Enterotoxemia is caused by the toxin produced by *Clostridium spiroforme* (Jenkins, 2004). Rabbits, particularly those recently weaned, are sensitive to foods high in sugars and starches (Gentz et al, 1995). Feeding these foods has been associated with at least some cases of enterotoxemia. Weanlings have an undeveloped population of normal GI flora and a high gastric pH, which allows proliferation of *C. spiroforme*. Nutritional counseling, therefore, is an important part of rabbit medicine, especially because many rabbit owners think lettuce, carrots and sugary treats are an appropriate diet for their animals.

## Obesity

Many household rabbits have limited opportunities for exercise with almost unlimited access to palatable foods. Therefore, obesity is common in pet rabbits.

Because rabbits vary widely in body size, optimal body weights are difficult to estimate. Frequent weighing of each rabbit and recording the results in the medical record are important components of a preventive medicine program. Owners can be shown gradual increases in their rabbit's weight from medical records and the need for intervention. Systems for body condition scoring have not been published for rabbits and would be a welcome addition to preventive medicine programs.

Because rabbits use fiber efficiently, obesity may occur even when high-fiber foods are fed. However, weight control may be achieved by limiting the quantity of food offered. The amount of food offered should be reduced gradually, perhaps 10% every two weeks, until the amount fed maintains the desired body weight and condition.

## Vitamin Deficiency and Toxicosis

Although cecal microbes synthesize B-complex vitamins and vitamin K and the rabbit obtains them via cecotrophy, manufacturers may add all of the essential vitamins to commercial foods. The requirement for vitamin D may be low because rabbits readily absorb calcium and phosphorus (Cheeke, 1995).

Signs of vitamin D toxicity include progressive emaciation and weakness, loss of appetite, diarrhea and paralysis. Soft tissues (i.e., liver, kidneys, artery walls and muscle) may become extensively calcified (Cheeke, 1995).

Vitamin A deficiency and excess may lead to reproductive disturbances. Low conception rates, fetal resorption, low survival of newborn kits and hydrocephalus in fetuses occur with toxic levels. Toxicosis is generally associated with adding synthetic vitamin A to foods that contain high levels of good-quality alfalfa

**Table 70-6.** Energy and nutrient contents of foods commonly fed as snacks to rabbits and rodents.*

| Food items | Weight (g) | Water (%) | Energy (kcal/g)** (As fed) | (DM) | Protein | Fat | Carbohydrate | Fiber | Ca | P |
|---|---|---|---|---|---|---|---|---|---|---|
| Lettuce, romaine | 100 | 94 | 0.18 | 3.0 | 36 | 7 | 50 | 11 | 1.1 | 0.4 |
| Spinach, raw | 100 | 91 | 0.26 | 2.9 | 36 | 3 | 48 | 7 | 1.0 | 0.6 |
| Mung bean sprouts, raw | 100 | 89 | 0.35 | 3.2 | 31 | 2 | 54 | 6 | 0.1 | 0.5 |
| Summer squash, 1/2 cup | 100 | 94 | 0.18 | 3.0 | 17 | 2 | 65 | 9 | 0.4 | 0.4 |
| Blueberries, 1 cup | 145 | 85 | 0.51 | 3.4 | 4 | 2 | 80 | 12 | 0.1 | 0.1 |
| Strawberries, 1 cup | 149 | 92 | 0.28 | 3.5 | 6 | 4 | 77 | 6 | 0.2 | 0.2 |
| Apple, no skin, 1 medium | 128 | 84 | 0.51 | 3.2 | 1 | 2 | 86 | 4 | tr | tr |
| Banana, 1 medium | 114 | 74 | 0.82 | 3.2 | 4 | 2 | 86 | 2 | tr | tr |
| Cantaloupe, 1 cup | 160 | 90 | 0.32 | 3.2 | 8 | 2 | 79 | 4 | 0.1 | 0.2 |

Key: Ca = calcium, P = phosphorus, DM = dry matter, tr = trace.
*Nutrients expressed as % dry matter, except water and as fed energy.
**To convert to kJ, multiply kcal by 4.184.

(Cheeke, 1995). Vitamin A-deficient rabbits exhibit poor growth, leg deformities, increased susceptibility to disease (e.g., enteritis) and hydrocephalus (Cheeke, 1995; Brooks, 2004).

Little information is available about the vitamin E requirements of rabbits. Signs of deficiency include muscular dystrophy, with paralysis of the hind legs, reproductive failure and neonatal death (Cheeke, 1995).

## Feeding Plan

A diet commonly recommended by veterinarians for pet rabbits is a commercial high-fiber (at least 18 to 22% DM), pelleted food containing 12 to 16% DM crude protein, fed at the rate of one-fourth cup/2.3 kg body weight, divided into two daily meals (Carpenter, 2003; Cheeke, 1995; Jenkins, 1991). Although alfalfa-based pellets may be appropriate for growing rabbits, timothy hay-based pellets are recommended for adult rabbits because they contain less protein and calcium than alfalfa. Although some rabbits may be offered pellets free choice, many adult rabbits fed in this manner may become obese or fail to consume an adequate amount of loose hay.

Loose hay (mixed grass hay, timothy hay or dried grass clippings), should be provided free choice (Jenkins, 1991; Kupersmith, 1998). Alfalfa hay can be offered throughout the growth stages, but then should be discontinued because it contains higher than needed protein and calcium levels.

The diet should be supplemented with judicious amounts of thoroughly washed leafy greens (romaine lettuce, kale, mustard greens, carrot tops, parsley and dandelion greens) and fresh vegetables (carrots, broccoli, green peppers, cauliflower and cabbage). Dark greens with a low oxalate content should be selected (Kupersmith, 1998). In addition, rabbits may be fed a small amount (up to one tablespoon/2.3 kg body weight) of fresh fruit (strawberries, other berries, apples) daily or several times per week. Amounts of these palatable snacks should be limited because all are nutritionally incomplete and may cause a dietary imbalance (**Table 70-6**). Rabbits should not receive sugary treats, crackers, bread, rolled oats or breakfast cereals, which can cause abnormal fermentation in the gut and an overgrowth of certain bacteria resulting in serious, often fatal diarrhea.

Because rabbits are perhaps the most efficient converters of poorly digestible materials to animal flesh, their nutritional requirements can be met with any good quality hay supplemented with fresh greens (Jenkins, 1999). Therefore, some veterinarians are proposing that a diet of hay and fresh greens may satisfy the nutritional needs of house rabbits and minimizes the chance of diet-induced disease (Jenkins, 1999).

Practitioners often receive telephone calls regarding the feeding of wild orphaned bunnies. Ideally, if the orphaned bunny is deemed healthy, it should be returned to its environment if at all possible. Exceptions to this include if the bunny is smaller than the size of a tennis ball and its mother is known to be dead, or if the patient is not in good health. If hand-rearing is required, the patient should be thoroughly examined and medical problems such as hypothermia and dehydration should be rectified before feeding (Taylor, 2002). Hand-raising of wild bunnies should be done by licensed, trained rehabilitators. Feeding guidelines for orphaned bunnies are available (Sleeman, 2005; Taylor, 2002).

