Diversity among the more than 6,500 species of reptiles challenges a veterinarian’s ability to know the feeding management, estimate the nutritional requirements and recommend appropriate diets for every species presented in practice. With the exception of field studies on free-living reptiles, nutritional research is limited. Thus, recommendations are based on knowledge of natural diets, feeding histories, clinical experience and principles of comparative nutrition.

Identification of different species becomes easier with experience, but is often complicated because owners may know only a common name for their reptile. Common names can be colloquial, or assigned to more than one species. Therefore, misidentification of a patient may result in serious errors in nutritional recommendations. Reference texts help identify species and provide information about natural history and diet (Obst et al, 1988; Mattison, 1987; Zimmerman, 1986; Rossi, 1992; de Vosjoli, 1994, 1996; Boyer, 1996; Frye, 1991). This information can guide recommendations for habitat, including requirements for temperature, light, humidity, substrate, furnishings and social interaction. Failure to provide a suitable environment can lead to stress, causing negative effects on food intake and metabolic status of the patient.

For purposes of clinical nutrition, reptiles may be grouped into herbivores, omnivores and carnivores according to broad generalizations about their natural diet (Table 71-1). These distinctions serve as initial guides for making recommendations about diet and feeding management.

**PATIENT ASSESSMENT**

**Signalment**

Examination of the patient begins with the signalment. After the reptile presented has been properly identified by species, its age and gender should be estimated. Consider its stage of growth, reproductive status and degree of health, because these factors affect dietary recommendations. For example, certain species of aquatic turtles (e.g., the common sliders often kept as pets) change from eating a primarily carnivorous diet to eating a more herbivorous diet with maturity. Thus, feeding recommendations may differ for juvenile and adult reptiles.

Nutritional needs for reproductively active reptiles tend to be greater than for nonreproductive reptiles. This is especially true for females that need energy for development of ovarian follicles, oviductal eggs and embryos and require calcium for egg laying (often multiple clutches in a breeding season). However, some reptiles may become anorectic during phases of reproduction. For example, male snakes may refuse food during courtship and copulation or during times that seasonally correlate with these activities (e.g., ball pythons may not eat during the “dry season”). Likewise, females may not accept food while gravid. Therefore, for reproductively active reptiles, consider...
recommending heavier feeding during nonreproductive periods to compensate for subsequent nutritional demands.

The nutritional requirements for sick reptiles may also differ from those of healthy reptiles. The overall health status of the patient dictates the need for a change from a traditional diet. Typically, the clinician should recommend diets with greater digestibility and availability (Donoghue and Langenberg, 1996).

History

For reptiles, nutritional disorders are often caused by errors in husbandry; thus, history taking should include specific questions about management. First, a general history is obtained (Boyer, 1996; Divers, 1996). Pertinent information includes the patient’s origin (e.g., private breeder, importer, pet shop), whether the patient was born in captivity or caught in the wild, length of ownership, whether there are other reptiles in the home and the disease history for the patient and the entire reptile collection. The history should include specific questions about husbandry (Table 71-2).

A dietary history allows the veterinarian to assess the animal’s intake of energy and nutrients, and may provide information about the animal’s clinical condition and behavior. It also may help in the early detection of nutritional problems before they become serious clinical disorders. Dietary histories may be complex for some reptiles (e.g., iguanas and tortoises) that consume a mix of different foods, including salads and supplements.

One goal of a diet history is to obtain information about all available foods offered to the patient. Foods that may be intentionally offered include commercial foods, homemade salads, snacks, treats and supplements. Foods may also be available unintentionally, such as houseplants for iguanas and tortoises that free range in homes.

Attention should be given to the quality and wholesomeness (absence of potential pathogens) of the food, cleanliness of feeding utensils and the skills and reliability of those responsible for feeding. The veterinarian should also determine whether the reptile has appropriate access to water.

It is best to query those directly responsible for feeding the reptile and not to rely on second-hand information. For complicated feeding programs involving a wide variety of foods, it may be best to ask owners to complete seven- to 10-day diaries, listing all foods offered and estimates of amounts consumed. For both written and oral dietary histories, care must be taken to avoid influencing responses by owners.

When obtaining a dietary history, include specifics about: 1) diet—what is fed, how often and how much, how the food is prepared, where the food is placed in the habitat, when the food is removed and which foods the reptile actually consumes, 2) supplementation—are supplements used, what type, how are they

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**Table 71-1. Foods and fuel sources vary in reptiles, depending on the carnivorous, omnivorous or herbivorous nature of the species.**

<table>
<thead>
<tr>
<th>Common pets</th>
<th>Carnivores</th>
<th>Omnivores</th>
<th>Herbivores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snakes</td>
<td>Mealworms</td>
<td>Slugs</td>
<td>Greens</td>
</tr>
<tr>
<td>Aquatic turtles</td>
<td>Flies</td>
<td>Snails</td>
<td>Fruits</td>
</tr>
<tr>
<td>Most monitors, tegus</td>
<td>Crickets</td>
<td>Fruits</td>
<td>Vegetables</td>
</tr>
<tr>
<td>Most lizards</td>
<td>Mice</td>
<td>Greens</td>
<td>Clover</td>
</tr>
<tr>
<td>Leopard geckos</td>
<td>Fish</td>
<td>Vegetables</td>
<td>Dandelions</td>
</tr>
<tr>
<td>Chameleons</td>
<td>Rats</td>
<td>Greens</td>
<td>Grasses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Foods</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
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<td>30-60</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>15-40</td>
<td>5-40</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>15-35</td>
<td>15-75</td>
<td>55-75</td>
<td></td>
</tr>
</tbody>
</table>