Other dietary recommendations for rabbits include:

- Because of the rabbit's intestinal microflora, food changes should be introduced gradually (over four to five days). For some rabbits with sensitive GI tracts, food changes may need to be made over a 10-day period (Harkness and Wagner, 1989). This is especially true for four- to 12-week-old rabbits. Current and new foods should be mixed 75:25 to begin the conversion. Quantities of the new food can then be increased gradually every few days.
- High-energy foods may increase susceptibility to mucoid enterotoxemia.
- Purchase small quantities of pellets at a time to prevent nutrient losses. Use pellets within 90 days of milling. Pellets can be stored in the freezer to reduce nutrient loss and spoilage.
- Clean, fresh water should be available at all times.

# RODENTS

## Introduction

The approximately 1,700 species of rodents in existence today represent over one-half of the total species of living mammals. The order Rodentia is divided into three suborders (sciuro-

morph, myomorph and hystricomorph) based primarily on variations in the origin of the masseter muscle. The word rodent originates from the Latin verb "rodere," to gnaw. Rodents are identified by their four prominent continuously erupting (hypsodontic) incisor teeth, which are frequently orange or yellow. Canine teeth are absent, and a gap, or diastema, exists between the incisor and cheek teeth. All rodents have six upper and six lower molar teeth, which may be either open- or closed-rooted, depending on the species. The presence or absence of premolar teeth is also species dependent.

Understanding rodent dentition is important because malocclusion and overgrowth of open-rooted teeth are common clinical problems, with sequelae such as weight loss, malnutrition and oral mucosal ulcerations. Normal gnawing behavior occurs when a rodent holds an object, frequently with the assistance of the forefeet, against the immobile upper incisor teeth and then shears with lateral to medial movements of the lower incisor teeth and jaw. During the gnawing process, the rodent moves the lower jaw forward, allowing apposition of incisor teeth but preventing occlusion and abrasion of cheek teeth. By withdrawing the cheek into the diastema, the rodent can compartmentalize the gnawed material into the cranial portion of the oral cavity, thus allowing for lengthy periods of gnawing without necessarily swallowing the gnawed material. During the chewing process, the lower jaw moves caudally to bring upper and lower cheek teeth into apposition. The complex muscles and anatomic variations in the associated skull bones, which allow for such specialized jaw movements, are a primary means of classifying rodent species (Sainsbury, 2003).

Although veterinarians may be presented with some very unusual pet rodents for examination, diagnosis and treatment of health problems, the most commonly seen pet rodents are guinea pigs (*Cavia porcellus*), chinchillas (*Chinchilla laniger*), hamsters (multiple species), Mongolian gerbils (*Meriones unguiculatus)*, rats (*Rattus norvegicus*) and mice (*Mus musculus*). Rodents are intelligent, relatively inexpensive to purchase and maintain and require little space. Unfortunately, however, owners are frequently unaware of specific husbandry requirements until problems resulting from conditions such as improper caging, poor nutrition and water deprivation become evident. A thorough history about husbandry practices can provide invaluable clues to the clinician when trying to address an owner's concerns.

## Cage Requirements

Proper caging is a critical aspect of rodent husbandry. This requirement should be considered when assessing suspected nutritional problems. Inadequate housing, poorly positioned food and water dispensers, dirty cages and a stressful environment can contribute to problems such as anorexia and dehydration. A variety of cages are available in pet stores, and one should be selected carefully, keeping in mind the characteristics of the species for which it will be used. In general, cages must be escape-proof and predator-proof, provide adequate ventilation, minimize the possibility of trauma, have mounted sipper bottles and provide adequate floor space.

Cages are typically constructed of metal, glass or plastic. Wood should not be used for caging rodents because it can be gnawed and is difficult to disinfect. Solid flooring is preferred to wire because it minimizes potential limb trauma and pododermatitis; however, it is more difficult to keep clean. Wire flooring can be used successfully if it is of proper mesh size and a portion of the cage contains solid flooring.

Bedding should be nonabrasive, nontoxic, clean, absorbent, inedible, dust-free and capable of being made into nests. Various medical problems have been associated with some frequently used bedding materials. Cedar shavings have been associated with dermatopathies and pulmonary and hepatic changes. Pine may affect hepatic enzyme activity. Hardwood shavings such as aspen and shredded nontoxic paper are the most commonly recommended bedding materials. Gerbils, hamsters and mice apparently prefer larger amounts of bedding than do guinea pigs, chinchillas and rats (Harkness, 1993). Frequency of cage cleaning and replacement of bedding varies with rodent type and cage.

Environmental enrichment in the form of nesting material, cage toys and different food items can be used to enhance the lives of laboratory and pet rodents, again keeping in mind the behavioral characteristics of the particular animal. Providing opportunities to forage allows animals to engage in natural behavior and can prevent boredom and provide exercise (Baumans, 2005).

## Common Aspects of Rodent Nutrition

Although little research has concerned pet rodents specifically, the popularity of rodents as laboratory animals has led to extensive nutritional studies. Nutrient requirements for laboratory rodents serve as initial guides to the nutrient requirements of pet rodents (**Table 70-7**) (NRC, 1978).

### *Coprophagy*

Most rodents are coprophagous, and fecal pellets are frequently ingested directly from the anus. Generally lighter, softer feces (cecotrophs) are selectively ingested. These feces are produced in the cecum and contain important B-complex vitamins and protein. Young rodents ingest maternal feces, thereby inoculating their own intestinal tracts with autochthonous flora (Clark, 1984; Manning et al, 1984).

### *Anorexia, Weight Loss and Dehydration*

Clinical problems related to anorexia, weight loss, dehydration or a combination of these factors are frequently observed in pet rodents. Common etiologies include husbandry-related factors such food and/or water deprivation, inability to reach or manipulate food or water utensils, inappropriate diet, sudden dietary changes, poor hygiene, overcrowding, inadequate temperatures and other environmental stressors (Harkness, 1993).

Careful and tactful questioning by the clinician is necessary for the client to realize or admit to the presence and significance of inadequate husbandry practices. If possible, the client should bring the rodent and its entire cage to the veterinary visit for a more thorough assessment of the animal's environment.

Following a complete physical examination, basic diagnostic

**Table 70-7.** Estimated nutrient requirements of laboratory rodents.* Some of these values were determined by rigorous comparative trials, others by examination of foods known to suffice for specific species. The data presented here are intended to be used only as starting points. The literature cited should be consulted for more information.

| Nutrients | Rats M | Rats Above M | Mice Above M | Gerbils Above M | Hamsters - |
|---|---|---|---|---|---|
| **Protein as casein (%)**** | 4.2 | 12 | 12.5-18 | 16-25 | 15.0 |
| **Fat (%)** | 5.0 | 5 | 5 | 5-20 | 5 |
| **Digestible energy (kcal/g)***** | 3,800 | 3,800 | - | - | 4.2 |
| **L-amino acids** | | | | | |
| Arginine (%) | - | 0.6 | 0.3 | - | 0.76 |
| Asparagine (%) | - | 0.4 | - | - | - |
| Glutamic acid (%) | - | 4.0 | - | - | - |
| Histidine (%) | 0.08 | 0.3 | 0.2 | - | 0.40 |
| Isoleucine (%) | 0.31 | 0.5 | 0.4 | - | 0.89 |
| Leucine (%) | 0.18 | 0.75 | 0.7 | - | 1.39 |
| Lysine (%) | 0.11 | 0.70 | 0.4 | - | 1.20 |
| Methionine (%) | 0.23 | 0.60 | 0.5 | - | 0.32 |
| Phenylalanine-tyrosine (%) | 0.18 | 0.80 | 0.4 | - | 0.83 |
| Proline (%) | - | 0.40 | - | - | - |
| Threonine (%) | 0.18 | 0.50 | 0.4 | - | 0.70 |
| Tryptophan (%) | 0.05 | 0.15 | 0.1 | - | 0.34 |
| Valine (%) | 0.23 | 0.60 | 0.5 | - | 0.91 |
| Nonessential (%) | 0.48 | 0.50 | - | - | - |
| **Minerals** | | | | | |
| Calcium (%) | - | 0.50 | 0.4 | 0.6-0.8 | 0.59 |
| Chloride (%) | - | 0.05 | - | 0.2-0.8 | - |
| Magnesium (%) | - | 0.04 | 0.05 | 0.1-0.2 | 0.06 |
| Phosphorus (%) | - | 0.40 | 0.4 | 0.3-0.4 | 0.30 |
| Potassium (%) | - | 0.36 | 0.2 | 0.7-0.9 | 0.61 |
| Sodium (%) | - | 0.05 | - | 0.2-0.4 | 0.15 |
| Sulfur (%) | - | 0.03 | - | - | - |
| Chromium (mg/kg) | - | 0.30 | 2.0 | - | - |
| Copper (mg/kg) | - | 5.00 | 4.5 | 0.4-4.0 | 1.6 |
| Fluoride (mg/kg) | - | 1.00 | - | 0-11 | 0.024 |
| Iodine (mg/kg) | - | 0.15 | 0.25 | 1-37 | 1.6 |
| Iron (mg/kg) | - | 35.00 | 25.00 | 130-470 | 140 |
| Manganese (mg/kg) | - | 50.00 | 45.00 | 3-45 | 3.65 |
| Selenium (mg/kg) | - | 0.10 | - | - | 0.1 |
| Zinc (mg/kg) | - | 12.00 | 30.00 | 0-8 | 9.2 |
| **Vitamins** | | | | | |
| A (IU/kg) | - | 4,000 | 500 | 18,000-32,000 | - |
| D (IU/kg) | - | 1,000 | 150 | 2,000-3,250 | 2,484 |
| E (IU/kg) | - | 30 | 20 | 9-1,200 | 3 |
| K (mcg/kg) | - | 50 | 3,000 | - | 4,000 |
| Choline (mg/kg) | - | 1,000 | 600 | 750-3,000 | 2,000 |
| Folic acid (mg/kg) | - | 1 | 0.5 | 100-1,800 | 2 |
| Niacin (mg/kg) | - | 20 | 10 | 22-90 | 90 |
| Pantothenate (mg/kg) | - | 8 | 10 | 25-60 | 40 |
| Riboflavin (mg/kg) | - | 3 | 7 | 4-20 | 15 |
| Thiamin (mg/kg) | - | 4 | 5 | 4-22 | 20 |
| $B_6$ (mg/kg) | - | 6 | 1 | 4-22 | 6 |
| $B_{12}$ (mcg/kg) | - | 50 | 10 | 0.18 | 10 |

Key: M = maintenance; healthy, non-stressed adults in comfortable surroundings. Above M = ill or stressed adults and growing, pregnant or lactating animals.
*Clark JD, Olfert ED. Rodents (Rodentia). In: Fowler ME, ed. Zoo and Wild Animal Medicine. Philadelphia, PA: WB Saunders Co, 1986; 728-733.
**Minimum protein requirements were determined with animals fed purified and semi-purified diets containing casein as a protein source. For animals fed commercial foods comprised of complex ingredients and relatively lower digestibilities, dietary protein should be higher.
***To convert to kJ, multiply kcal by 4.184.

studies such as complete blood counts, biochemistry profiles, radiographs and fecal examinations should be conducted whenever possible to rule out malocclusion, GI disease and other primary disease problems. Fecal culture and abdominal ultrasound are also often useful.

The prognosis for an anorectic, dehydrated rodent with significant weight loss is guarded. Supportive care includes administering oral, subcutaneous, and/or intraperitoneal fluids and offering a variety of sweetened foods or treats to encourage food intake. Many rodents will also tolerate gentle force-feeding. Pelleted rodent feed may be blenderized with water and appropriate supplements such as yogurt, vegetable baby foods or both. Alternatively, liquid enteral products formulated for people or pets may be fed without supplementation.

Feeding is best accomplished by wrapping the animal gently in a towel, placing the feeding syringe into the diastema, expressing small volumes into the oral cavity and allowing the animal to swallow. One-ml syringes can be used to feed mice, and 3- to 10-ml catheter-tipped syringes used to feed larger rodents. Owners can be shown how to feed their pets at home; however, they must be able to recognize when the animal is responsive enough to allow force feeding, to minimize potential problems with aspiration. Small meals should be fed several times throughout the day.

## Malocclusion

Malocclusion is another common clinical problem in pet rodents. The incisor teeth are usually involved, although the cheek teeth may also be malocclucded, depending on the species. Etiologies include genetic, dietary, infectious and traumatic factors. Overgrown teeth can result in tongue and oral ulcers, ptyalism, anorexia and weight loss. An oral examination is an important but often difficult component of a rodent physical examination. An otoscope may help visualize cheek teeth, but the patient may require sedation for the procedure. Skull radiographs are also useful for assessing severe malocclusion and tooth root abscesses. Specialized equipment, including specula, mouth gags and long-shank dental burrs, are available for use in rodents.

Inhalant anesthesia, preferably isoflurane administered through a facemask, is adequate for short dental procedures, such as trimming incisor teeth. The animal is masked down and the mask is removed when the animal attains an appropriate level of anesthesia. Its mouth is held open with a specialized speculum or gauze strips around the upper and lower incisors, and the incisor teeth are cut quickly, preferably with a high-speed dental drill. A variable-speed, rotary power tool with a circular cutting blade (Dremel Moto-Tool[d]) can also be used. Care should be used not to injure the tongue and surrounding tissues. Although sharp clippers have been used to trim the teeth of smaller rodents, teeth may split or shatter with this method; therefore, this technique is not recommended. Inhalant anesthesia delivered by facemask may be challenging for lengthier dental procedures on cheek teeth, which may require clipping with bone rongeurs or, preferably, using a guarded flat or taper fissure burr in a straight, low-speed dental handpiece (Quesenberry, 1994; Harkness and Wagner, 1995; Crossley and Aiken, 2004). Injectable anesthesia may be required for these procedures because small rodents are very difficult to intubate.

Rodents with chronic malocclusion problems may need teeth trimming every few months. Owners should monitor animals for anorexia and drooling. Breeding rodents with malocclusion problems should be discouraged.

## Guinea Pigs

### *Husbandry*

Domestic guinea pigs belong in the Caviidae family, which consists of short-tailed or tailless rodents that have one pair of mammary glands, four digits on the forefeet and three digits on the hindfeet. The most commonly seen breeds are: 1) the Shorthair or English, which has very uniform short hair, 2) the Abyssinian, which has a coat arranged in whorls or rosettes and 3) the Peruvian, which can have a coat several inches long. Various coat colors and multicolored patterns also exist for each species. Pet guinea pigs live for five to seven years and weigh 450 to 750 g. Gestation averages 68 days, and litter size ranges from two to four young (Clark, 1984; Anderson, 1987; Quesenberry et al, 2004).