---

**Table 71-2. Husbandry questions for reptile owners.**

**Housing**
- Description of cage substrate and furniture
- Frequency of and routine for cleaning
- Location (indoors, outdoors)
- Presence of cage mates
- Type and size of habitat

**Temperature**
- Measured temperature ranges within habitat (should be gradients of temperature)
- Positioning of heat in cage
- Safety precautions used to prevent thermal injury
- Type of heating (radiant, ventral sources)

**Light**
- Is the light filtered by glass or Plexiglas (these filter out ultraviolet light)
- Length of light cycle
- Positioning of light source
- Type of lighting provided (incandescent, fluorescent, natural sunlight)
offered, how often, does the animal eat the food when the supplement is offered and 3) water—how is water offered, frequency of water changes and has the owner observed the animal drinking.

For carnivorous reptiles, dietary histories should concern type, source and health of the prey offered and the frequency of feeding. Look for problems with over- or underfeeding, offering malnourished prey, feeding only or mostly invertebrate prey, failure to provide additional supplementation, etc.

For herbivorous reptiles, dietary histories should especially concern the sources of protein, calcium and fiber. Another concern is whether commercially prepared foods are being diluted by excessive amounts of fruits or vegetables. For those patients fed mixed salads, look for sources of protein (romaine lettuce, legumes), calcium (calcium carbonate), fiber (crumbled hay cubes or fresh grasses). For commercial foods, check labels for ingredients.

**Physical Examination**

Initially observe the undisturbed patient from a distance. Posture, respiratory rate and movement, activity level, agility, strength and symmetry should be noted and compared with the results of the hands-on examination.

The reptile may be evaluated physically after it is appropriately restrained. The physical examination should be consistent and follow a similar pattern with each patient. This process reduces the likelihood that something will be overlooked. A typical approach is to start at the head and work caudally.

Many signs of malnutrition may be evident during the examination and should be noted in the patient’s record. Examples include corneal and conjunctival abnormalities and respiratory disease, which may indicate hypovitaminosis A. Enophthalmos may suggest dehydration or inanition and cachexia. Abnormal color in the oral cavity may be due to anemia or icterus. (Note: This finding may be misleading in the bearded dragon, for example, which naturally has yellow oral mucous membranes.) Increased amounts of mucus in the mouth may indicate hypovitaminosis A. Dysecdysis (abnormal shedding) may suggest dehydration or hypovitaminosis A.

After a thorough physical examination, the reptile should be weighed. Patients may also be scored for body condition (fat:lean ratio, degree of emaciation or fat loss) and muscle wasting (cachexia, sarcopenia, protein depletion) (Chapter 1). Average weights and morphometrics have not been established for reptiles, but in-house ranges can be established at a practice.

A general guide for reptiles (and mammals) is that an acute loss of 10% or chronic loss of 20% of body weight indicates the need for nutritional intervention. Body weight, however, provides limited quantitative data about lean body mass. All weight loss, even in healthy reptiles, is accompanied by loss of lean and adipose tissue. Losses of body fat and tissue protein will be accelerated in ill reptiles and those recovering from surgery. Muscle wasting is typically characterized clinically by loss of muscle mass and body weight. Protein catabolism results in cumulative losses of skeletal muscle mass and eventually loss of function of enzyme systems. Tissue proteins usually continue to be depleted during initial recovery from illness and surgery. Weight gain immediately after illness or surgery typically represents water and fat replacement whereas tissue protein is restored later.

**Diagnostic Testing**

In addition to a thorough physical examination, diagnostic testing helps assess nutritional and overall health status. This is especially important because reptiles, like birds, attempt to hide their illnesses. Diagnostic tests such as hematology and serum biochemistry analyses may be helpful.

Reptile blood is fragile. It is best preserved with heparin and should be processed immediately (Frye, 1991a; Bolten et al, 1992). Reptiles tend to have lower normal hematocrit values than other companion animals. Blood samples should be processed in-house or sent to a commercial clinical laboratory that specializes in reptile blood analysis. This is important to obtain consistently accurate total white blood cell and differential counts. Experienced laboratory technicians can describe the morphology of the cells (i.e., toxic, degranulating, shrunk), which can be just as valuable as the white blood cell total and differential counts. Serial samples are helpful for assessing progression of disease and health status.

Kidney disease is common in reptiles; however, uric acid levels may be affected by the most recent meal eaten by the reptile and may not be a sensitive indicator of renal function. In many cases, elevated serum phosphorus and subsequent decreased serum calcium values (usually in an inverse ratio of phosphorus to calcium) may indicate renal disease much earlier than elevated uric acid concentrations.

Deficiencies of calcium and vitamin D are common in reptiles. Radiographs can be a valuable tool to evaluate quality and density of bones. Additionally, radiography and ultrasonography are useful in assessing fat reserves and evaluating reproductive status of females.

**Key Nutritional Factors**

Reptiles differ from mammalian and avian patients in the metabolism of energy and nitrogen. These differences affect water balance, intake of essential nutrients, prevalence of diet-related diseases and causes of mortality. This section discusses the key nutritional factors that affect reptiles as well as common diseases caused by nutrient excesses and deficiencies.

**Energy**

Reptiles are ectothermic and heterothermic. Their body temperature depends on ambient environmental temperatures, rather than on internal metabolism, and varies with fluctuating temperatures. This effect of ambient temperature on body temperature affects metabolic rate (hence caloric needs), activity (e.g., food procurement) and digestion. In most cases, reptiles maintain an appropriate core body temperature if provided with a sufficient temperature gradient within their habitat. However, temperatures that are too cold will limit food consumption and impair digestion. Temperatures that are too hot will lead to excessive stress, decreased food intake and weight loss.
Because energy is not used to maintain body temperature, reptiles require fewer calories than birds and mammals. Metabolic rates in reptiles relate to metabolic body size—the smaller the animal, the greater its metabolic rate per unit body weight. The metabolic rates of reptiles average about one-fourth those of mammals. Energy requirements increase with eating, activity, reproduction, growth, protein synthesis (i.e., wound healing) and certain disorders (Table 71-3). Daily energy intakes should be calculated by multiplying the metabolic rate by a factor (i.e., 1.1 to 2.5) that accounts for activity and other conditions that increase metabolic rate. Unlike birds and mammals, energy requirements for reptiles do not increase with cold ambient temperatures. Estimates of daily calorie intakes are generally derived from experimental studies using a limited number of species, field work on species not often seen in practice and on clinical experiences of knowledgeable herpetoculturists (Frye, 1991; Donoghue and Langenberg, 1996).

Table 71-3. Estimates of standard metabolic rate (MR) in kcal/day and fractional increases for feeding and activity for reptiles at 30°C (86°F).*

<table>
<thead>
<tr>
<th>Body weight (g)</th>
<th>MR 1.1</th>
<th>MR 1.25</th>
<th>MR 1.5</th>
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</tr>
<tr>
<td>25</td>
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<td>2.3</td>
<td>2.8</td>
<td>3.8</td>
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<td>813.0</td>
<td>976.0</td>
<td>1,302.0</td>
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</tbody>
</table>

likely to stay relatively high in these species.

For herbivores (e.g., tortoises, green iguanas, prehensile tail skinks [Corucia zebrata] and spiny tail lizards [Uromastyx spp.]), exogenous fuel sources are primarily carbohydrate (about 3.5 kcal/g [14.6 kJ/g]) and protein (about 3.5 kcal/g [14.6 kJ/g]). Dietary fat (providing about 8.5 kcal/g [35.6 kJ/g]) is usually less than 10% of dry matter (DM) (Table 71-1). Fermentation of fiber in the lower bowel of herbivores yields short-chain fatty acids that are also used for energy (perhaps providing about 2 kcal/g [8.4 kJ/g] of fiber).

**ENERGY DEFICIENCY AND EXCESS**

Low calorie intake leads to underweight and cachectic conditions. Ribs and vertebral processes are prominent or palpable in underweight snakes and lizards. Some exhibit longitudinal folds of skin along the lateral body wall. Thin turtles and tortoises lack heft. Poor body condition may be caused by: 1) improper husbandry, 2) stress, 3) improper temperature, 4) inappropriate diets or too little food and 5) underlying diseases that affect appetite and metabolism.

Excessive caloric intake leads to rapid growth in juveniles and overweight and obese conditions in adults. Especially at risk are those species with a sedentary nature, such as large snakes and lizards. Also at risk are reptiles kept in small habitats and fed high-fat diets, such as aquatic turtles maintained in small tanks. Treatment includes decreasing caloric intake and increasing activity. For example, an obese aquatic turtle that is fed commercial pellets daily can, instead, be fed pellets only three times per week and be offered greens on the other days of the week. Tank size should also be increased to encourage activity.

**Water**

All captive reptiles should have access to fresh water. Proper delivery of water is important. Turtles and snakes generally drink from bowls. Some lizards such as anoles, chameleons and day geckos lap up droplets sprayed or dripped onto foliage. Other lizards, such as iguanas and monitor lizards learn to drink from bowls and smaller reptiles from lids (e.g., plastic caps for pet food cans). Some reptiles may reject water held in plastic containers, presumably because of odor or taste. A switch to glass, ceramic or stainless steel bowls usually corrects the situation. Tortoises and some snakes soak in large, shallow bowls. Soaking enhances water uptake and stimulates excretion.

Desert animals require less water than temperate and tropical species. Some species receive enough water from food to meet requirements. Empirically, daily parenteral doses of water for rehydration are 10 to 25 ml/kg body weight (Frye, 1991a).

**WATER-RELATED PROBLEMS**

Water is critically important for reptiles and relates to many of the diseases seen in practice, such as gout and dysedcysis. Aquatic species are at least risk for dehydration, but water quality is critical for these animals. Routine water analyses may be important for maintaining health in aquatic reptiles (Donoghue and Langenberg, 1996). Water should be fresh for all species. Bacterial counts and culture can be included in routine water analyses. The method of providing water to reptiles will influence the humidity in the environment.