Guinea pigs are herbivores with simple stomachs. Their teeth are open-rooted and erupt continuously. The dental formula is I1/1, C0/0, P1/1 and M3/3. The incisors are white unlike that of other rodents, which normally have yellow incisors. Guinea pigs have a long digestive tract with a gastric emptying time of approximately two hours and a total GI transit time from eight to 20 hours. Normal GI flora consists primarily of *Lactobacillus* and occasionally *Streptococcus* spp., yeast and soil bacteria (Manning et al, 1984; Harkness and Wagner, 1995a). Much of the digestive process occurs in the cecum, which is a thin-walled sac divided into numerous lateral pouches by smooth muscle bands (taenia coli). The cecum is normally found on the central and left side of the abdomen and may contain as much as 65% of the GI contents (Richardson, 1992; Quesenberry et al, 2004). Guinea pigs are coprophagous.

### *Special Nutritional Needs*

Guinea pigs, people and other primates are unable to synthesize vitamin C (ascorbic acid) because they lack the enzyme L-gluconolactone oxidase, which is needed to convert glucose to ascorbic acid. Adequate dietary supplementation is, therefore, critical to prevent hypovitaminosis C (scurvy), as detailed below. (See Feeding Plan.)

Guinea pigs display behavioral characteristics that influence their overall nutritional status. For example, they are extremely susceptible to stressful situations such as inadequate housing, moving into a new household or different cage and changing feeding schedules. Stressed guinea pigs may become anorectic and lose weight. Furthermore, guinea pigs do not tolerate dietary or environmental changes well. Guinea pigs develop dietary preferences early in life and do not adapt readily to change. For this reason, young guinea pigs should be exposed to different dietary items to allow them to become accustomed to variety (Quesenbery et al, 2004).

Proper housing accommodations can be provided by an open-topped enclosure at least 10 inches high, with a floor space of at least 101 square inches for an adult animal, and twice this floor space for a breeding sow. Either solid or wire flooring can be provided. Wire flooring allows for feces and urine to drop to the bottom of the cage. However, it may cause foot injuries and subsequent pododermatitis. Wire flooring should consist of a rectangular mesh 38 by 12 mm. At least a portion of the cage should have a solid bottom (Quesenberry, 1994). Solid floors with a substrate of shredded paper or hardwood shavings generally require more frequent cleaning but are preferable for pet guinea pigs.

Because guinea pigs are easily startled, the cage should be placed in a quiet area in the home to minimize exposure to sudden movements and loud noises. Ideally, a relatively constant

temperature between 18 to 24°C (65 to 75°F), and humidity between 40 and 70% should be maintained (Harkness and Wagner, 1995a). Elevated temperatures may cause heat stress. A cool, damp environment can predispose guinea pigs to respiratory diseases.

Additional behavioral characteristics of guinea pigs include their tendency to contaminate food and water dishes with excreta. Sipper bottles are preferred to minimize contamination of drinking water. However, guinea pigs can pass ingesta into sipper tubes. Guinea pigs also play with the end of the sipper tube, which may cause leaks, resulting in wet bedding and an empty water bottle. All food and water utensils should be cleaned and soiled bedding removed daily.

Any changes in access to food and water should be made gradually, over five to 10 days. Owners should also be cautioned to monitor for any signs of anorexia or decreased water intake when husbandry changes are recommended (Peters, 1991).

## *Common Nutritional Disorders*

### HYPOVITAMINOSIS C

Although quality commercial guinea pig foods are formulated with adequate vitamin C, hypovitaminosis C (scurvy) is still a common clinical problem because of this nutrient's lability during storage. Also, feeding guinea pigs rabbit food without providing additional vitamin C may cause scurvy. Because guinea pigs are incapable of storing vitamin C, scurvy appears within one to two weeks after a vitamin C deficient diet is fed. Death usually occurs within three weeks (Tobin, 1996; O'Rourke, 2004).

Guinea pigs with scurvy present with anorexia, bruxism, weight loss, an unkempt appearance and gingivitis. Affected animals are reluctant to move because of joint and muscle pain. Discomfort is apparent when limbs are palpated. Ascorbic acid is required for normal collagen formation; therefore, deficiencies primarily affect the musculoskeletal system. Sequelae include enlarged costochondral junctions, hemorrhage into muscles and joints and abnormalities in epiphyseal growth centers with subsequent pathologic fractures. Secondary infections, delayed wound healing and diarrhea may also be present. Subclinical vitamin C deficiency should be considered in any guinea pig presented with generalized illness. Young animals and pregnant sows are most severely affected (Harkness and Wagner, 1995; Peters, 1991).

Diagnosis of vitamin C deficiency is based on the history and clinical signs. Radiographs may reveal enlargement of long bone epiphyses and costochondral junctions.

Treatment involves parenteral supplementation with 50 to 100 mg vitamin C/kg body weight until clinical signs resolve (Quesenberry, 1994) one to two weeks after a vitamin C deficient diet is fed. Death usually occurs within three weeks (Tobin, 1996; O'Rourke, 2004). Oral vitamin C can then be initiated at the same dosage. Owners can supplement the diet with liquid pediatric vitamin C products obtained over-the-counter from pharmacies and supermarkets. (Appropriate dietary supplements are discussed in the Feeding Plan section.) Anorectic and dehydrated animals should receive supportive care such as fluids and forced alimentation as discussed in the Introduction to Rodents section. Client education about dietary requirements of guinea pigs plays a critical role in preventing this disease.

### PREGNANCY TOXEMIA

Pregnancy toxemia or ketosis occurs primarily in obese, primiparous, anorectic, stressed guinea pig sows. Boars are also susceptible to ketosis, although obviously pregnancy is not a factor. Obesity and anorexia are the most critical inciting factors for the development of ketosis. Genetics may also play a role. The onset of clinical signs is abrupt and occurs within about five days (before and after) of parturition. Clinical signs include lethargy, ruffled coat, anorexia, prostration, muscle spasms and death.

Diagnostic tests may reveal hypoglycemia (perhaps terminal hyperglycemia), hyperlipidemia, ketonemia, hyperkalemia, hyponatremia, hypochloremia, proteinuria and urinary pH less than six.

Supportive care includes administration of fluids, 5% glucose given orally or intravenously, antibiotics and judicious use of corticosteroids if the animal is in shock. Caesarean section may be attempted to save the fetuses. Prognosis, however, is poor and treatment is generally unsuccessful. Preventing obesity in sows (preferably body weight <500 g), providing a good food, minimizing stress and avoiding fasting or undernutrition in late pregnancy will reduce the risk of pregnancy toxemia.

### CECAL IMPACTION

Low fiber intakes (perhaps <10% DM crude fiber) predispose guinea pigs to cecal impaction. Prevention is best accomplished by providing adequate long-stem fiber in the form of chopped grass hay. Hay should be offered free choice, even when fiber-containing guinea pig pellets are fed.