Clinical impressions suggest that inadequate humidity may contribute to dehydration, stress and dysedcysis. Likewise, excessive humidity may contribute to skin infections and hyperkeratinization.

**Nitrogen**

Lizards and snakes excrete mostly uric acid. Aquatic turtles tend to excrete more ammonia and urea than uric acid, whereas terrestrial tortoises excrete relatively more uric acid (Schmidt-Nielsen, 1990). Excretory patterns are clinically important because of difficulties in maintaining positive water balance and the prevalence of dehydration seen in reptiles.

Dehydration is common, especially in sick reptiles. It may result from water provided in improper form or anorexia, or may occur secondary to disease. Uricotelic species require large amounts of water to sustain normal excretion. Dehydration in these species may result in urinary stasis, hyperuricemia and gout, a disease characterized by deposition of urate crystals in soft tissues and joints. Prevention is based on maintaining adequate hydration. Reducing protein levels may restrict purines. Restriction of purines is feasible by avoiding high-purine foods such as liver (Table 71-4).

Many reptiles appear to have marked protein requirements. Those that are strict carnivores naturally consume diets consisting of 30 to 60% protein (metabolizable energy [ME] basis).
Herbivorous reptiles consume less protein, but optimal ranges remain to be defined. Feeding trials in green iguanas suggested that dietary protein levels of about 28% DM are needed for optimal growth (Donoghue, 1994, 1997).

### Other Nutrients

Intake of nutrients varies with feeding habits. For large carnivorous reptiles, vertebrate prey are assumed to be “complete and balanced” packages that contain all of the essential nutrients. However, neonatal prey (e.g., pinkie [newborn] mice) that are fed to smaller carnivores and omnivores, may lack sufficient calcium and fat-soluble vitamins (Douglas et al, 1994). In adult prey, calcium, phosphorus and magnesium are provided by bone, most trace minerals and vitamins by liver and kidneys, iodine by thyroid glands and zinc by the pancreas. The protein quality is high. Calories are provided almost entirely by fat and

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**Table 71-5. Caloric and nutrient content of vertebrate prey.**

<table>
<thead>
<tr>
<th>Food items (g)</th>
<th>Water (%)</th>
<th>Energy (kcal/g)* (As fed) (DM)</th>
<th>Protein (% kcal)</th>
<th>Fat (% kcal)</th>
<th>NFE (% kcal)</th>
<th>Calcium (mg/kcal)</th>
<th>Phosphorus (mg/kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic herring (100)</td>
<td>69</td>
<td>1.8</td>
<td>5.7</td>
<td>39</td>
<td>58</td>
<td>3</td>
<td>na</td>
</tr>
<tr>
<td>Atlantic smelt (100)</td>
<td>77</td>
<td>1.0</td>
<td>4.3</td>
<td>63</td>
<td>31</td>
<td>6</td>
<td>3.2</td>
</tr>
<tr>
<td>Chick, day old (40)</td>
<td>73</td>
<td>1.3</td>
<td>4.8</td>
<td>52</td>
<td>44</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>Mouse, adult (27)</td>
<td>65</td>
<td>1.7</td>
<td>4.8</td>
<td>48</td>
<td>47</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>Mouse, pup (1.5)</td>
<td>81</td>
<td>0.8</td>
<td>4.2</td>
<td>57</td>
<td>40</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td>Mouse, pup (4)</td>
<td>71</td>
<td>1.7</td>
<td>5.9</td>
<td>29</td>
<td>69</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Rat, adult (330)</td>
<td>66</td>
<td>1.6</td>
<td>4.7</td>
<td>55</td>
<td>43</td>
<td>2</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Key: NFE = nitrogen-free extract (digestible carbohydrate), DM = dry matter, na = not available.

*To convert to kJ, multiply kcal by 4.184.

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**Table 71-6. Representative energy and nutrient content of invertebrate prey.**

<table>
<thead>
<tr>
<th>Food items (g)</th>
<th>Water (%)</th>
<th>Energy (kcal/g)* (As fed) (DM)</th>
<th>Protein (% kcal)</th>
<th>Fat (% kcal)</th>
<th>NFE (% kcal)</th>
<th>Calcium (mg/kcal)</th>
<th>Phosphorus (mg/kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acheta domestica (commercial cricket)</td>
<td>62</td>
<td>1.9</td>
<td>4.8</td>
<td>50</td>
<td>44</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Galleria mellonella (wax worm larvae)</td>
<td>63</td>
<td>2.1</td>
<td>5.7</td>
<td>27</td>
<td>73</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Gryllus domesticus (house cricket)</td>
<td>68</td>
<td>1.0</td>
<td>3.1</td>
<td>40</td>
<td>54</td>
<td>6</td>
<td>0.3</td>
</tr>
<tr>
<td>Lumbricus terrestris (earthworm)</td>
<td>84</td>
<td>0.5</td>
<td>3.1</td>
<td>73</td>
<td>13</td>
<td>14</td>
<td>Variable</td>
</tr>
<tr>
<td>Musca domestica (fly larvae)</td>
<td>70</td>
<td>1.5</td>
<td>4.9</td>
<td>48</td>
<td>44</td>
<td>8</td>
<td>0.1</td>
</tr>
<tr>
<td>Tenebrio molitor (mealworm larvae)</td>
<td>58</td>
<td>2.1</td>
<td>5.0</td>
<td>37</td>
<td>60</td>
<td>3</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Key: NFE = nitrogen-free extract (digestible carbohydrate), DM = dry matter, na = not available.

*To convert to kJ, multiply kcal by 4.184.

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**Table 71-7. Caloric and nutrient content of produce on a percent dry matter basis.**

<table>
<thead>
<tr>
<th>Food items</th>
<th>Weight (g)</th>
<th>Water (%)</th>
<th>Energy (kcal/g)* (As fed) (DM)</th>
<th>Protein</th>
<th>Fat</th>
<th>NFE</th>
<th>Fiber</th>
<th>Calcium</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romaine lettuce</td>
<td>100</td>
<td>94</td>
<td>0.18</td>
<td>3.0</td>
<td>36</td>
<td>7</td>
<td>50</td>
<td>11</td>
<td>1.1</td>
</tr>
<tr>
<td>Spinach (raw)</td>
<td>100</td>
<td>91</td>
<td>0.26</td>
<td>2.9</td>
<td>36</td>
<td>3</td>
<td>48</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>Dandelion greens (raw)</td>
<td>100</td>
<td>86</td>
<td>0.44</td>
<td>3.1</td>
<td>18</td>
<td>5</td>
<td>61</td>
<td>11</td>
<td>1.2</td>
</tr>
<tr>
<td>Alfalfa sprouts (raw)</td>
<td>100</td>
<td>88</td>
<td>0.39</td>
<td>3.2</td>
<td>37</td>
<td>4</td>
<td>39</td>
<td>12</td>
<td>0.3</td>
</tr>
<tr>
<td>Bamboo shoots (canned, 1 cup)</td>
<td>133</td>
<td>94</td>
<td>0.18</td>
<td>3.0</td>
<td>28</td>
<td>1</td>
<td>51</td>
<td>13</td>
<td>0.2</td>
</tr>
<tr>
<td>Vegetables (mixed, frozen, 2/3 cup)</td>
<td>100</td>
<td>83</td>
<td>0.47</td>
<td>2.8</td>
<td>16</td>
<td>2</td>
<td>68</td>
<td>7</td>
<td>0.1</td>
</tr>
<tr>
<td>Mushrooms (raw, 10 small)</td>
<td>100</td>
<td>90</td>
<td>0.27</td>
<td>2.7</td>
<td>30</td>
<td>6</td>
<td>49</td>
<td>9</td>
<td>0.1</td>
</tr>
<tr>
<td>Sweet potato (1 large)</td>
<td>180</td>
<td>64</td>
<td>0.82</td>
<td>2.8</td>
<td>5</td>
<td>1</td>
<td>84</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>Apple (no skin, 1 medium)</td>
<td>128</td>
<td>84</td>
<td>0.51</td>
<td>3.2</td>
<td>1</td>
<td>2</td>
<td>86</td>
<td>4</td>
<td>tr</td>
</tr>
<tr>
<td>Banana (1 medium)</td>
<td>114</td>
<td>74</td>
<td>0.82</td>
<td>3.2</td>
<td>4</td>
<td>2</td>
<td>86</td>
<td>2</td>
<td>tr</td>
</tr>
<tr>
<td>Cantaloupe (1 cup)</td>
<td>160</td>
<td>90</td>
<td>0.32</td>
<td>3.2</td>
<td>8</td>
<td>2</td>
<td>79</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Strawberries (1 cup)</td>
<td>149</td>
<td>92</td>
<td>0.28</td>
<td>3.5</td>
<td>6</td>
<td>4</td>
<td>77</td>
<td>6</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Key: NFE = nitrogen-free extract (digestible carbohydrate), DM = dry matter, tr = trace.

*To convert to kJ, multiply kcal by 4.184.
protein, and carbohydrate sources are limited to the intestinal content of the prey (Table 71-5).

Invertebrate prey also contain much fat and protein but lack a calcium-rich skeleton (Table 71-6). The chitinous (amino-cellulose) exoskeleton of most invertebrates contains nonprotein nitrogen. The digestibility of this chitin is questionable (Donoghue and Langenberg, 1996).

Invertebrates are routinely “dusted” with powdery vitamin-mineral supplements to supply calcium and other nutrients lacking in the diet. Dusting can be problematic; it may induce nutrient toxicities if excessive and create deficiencies if too little is provided. Additionally, some reptiles will refuse foods that have been dusted because calcium salts and many vitamins are unpalatable.

Domestic fruits and vegetables available from grocery stores are lower in nutritional value (especially protein and fiber) than fruits and plants consumed in the wild. Among domestic produce, higher protein levels are found in greens (e.g., romaine lettuce, collard greens and spinach), alfalfa and mung-bean sprouts, mushrooms and bamboo shoots. Domestic produce rarely provides enough protein, calcium and fiber, or adequate levels of trace minerals and vitamins to support growth and reproduction in reptiles; therefore, produce needs supplementation (Table 71-7) (Donoghue and Langenberg, 1996).