### SOFT-TISSUE CALCIFICATION

Guinea pigs are reportedly susceptible to a syndrome involving calcification of soft tissues, especially in the forelimbs. The syndrome is thought to be related to dietary levels of calcium, phosphorus, magnesium, potassium and vitamin D (Tobin, 1996). Means of prevention are unknown, but efforts should be made to restrict use of supplements and to maintain DM vitamin D levels below 2,000 IU/kg (Tobin, 1996).

## *Feeding Plan*

### FEEDING ADULTS

Guinea pigs are strict herbivores and should be maintained on a feed specifically labeled for the species. Commercial dry rabbit food, although similar in appearance, should not be used because it contains inadequate levels of protein and vitamin C.

#### Vitamin C

Adequate dietary vitamin C levels are critical for overall good health, and although commercial guinea pig foods are formulated with approximately 800 mg DM vitamin C/kg, low vitamin C intake is still a common problem due to the vitamin's lability. Heat, moisture and contact with metals hasten its deterioration

during storage. Ideally, guinea pig pellets should be stored at 22°C (72°F) and used within 90 days of milling (Quesenberry, 1994; Quesenberry et al, 2004). Consumers may have difficulty determining how long the product has been on the shelf at the time of purchase because: 1) the milling date is frequently not stated on the food container and 2) many pet stores buy feed in bulk and then repackage product for resale. Owners should therefore be encouraged to buy food in small quantities from a reputable pet store that has a relatively high turnover of food products and to store the food properly at home.

Guinea pigs require approximately 10 mg vitamin C/kg body weight daily for maintenance and 30 mg/kg body weight daily for gestation. If the freshness of guinea pig pellets is unknown, 200 mg/ml vitamin C can be added to the drinking water. However, the half life of this nutrient in clean, fresh water is only 24 hours, and shorter if organic debris is present or if metal containers are used. Vitamin C can also be given orally on a daily basis using human pediatric vitamin C formulations (Quesenberry, 1994). Daily feeding small amounts of vegetables with a high vitamin C content such as red or green peppers, tomatoes, spinach and asparagus can augment vitamin C intake. Excess ingested vitamin C is excreted rapidly in the urine, with 80% of the ingested amount being eliminated in three days. Fresh vegetables should be thoroughly rinsed to minimize potential pesticide contaminants and bacterial pathogens such as *Salmonella* spp. (Harkness, 1993a).

## Protein, Fiber and Water

Commercial guinea pig pellets contain approximately 20% DM crude protein and 9 to 18% DM crude fiber. For an adult guinea pig, average daily food consumption is 6 g/100 g body weight and average daily water consumption is 10 ml/100 g body weight (Harkness, 1993a). Because guinea pigs are such fastidious eaters, owners should be discouraged from frequently changing brands of food to avoid anorexia. High-quality timothy or grass hay should be available at all times (Quesenberry et al, 2004). Oral lesions may occur if the hay is too coarse. Secondary infection of these lesions with beta-hemolytic *Streptococcus* spp. can lead to cervical lymphadenitis and abscess formation. Owners who allow their guinea pigs access to the yard should also be forewarned about possible herbicide/pesticide exposure. Overgrazing on lush lawns or fresh grass clippings can result in diarrhea. The recommended diet for guinea pigs is comprised of guinea pig pellets and high-quality grass hay supplemented with fresh vegetables.

### FEEDING NEONATES

Newborn guinea pigs are precocious, with teeth, a full coat and open eyes. Birth weights vary from 60 to 100 g. Neonates weighing less than 50 to 60 g rarely survive. Birth weight is related to genetic characteristics and maternal nutritional status, and is directly proportional to gestation length and inversely proportional to litter size. Neonatal guinea pigs remain close to the sow but generally will not nurse for the first 12 to 24 hours and, therefore, should not be force fed during this time. Neonates usually begin eating solid food at four to five days of age (i.e., guinea pig chow softened with cow's milk or water). If several lactating sows are present, the young may nurse alternately among them. In this case, the smaller piglets must be monitored to ensure that they nurse adequately. Weaning age varies from 14 to 28 days when body weight reaches 150 to 200 g. Average daily weight gain should be 2.5 to 3.5 g daily until 60 days of age (Manning et al, 1984).

# Chinchillas

## *Husbandry*

Chinchillas belong in the Chinchillidae family and are closely related to guinea pigs. Chinchillas originate from the rocky slopes of the South American Andes, where they were nearly hunted to extinction in the early part of the 1900s because of their prized pelts. A small group of chinchillas brought to the United States at that time were successfully bred in captivity and are progenitors for the majority of today's pet population.

Chinchilla breeds are characterized by their coat color, which in the wild is a smoky blue-gray. Other color variations represent mutations. The normal coat is thick and soft, an attribute that often masks problems such as weight loss. Adult chinchillas weigh from 400 to 600 g and have an average life span of 10 years, with a maximum up to 20 years. The average gestation period is 111 days, and average litter size is two, with a range of one to six. The dental formula is I1/1, C0/0, P1/1 and M3/3. All teeth are open-rooted. Incisor teeth grow 6.2 to 7.6 cm per year (Hoefer, 1994; Quesenberry et al, 2004).

Chinchillas are hindgut fermenters and have a long alimentary tract, measuring more than 3.5 m in adult animals. The proximal colon is sacculated and communicates with the large thin-coiled cecum. The longer distal colon is smooth (Williams, 1979). Chinchillas are also coprophagic. Chinchillas ingest more than 70% of their total food intake at night (Quesenberry et al, 2004).

Proper housing is a critical factor for a chinchilla's overall well being. The animal's native environment includes a relatively low temperature and humidity and a sloping, hard, rocky habitat that requires that chinchillas jump from one crevice to another. Chinchillas should therefore be housed in a large (minimum of 1,650 $cm^2$ floor area per animal), multilevel cage to accommodate normal, active behavior. If wire mesh flooring is used, the mesh size should be small enough to prevent leg entrapment. Some areas of solid flooring should be provided to minimize foot lesions. The optimal temperature range is 16 to 21°C (60 to 70°F). Temperatures as low as 0°C (32°F) can be tolerated if the animal has been acclimated. Temperatures greater than 27°C (80°F) can result in heatstroke, particularly in the presence of high humidity (Quesenberry et al, 2004).

Chinchillas are fastidious groomers and should be provided with a dust bath for a short time (30 to 60 minutes) each day. Keeping the dustpan dish in the cage continuously results in fecal contamination of the dish and subsequently of the coat, and can lead to conjunctivitis. Dust can be obtained commercially and consists of a mixture of 9:1 silver sand to Fuller's earth (Jenkins, 1992; Hoefer, 1994).

Because chinchillas are hindgut fermenters, they have complex digestive processes for fermenting dietary fiber. Any disruption of these processes can result in diarrhea, constipation, mucoid enteritis, bloat, intussusception and rectal prolapse. Inappropriate foods and sudden food changes are common causes of these problems. Inappropriate foods include those that contain high levels of simple carbohydrates and protein or not enough fiber. Such foods alter cecal fermentation processes with subsequent changes in pH, motility and flora, resulting in enteritis. Any change in the normally gram-positive GI flora can lead to overgrowth of bacteria such as *Escherichia coli* and *Clostridium, Proteus* and *Pseudomonas* spp. Therefore, antibiotics such as ampicillin, amoxicillin, penicillin, cephalosporins, clindamycin, lincomycin and erythromycin should be avoided (Ness, 2005). Other causes of enteritis include *Salmonella* spp., *Giardia lamblia, Cryptosporidium* spp., coccidia and nematodes (Williams, 1979; Jenkins, 1992; Hoefer, 1994; Donnelly, 2004b). Unfortunately, the exact cause of gastroenteritis frequently remains undetermined, thus subsequent treatment is symptomatic, including administration of fluids, dietary changes (adding fiber) and appropriate antibiotics.