Herbivorous reptiles consume fruits readily, probably because of the bright colors, sweet taste and moist texture. However, fruits contain mostly water, fructose and small amounts of fiber. Even small amounts of fruit can markedly dilute the calories, nutrients and fiber provided by greens.

**Nutrient Deficiencies and Excesses**

With the exception of those species consuming whole prey, many reptiles suffer from deficiencies and excesses of nutrients. Common among many species are deficiencies of calcium and vitamin D3.

Vitamin D3 is problematic. Limited research data, anecdotal evidence and clinical impressions suggest that, at least in some species, dermal synthesis of 1,25-dihydroxycholecalciferol may be more efficient than gastrointestinal absorption of dietary vitamin D3. Thus, exposure to natural sunlight or ultraviolet (full spectrum) lighting may be critical for adequate vitamin D3 synthesis in some reptile species. Interactions between vitamin D, calcium and phosphorus, and secondary interactions with vitamin A and several trace minerals, complicate nutritional requirements. For now, general recommendations include consistent but not excessive supplementation of diets (except when feeding whole vertebrate prey) with both calcium and vitamin D3, exposure to full-spectrum lights and, whenever possible, exposure to direct sunlight.

Diet-related nutritional deficiencies in carnivores include calcium deficiency from feeding primarily unsupplemented invertebrates or muscle meat, vitamin A deficiency from feeding primarily iceberg lettuce and muscle meat and thiamin (vitamin B1) and tocopherol (vitamin E) deficiency from feeding fish containing thiaminases and high levels of polyunsaturated fatty acids.

Common problems in herbivores include multiple deficiencies, especially calcium deficiency, from feeding unsupplemented produce and protein deficiency from feeding diets containing large amounts of fruit.

Over-supplementation may potentially lead to toxic intakes of vitamins A and D, phosphorus, selenium, iodine and other trace minerals. Some nutrient interactions may occur in reptiles. For example, excess dietary calcium may interfere with the absorption of zinc and copper and affect the thyroidal uptake of iodine.

**METABOLIC BONE DISEASE**

Metabolic bone disease is probably the most common nutritionally related disease seen in lizards, especially green iguanas. This disease is caused by a dietary deficiency of calcium, excess of dietary phosphorus, deficiency of vitamin D3 or a combination of these factors. Clinical signs include soft mandibular and maxillary bones, deformed or fractured bones, muscle tremors, poor growth, spinal deviations and paralysis (Frye, 1991a). The disease is most commonly seen in young, growing lizards and adults maintained indoors. Metabolic bone disease is also common in chelonians (tortoises and turtles). Clinical signs include a soft carapace and plastron, improper shell growth and fractured limbs (Frye, 1991a). Treatment includes dietary correction and provision of natural sunlight or full-spectrum ultraviolet light. For severe cases, parenteral injections of calcium, vitamin D3 and calcitonin may be necessary (Boyce, 1996; Donoghue and Langenberg, 1996; Rossi, 1992; Mader, 1993; Barten, 1995).

**HYPOVITAMINOSIS A**

Deficiency of vitamin A occurs in lizards fed unsupplemented produce and insects. It is characterized by squamous metaplasia, which causes shedding problems, stomatitis, palpebral edema, conjunctivitis and respiratory disease (Frye, 1991a). Secondary bacterial infections are also common. Treatment includes vitamin A supplementation, parenterally and orally, and dietary correction.

Hypovitaminosis A is likely the most common nutritional disease of chelonia. These animals are typically fed unsupplemented iceberg lettuce, hamburger or other foods deficient in vitamin A. Squamous metaplasia results in palpebral edema and respiratory disease. Common clinical findings include conjunctivitis, nasal discharge, wheezing and stridor (Frye, 1991a). Additionally, respiratory disease may cause water turtles to swim in a lopsided fashion due to fluid buildup in one lung. Secondary bacterial infections are common. Poor skin and shell quality may also be noted.

Treatment of hypovitaminosis A includes dietary correction and oral administration of vitamin A (200 to 300 IU/kg body weight). Secondary bacterial infections are treated with an appropriate antibiotic. Dietary vitamin A should be increased (2,000 to 10,000 IU/kg diet DM).

**FAT-SOLUBLE VITAMIN TOXICITIES**

Over-supplementation with fat-soluble vitamins may result in renal disease, hepatic disease and metastatic calcification.
The exact requirements of vitamins A and D₃ are currently unknown, but excessive amounts may cause problems in lizards. Clinical signs are consistent with multiple organ failure. The most common example is seen in green iguanas maintained on dog and/or cat food. Renal failure and metastatic calcification of major vessels typically occur. Treatment in most cases involves attempts to reverse organ damage through supportive care, especially fluid therapy. Additionally, calcitonin⁴ may be used (2 IU/kg body weight, given intramuscularly q24h) to help reverse metastatic calcification (Frye, 1991; Barten, 1995).

Tortoises and box turtles are very sensitive to injections of vitamin A. When given parenterally, these drugs may cause sloughing of the skin, resulting in severe skin ulceration (Frye, 1991, 1991a). These preparations are best given orally. Treatment for vitamin toxicity in most cases is supportive care and removal of the vitamin source.