Few integumentary disorders of chinchillas are directly associated with specific nutrients. Fatty acid deficiency leads to a poor coat, skin flaking and possibly cutaneous ulcers. Zinc deficiency can result in alopecia (Scott et al, 1995).

### *Feeding Plan*

#### FEEDING ADULTS

Specific nutrient requirements for chinchillas have not been well established. With the exception of being placentophagic, chinchillas are considered to be strict herbivores and subsist in the wild on shrubs and grasses. Controversy exists among various authors as to what type of feeding plan is most suitable for captive animals. All recommendations reflect a high overall dietary fiber requirement. Experts generally agree that good nutritional status can be achieved by feeding a combination of pellets and free-choice, good-quality grass or timothy hay. Commercially available chinchilla pellets are preferred to guinea pig and rabbit pellets because of formulation and size differences. Because chinchillas often use their forefeet to hold their food, the shape and size of the pellets affect ease of food handling and amount of wastage. Pellets should consist of 18 to 20% DM crude protein, 15 to 35% DM crude fiber and 4% DM fat.

Adult chinchillas eat an average of 21 g of food per day. Only one to two tbs of pellets should be fed per day, because overfeeding may cause enteritis. High-quality grass hay should be available free choice. Treats such as fresh fruits, vegetables and nuts can be offered occasionally but should be limited to not more than 1 tsp per day (Harkness, 1993b; Hoefer, 1994; Quesenberry et al, 2004). Fresh water in clean sipper bottles should always be available.

#### FEEDING NEONATES

Newborn chinchillas are precocious and weigh 30 to 50 g. They generally begin eating pelleted food at one week of age, and are completely weaned by six to eight weeks. Orphaned neonates can be hand-reared or fostered onto other chinchillas, and can survive independently after two to three weeks of age. Two reportedly successful hand-feeding formulas vary markedly. One is a mixture of one part unsweetened condensed milk and two parts water. The other is a mixture of one-half water, one-half evaporated milk, with glucose added to achieve a final concentration of 25% (Williams, 1979; Kraft, 1987). Milk replacers, however, may be a better alternative to condensed or evaporated milk.

## Hamsters

### *Husbandry*

Hamsters are rodents in the Cricetidae family. There are many species of hamsters. The most commonly seen are the golden or Syrian hamster (*Mesocricetus auratus*), the Chinese hamster (*Cricetulus griseus*) and the dwarf hamster (*Phodopus sungorus*). Hamsters were introduced into the United States in 1938 for research purposes.

Although hamster species vary markedly, male and female adults weigh 85 to 130 g and 95 to 150 g, respectively. Females tend to be larger and more aggressive than males. Life spans are relatively short and average from 18 to 24 months. The gestation period is 15 to 16 days. Litter size ranges from five to nine. Young are born without hair, with eyes and ears closed, but with erupted incisor teeth. The dental formula is I1/1, C0/0, P0/0 and M3/3. Incisor teeth grow throughout life; however, molar teeth are closed-rooted. Hamsters possess large cheek pouches that are used to transport and store food. When alarmed, hamsters will also temporarily store their young in these pouches. The stomach is divided into glandular and nonglandular portions. The nonglandular forestomach is lined with keratinized epithelium and is the site of pregastric fermentation (Van Hoosier and Ladiges, 1984; Battles, 1991). Like rabbits and many rodents, hamsters are coprophagic.

Hamsters are nocturnal animals. Although they are not true hibernators, hamsters enter a period of "pseudohibernation" from which they can be aroused, when exposed to shorter day lengths and temperatures below 4.4°C (40°F). In the wild, hamsters are solitary animals that live in burrows. Hamsters are very active at gnawing and escape by chewing through cages or by pushing open cage lids. Subsequent ingestion of inappropriate household items can lead to serious GI problems. Therefore, proper caging, as with other rodents, is critical to the overall well being of these animals.

Cages for adult hamsters should have a floor space of at least 125 $cm^2$ and a height of at least 15 cm. The traditional slotted metal food hoppers that are placed on top of the cage and frequently used for rats and mice are generally inappropriate for hamsters. The flat face of these pets makes it difficult for them to retrieve food items. If slotted metal food hoppers are used, the slots should be at least 7/16 in. wide. Clean water in a sipper bottle should always be available and the bottle should be placed low enough for the hamster to reach. The recommended environmental temperatures for hamsters are 18.3 to 21.1°C (65 to 70°F). Relative humidity should be between 30 and 70%

(Wagner and Farrar, 1987; Harkness, 1993c).

Acute enteric diseases are common problems among hamsters, especially weanlings. Underlying causes often remain unknown; however, stress, inadequate diet and improperly positioned feeders are often contributing factors. Processed feed should have a minimum of 8% crude fiber content to prevent diarrhea. An intracellular bacterium, *Lawsonia intracellularis*, is the causative agent of proliferative ileitis diarrhea or "wet tail;" however, *Escherichia coli*, *Clostridium* spp. or *Bacillus* spp. may also be involved. Rapid weight loss, dehydration and staining of the perineal region are present clinically. Other possible sequelae include intestinal blockage, prolapse and intussusception. Administration of inappropriate antibiotics (e.g., penicillin, ampicillin, lincomycin and bacitracin) can result in overgrowth of *Clostridium difficile* and a subsequent fatal enterocolitis (Harkness, 1993c).

The prognosis for hamsters presenting with signs of enteritis is generally guarded. Treatment involves supportive care such as administration of fluids subcutaneously or intraperitoneally, appropriate antibiotics (e.g., trimethoprim-sulfadiazine, chloramphenicol or enrofloxacin) and oral bismuth salicylate. Hamsters with enteritis should be hand-fed and placed in a warm environment.

Few reports document specific nutrient deficiencies in hamsters. Generalized alopecia and skin problems have been associated with low protein (<16%) and with deficiencies in pantothenic acid, riboflavin, pyridoxine, niacin, fatty acids and copper. Vitamin E deficiency can lead to muscular weakness, ocular secretions and death. Hamsters fed foods high in polyunsaturated fat are more susceptible to vitamin E deficiency and subsequent muscular dystrophy (Harkness, 1993c; Scott et al, 1995).

### *Feeding Plan*

Specific nutrient requirements for hamsters have not been well established. In the wild, hamsters are omnivorous, ingesting a variety of plants, seeds, fruits and meats. Pelleted rodent foods that provide 16 to 20% crude protein appear to provide good growth rates, whereas those containing 8 to 12% crude protein appear to be inadequate. Hamsters tend to ingest fruits, nuts, cereals and prepackaged "rodent treats" preferentially to the more nutritionally balanced rodent foods; therefore, these items should be provided in limited quantities. Adult food consumption averages 15 to 20 g/day (Harkness, 1993c).

Pregnant and lactating females have markedly increased food consumption. A one-week supply of food should be placed in the cage at about the Day 13 of gestation to minimize disturbances during parturition. Food should be placed on the cage floor rather than in a hopper to minimize the dam's distraction with food gathering, which may result in neglect of the young. This practice also allows easier access to food for pups as they approach weaning. Pups should also have easy access to the water bottle, and they should be observed closely to ensure that they can pull hard enough on the sipper tube to obtain water. Neonatal hamsters are altricial, and have birth weights from 2 to 3 g. Young begin gnawing on solid food at seven to 10 days of age and are weaned around 21 days. Weaning weights average 35 g. Attempts at hand raising or cross-fostering of orphaned hamster neonates onto other rodent species are generally unsuccessful (Wagner and Farrar, 1987).

## Gerbils

### *Husbandry*

Gerbils are rodents in the Cricetidae family. The Mongolian gerbil is the most common pet species. A frequent color pattern is agouti or brown; however, other color variations such as black, white and cinnamon also exist. Gerbils are social, burrowing animals native to the desert regions of central Asia. As pets, they are generally friendly and easily handled. Because of their water conservation mechanisms, they produce only a few drops of urine daily and are, therefore, virtually odor free. Adult gerbils weigh from 55 to 100 g and have a life span of three to four years. Gerbils generally form monogamous pairs, which is unique among rodents. Gestation length is 24 to 26 days, with a litter of size of four to seven. Neonates are altricial. Approximately half of the pet gerbil population exhibits spontaneous, convulsive seizures that are induced by strange environments or excitement. Fatalities are uncommon and anticonvulsant therapy has not been recommended (Harkness, 1993d, Harkness, 1995a; Donnelly, 2004c).

Gerbils can be housed as described for hamsters. They also actively gnaw so cages need to be escape-proof. Adult gerbils should be provided with a minimum floor space of 230 $cm^2$ with sides at least 15 cm high. Temperatures should be maintained between 18 to 29°C (65 to 85°F) and humidity levels between 30 and 50%. Gerbils do not tolerate high temperatures and their coat appears greasy under conditions of high humidity (Wagner and Farrar, 1987).

Diarrhea can result from food changes, contaminants or deprivation and protozoal or bacterial infections, such as salmonellosis. Treatment is symptomatic as described for hamsters, because the specific etiology frequently remains undetermined.

Specific nutrient deficiencies are uncommon in gerbils fed commercial dry rodent food. Animals maintained on high-fat diets such as excessive amounts of sunflower seeds develop lipemia and hypercholesteremia with excess fat deposits throughout the body. However, atherosclerosis does not appear to occur under these conditions, which has made gerbils important in cardiac disease research. Weanling animals are especially susceptible to malnutrition and dehydration as a result of poor accessibility to food and water (Wagner and Farrar, 1987).

### *Feeding Plan*

In the wild, gerbils feed on plants, seeds and insects. In captivity, they should be fed a commercial dry rodent food that is suitable for gerbils, offered free choice. Gerbils maintained on a standard rat or mouse diet for longer than six months may develop periodontal disease (Donnelly, 2004c). Gerbils will ingest seeds preferentially, which results in a diet high in fat and low in calcium. Gerbils generally eat about eight meals per day, with a total food consumption of 5 to 8 g/100 g of body weight. Because they eat frequent small meals, rapid weight loss occurs

if food quantities are limited. Clean water in easily accessible sipper bottles should always be available. Young gerbils generally begin eating solid food at 14 to 16 days of age and are weaned at 20 to 26 days. Dry rodent food can be softened with water for weanlings (Harkness, 1993d).

## Rats

### *Husbandry*

The common pet rat belongs in the Muridae family and originated in central Asia. Adult female and male rats weigh from 250 to 300 g and 450 to 520 g, respectively. The average life span ranges from 2.5 to 3.5 years. The gestation period is 21 to 23 days, and litter size ranges from six to 12. The rat's dental formula is I1/1, C0/0, P0/0 and M3/3. Incisor teeth erupt continuously, but molar teeth are permanently rooted. Rats have a divided stomach, a large cecum, no gallbladder and a GI transit time of 12 to 24 hours.

A variety of cages, usually constructed of plastic or metal, are available in pet stores. General guidelines for optimal caging were discussed previously. (See Rodents, Cage Requirements.) Cages should be made escape-proof because rats are adept at chewing through cages, lifting lids and opening small cage doors. Adult rats should be provided with a minimum of 250 $cm^2$ of floor space and a cage height of 18 cm. Ambient temperatures should be 18 to 27°C (65 to 80°F) with an optimum temperature of 22°C (72°F). Relative humidity should be maintained at 40 to 70% (Kohn and Barthold, 1984; Harkness, 1993e).

The formulations of complete rodent diets, including those for rats, have been published, and most animal diet manufacturers have access to computer programs for formulating diets (Knapka, 1999). So, although various nutrient deficiencies have been produced in experimental rats and are described in detail in the literature, they are uncommon in pet rats fed commercial dry rodent food. Protein deficiencies are probably most common and can result in anemia, cataracts, poor growth and impaired reproduction.

### *Feeding Plan*

Rats should be fed a commercial dry rodent food, offered free choice. They are primarily nocturnal feeders. Adult rats consume approximately 10 g of food/100 g of body weight. Treats should not exceed 10% of food intake. Dietary fiber content should be at least 5% to minimize problems with diarrhea. On a dry matter basis, crude protein requirements are approximately 10% for maintenance, and 20% for growth and reproduction. Young rats are weaned at 21 days of age at which time body weight ranges from 40 to 50 g (Harkness, 1993e; Harkness and Wagner, 1995a). Fresh water should be available free choice.

## Mice

### *Husbandry*

Mice belong in the Muridae family and originated in Asia. Average life span is 1.5 to 3 years and adult weight ranges from 20 to 40 g. Gestation lasts 19 to 21 days, with litter sizes ranging from 10 to 12. The dental formula is I1/1, C0/0, P0/0 and M3/3. Only the incisor teeth are open-rooted. GI transit time is eight to 14 hours (Jacoby and Fox, 1984; Harkness and Wagner, 1995a).

Cage requirements are similar to those described for rats. (See Rodents, Cage Requirements.) Floor space per adult mouse should be at least 97 $cm^2$, and 390 $cm^2$ for breeding females. Ambient temperatures should be maintained between 18 to 29°C (65 to 85°F), with an average of 22°C (72°F). Humidity should range from 30 to 70% (Harkness, 1993f).

### *Feeding Plan*

Mice should be fed a clean, fresh, commercial dry rodent food. Optimal nutrient requirements have not been established and probably vary markedly among various strains of mice. The literature suggests that foods containing 17 to 24% protein, 5% or less fat and 2.5% fiber result in adequate performance levels. Mineral requirements are unknown. Adult mice ingest 4 to 5 g of food daily. Young mice generally begin eating dry food at 10 days of age and are weaned at 21 days (Harkness, 1993f; Harkness and Wagner, 1995a). Clean, fresh water in sipper bottles should always be available.

## ENDNOTES

a. Lambert Key, Cranbury, NJ, USA.
b. Abbott Laboratories, Columbus, OH, USA.
c. Oxbow Pet Products, Murdock, NE, USA.
d. Dremel, Racine, WI, USA.

## REFERENCES

The references for **Chapter 70** can be found at www.markmorris.org.