Although commercially prepared foods may occasionally be involved, the excessive use of vitamin supplements is more commonly the cause of vitamin toxicities.

**THIAMIN DEFICIENCY**

Thiamin deficiency is seen occasionally in garter snakes and water snakes fed exclusively frozen fish. Thiaminases, found in many species of fish, deplete available thiamin. Thiamin-deficient snakes typically present with neurologic disease characterized by ataxia, seizures, twisting and rolling. Treatment involves changing the diet to include fresh fish, insects and mice scented with fish, and medicating with oral or parenteral thiamin hydrochloride (25 mg/kg body weight, per os or intramuscularly) (Frye, 1991).

**FEEDING PLAN**

The advantages and disadvantages of feeding reptiles commercially prepared foods and homemade diets were discussed above. If an individual reptile is healthy and exhibits no signs of deficiency disease, the owner probably is feeding the reptile appropriately and there is no need to change the food.

Although some prepared foods have been available for only a limited time, the overall nutritional quality of commercially prepared foods is rapidly improving as manufacturers consider new scientific information when they prepare their formulations. As commercially prepared foods become more widely used, many of the diet-induced diseases currently observed by veterinarians will become of historical interest only, just as they have for other companion pets.

**Assess and Select the Food**

Foods appropriately balanced with carbohydrates, proteins, fats, vitamins, minerals and water are essential for all reptiles. Care of captive reptiles must address good nutrition at several levels; the daily satisfaction and health of the reptile as well as the long-term contributions to growth, maturation, defense against disease and reproductive health—the hallmark of good nutrition.

Three methods of providing nutrients and achieving these objectives are commonly used: 1) commercially prepared foods, 2) homemade mixed foods or 3) a combination of commercial and homemade foods, with or without supplements.

**Commercially Prepared Foods**

Reptiles may be fed commercially prepared foods formulated for the species or the most similar domestic animal. There is little scientific literature about the nutrient requirements of reptiles. However, several reports provide some insight into the levels of dietary nutrients required to result in a nutritionally adequate diet (Allen et al, 1989). These reports make it possible to formulate prepared foods with a high probability of nutritional adequacy for some reptilian species.

Testing protocols for nutritional adequacy have not yet been established for reptile foods, as they have been for commercially prepared canine and feline foods. As commercially prepared reptile foods become more widely used, testing protocols for nutritional adequacy will be established and required.

Commercially prepared foods offer many benefits, including nutrient balance and convenience. A moist, extruded or pelleted food will supply all the nutrients in one particle or form. Thus, the probability of producing a nutritional imbalance by feeding a commercially prepared food is much less than when reptiles are fed individual human foods prepared by uninformed owners.

If commercially prepared food is offered, examine the label for nutrient information or guarantees. The primary nutrients of concern depend on whether the reptile is carnivorous, omnivorous or herbivorous. Protein, fat, digestible (soluble) carbohydrate, fiber, vitamin and mineral levels should be appropriate for the individual reptile. Label space does not allow for detailed nutrient information. Therefore, the manufacturer should be contacted for additional nutritional information. When purchasing or recommending commercial herbivore foods, read labels with extreme care. Some may contain low levels of antibiotics and other growth promotants that have unpredictable and potentially deleterious effects on reptiles. Regardless of the type of food fed, a sample can be submitted to a commercial laboratory for analysis. Consult the laboratory in advance to determine the sample size needed, preservation techniques recommended and shipping instructions.

Compare the nutrient levels of the commercial food to those recommended in this chapter to determine if there are any discrepancies in the nutrient profile. If the food does not meet recommended nutrient levels, the owner should change or supplement the diet. The food should not be fed if its label contains no nutrient information and the manufacturer does not provide nutrient levels in other promotional literature or is unavailable to answer questions by phone.

Commercial forages for herbivorous reptiles include legumes, primarily alfalfa, which can be pelleted, cubed and chopped. Unfortunately, most tortoises and herbivorous lizards show limited interest in alfalfa-based meals, eating these items only when disguised with fresh produce or when no other foods are available.

Hay can be purchased from feed stores and farms. Chopped
and cubed hay is sold in pet shops and feed stores. Care should be taken to avoid prolonged storage of these products because about half the vitamin A activity from β-carotene is lost from hay within a year of cutting.

Hay-based pellets range from 12 to 28% DM crude protein and 14 to 19% DM crude fiber. Some success has been noted in the use of hay-based pellets as bedding for juvenile herbivorous reptiles. Although these products are safe if wholesome, pellets can mold quickly and the reptile may then be at risk to develop respiratory disease and digestive upset.

Some commercially prepared foods marketed specifically for iguanas are variable in content. Look for products with at least 18% DM crude protein. Pellets may be soaked in water or fruit juice before feeding. Wet pellets may mold, so they should be offered fresh daily.

Some commercially prepared foods marketed specifically for aquatic species are sold as complete diets and are made from fish and crustacean meals, plant-based ingredients and various additives. Some manufacturers fail to add essential vitamins and minerals. Processes used in extrusion and pelleting involve high temperatures that partially destroy labile vitamins. Mineral and vitamin content of fish meals vary with the species, season of harvest and processing. Examine labels and products carefully. Some foods may not be adequate to sustain growth or even maintenance of carnivorous reptiles. However, the alternative homemade diet is often less desirable.