## CASE 70-1

### Calciuria in a Rabbit

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### Patient Assessment

A six-year-old, neutered male mini-lop rabbit presented for a one-week history of decreased activity, reduced appetite and spending more time in the litter box. The rabbit was kept indoors, housed in a wire hutch with straw substrate and supervised outdoors one to two hours several times weekly.

On physical examination, the rabbit was overweight, resented abdominal palpation and had gritty material on its fur around the prepuce and on the ventral aspect of its tail. All other physical examination parameters were normal.

### Assess the Food and Feeding Method

The diet consisted of free-choice hay and rabbit pellets, one-half cup of leafy green vegetables daily and occasional fruit as a treat. Water was available in a sipper bottle at all times.

### Questions

1. What additional questions should be asked about the diet?
2. What is this rabbit's most likely clinical problem?
3. What diagnostic tests should be performed?
4. What are some treatment options?

### Answers and Discussion

1. The owner should be asked what type of hay and pellets are being offered to the rabbit. Also, it is important to ask how much the rabbit consumes (proportionately) of each food item offered. Additional information should include how often the water is changed. In this case, the owner was feeding alfalfa hay and alfalfa-based pellets. The rabbit seemed to prefer the pellets but also ate the hay. The water was changed two to three times weekly.
2. The most likely clinical problem based on the dietary history and physical examination is urolithiasis/calciuria. This problem in rabbits is linked to a high concentrate diet, obesity and lack of exercise. Rabbits, unlike most mammals, have a fractional urinary excretion of calcium between 45 to 60%. Increased dietary calcium leads to increased excretion of calcium through the urinary tract. Alfalfa is high in calcium and protein, which contributed to hypercalciuria and obesity in this rabbit. Alfalfa hay and pellets are acceptable for young, growing rabbits but are not recommended for most adult pet rabbits. Chronic, low-grade dehydration may also contribute to the problem. Rabbits have a high water intake (120 ml/kg/day) and need fresh clean water available at all times.
3. Radiographs, urinalyses and blood work (i.e., complete blood counts and serum biochemistry profiles) should be performed to confirm the diagnosis and to assess treatment options. If bacteria are identified, a urine sample collected by cystocentesis should be submitted for culture.
4. The type of treatment is based on the severity of the clinical problem. The presence of large cystic or urethral calculi will mandate either a cystotomy or perineal urethrostomy. If there are nonobstructive calculi or large amounts of dense calcium "sand" filling the bladder, urohydropropulsion or simply administering intravenous or subcutaneous fluid will help flush the bladder. Manual expression of the bladder may aid in the passage of the calcium precipitates. Changing the diet will help prevent recurrence. The diet for an adult pet rabbit should be based on grass hay and green vegetables with limited amounts of timothy hay-based pellets. Fresh water should be available free choice. Ample exercise is also important to prevent obesity.

## CASE 70-2

### Anorexia in a Guinea Pig

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#### Patient Assessment

A one-year-old female Peruvian guinea pig was examined for a two-week history of anorexia and decreased activity. The volume and consistency of the feces were normal. The owner had purchased the guinea pig at two months of age; no other pets were in the household. The animal was housed in a 30-gallon aquarium that contained a shredded paper substrate. The aquarium was located in a quiet area in the living room. The animal was handled daily. No recent changes in environment or husbandry had occurred, and there was no history of trauma.

Physical examination revealed a bright, alert, thin guinea pig with a dull coat. The incisor and cheek teeth and oral mucosa appeared normal. The animal was reluctant to move. Although the guinea pig's joints were not palpably swollen, the animal seemed uncomfortable when the elbow and hock joints were gently flexed and extended. Abdominal palpation was normal.

#### Assess the Food and Feeding Method

Commercial dry guinea pig food and fresh water in a sipper bottle were provided free choice.

#### Questions

1. What other questions should be included in the dietary history?
2. What is this patient's most likely nutritional problem?
3. What further diagnostic tests should be offered to the client?
4. What treatment should be recommended?

#### Answers and Discussion

1. The owner should be questioned about the source of the commercial dry guinea pig food, its length and manner of storage in the home and what other food items the guinea pig consumes. This question revealed that, for the sake of convenience, the owner purchased several bags of food at a local discount grocery store. This supply lasted for two to three months.
2. Hypovitaminosis C is the most likely nutritional problem, based on the history and clinical signs.
3. A complete blood count, serum biochemistry profile and whole body radiographs would reveal the extent of the disease and help disclose other underlying problems that might be present.
4. This patient's food should be supplemented with oral or injectable vitamin C. The client should be educated about proper nutrition and other aspects of husbandry at this time.

## CASE 70-3

### Dysphagia in a Chinchilla

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#### Patient Assessment

A five-year-old female chinchilla was examined for a three-month history of dysphagia, decreased appetite and an unkempt appearance. The owner adopted the chinchilla three years earlier and reported that the patient never had any medical problems. The chinchilla was housed indoors in a multi-tiered cage with predominantly wire flooring although areas with solid flooring were available. The patient was provided with a dust bath several times weekly. The chinchilla appeared interested in the normal pelleted food but seemed to not eat as vigorously as before. No changes had been made in the diet. The owner reported that fecal output seemed reduced.

On physical examination, the patient was bright and alert. However, its mandibular fur was moist, matted and discolored. Oral inspection revealed overgrown incisor teeth and the patient was palpably thin. No other abnormalities were detected.

## Assess the Food and Feeding Method

Commercial chinchilla pellets and fresh water in a sipper bottle were available free choice and approximately 1/2 cup of mixed leafy greens was provided once or twice weekly.

## Questions

1. What other questions should be asked about housing and diet?
2. What is the most likely cause of this chinchilla's clinical signs?
3. What nutritional deficit is likely to have caused this patient's clinical problems?
4. What diagnostic tests should be performed?
5. What treatment options should be considered?

## Answers and Discussion

1. The owner should be asked if hay and chew toys were provided. The owner revealed that hay was offered when the chinchilla was first adopted but the patient showed more interest in the pelleted food; therefore, hay was no longer provided regularly. No chew toys were available.
2. Dental malocclusion is the most likely problem based on clinical signs, dietary history and physical examination findings.
3. A lack of hay is the primary factor contributing to this patient's malocclusion. Mastication of hay or other chew items continuously wears cheek teeth; thus, without items to chew, growing teeth are not adequately worn and will become maloccluded.
4. Anesthesia should be administered and the patient's oral cavity examined. Although the incisor teeth are readily visualized in chinchillas without anesthesia, the narrow opening to the oral cavity and the caudal location of the premolars and molars (cheek teeth) preclude adequate visualization even with instruments such as an otoscope. The mucosal surfaces and tongue should be evaluated for abrasions. The occlusal surfaces of the teeth should be assessed. Skull radiographs should be obtained to better evaluate the teeth, including the roots, and to determine if there is evidence of osteomyelitis or apical abscesses. A complete blood count and serum biochemistry profile should also be performed as part of the clinical workup.
5. Overgrown incisor teeth can be trimmed using a high-speed dental hand-piece equipped with a cutting burr. Modifying the diet to include hay may be curative in uncomplicated cases. Malocclusions of the cheek teeth require leveling, and again, dietary changes may be curative in cases that are detected early and are the direct sequela of a poor diet. Advanced cases may require extractions and trimming of the remaining teeth at regular intervals.