Protein in dog and cat foods ranges from 16 to 40% of ME; many pet foods provide more than 22% of ME from protein and more than 25% of ME from fat. These protein levels are likely to be adequate for carnivorous reptiles.

Herbivores generally suffer digestive upset when dietary fat exceeds about 12%. Herbivorous reptiles are unlikely to thrive on diets containing more than 12% fat, which limits the use of commercial pet foods to the “light” varieties. Light varieties often contain higher levels of fiber, which is favorable for herbivores.

**Homemade Diets**

A wide variety of homemade diets have been suggested for reptiles. Although homemade diets may provide adequate nourishment, most reptile owners are unwilling to devote the time necessary to properly prepare these diets. Additionally, owners must be willing to regularly observe which food components are being consumed to prevent reptiles from developing or reverting to preferential selection of specific ingredients. Considering these factors, well-formulated commercially prepared foods are a better alternative for most captive reptiles.

**Supplements**

Supplements are marketed as containing primarily vitamins and minerals in various amounts. Few if any supply all vitamins and minerals known to be essential for domestic species including reptiles. The tendency is to leave out those that are unpalatable or expensive. Until more work is done about reptile nutrition, no one product should be relied upon to supply all essential nutrients to captive reptiles. Better value may be achieved by using a broad-spectrum micronutrient product designed for people or domestic animals. These products may be used for reptiles, but care must be taken to provide vitamin D3 (not vitamin D2) and to avoid overdosage (Donoghue and Langenberg, 1996). A general mammalian guideline that may also be useful in assessing reptile supplements is vitamins A:D:E should be present in a ratio approximating 100:10:1. A review of the nutrient content of many of the commonly used supplements for reptiles has been published (Donoghue and Langenberg, 1996). If a commercially prepared food constitutes more than 50% of total dietary intake, supplements are contraindicated.

Although calcium is often included in commercial vitamin-mineral supplements, it is rarely present in quantities sufficient to meet requirements for reptiles fed mixed salads or invertebrates. Additional calcium may be provided as limestone (38% calcium), or as calcium salts-carbonate (40% calcium), lactate (18% calcium) and gluconate (9% calcium). Calcium and phosphorus are supplied in bone meal (24% calcium, 12% phosphorus) and dicalcium phosphate (18 to 24% calcium, 18% phosphorus). Bone meal tablets vary in size. A small (aspirin size) tablet weighs 0.75 g and provides about 180 mg calcium and 90 mg phosphorus. Products vary, so read labels carefully. Powdered calcium supplements can be dusted on salads and tablet forms can be crushed and mixed with food.

**Assess and Select the Feeding Method**

It may not always be necessary to change the feeding method when managing reptile patients; however, a veterinarian should verify that an appropriate feeding method is being used. Items to consider include feeding route, amount fed, how the food is offered and who feeds the reptile. All of this information should be gathered when the nutritional history is obtained. If the reptile has normal body condition and weight, the amount of food previously fed (on an energy basis) was probably appropriate.

**Lizards**

Lizard species (Sauria) may be herbivorous, omnivorous or carnivorous. Lizards that are carnivorous may consume either invertebrate or vertebrate prey, or both. Gastrointestinal morphology reflects feeding behavior. Thus, herbivorous lizards have hindguts adapted for fermentation of dietary fiber, and carnivorous lizards have relatively short and simple intestinal tracts suited for hydrolysis in the small intestine.

**Herbivores**

The green iguana (Iguana iguana) is the most common herbivorous lizard seen in veterinary practice. These large, arboreal, diurnal lizards originate from Central and South America and require tropical temperatures (approximately 32°C [90°F]) and humidity (approximately 90% relative humidity). With proper care, green iguanas may live 10 to 15 years in captivity. However, mistakes in husbandry and diet often lead to an early demise.

Other herbivorous lizards occasionally seen in practice include prehensile tail skinks (Corucia spp.) and chuckwallas (Sauromalus spp.). Others, such as spiny tailed lizards (Uromastyx spp.) and rock iguanas (Cyclura spp.), use hindgut fer-
mentation and are often classified as herbivores, but also are known to consume invertebrate prey.

Diets for herbivorous lizards should include leafy greens such as romaine lettuce and collard greens, mustard greens and endive, dandelion and clover. Vegetables such as green beans, okra, carrots, yellow squash, zucchini and commercial thawed frozen mixed vegetables can make up a small fraction, perhaps 10 to 20%, of the diet.

Spinach, cabbage, peas, potatoes and beet greens contain oxalates that bind calcium and trace minerals, inhibiting their absorption. Trace mineral deficiencies may result if the diet is composed primarily of these foods and mineral intakes are marginal. Goitrogens are found in cabbage, kale, mustard and other cruciferous plants. Large intakes of these foods with marginal iodine intake may lead to hypothyroidism. Small amounts of these oxalate-containing and goitrogenic vegetables may still be fed safely as part of the diet.

Fruits can be used as “treats” or as a very small portion of the diet. Palatable choices include papaya, mango, cantaloupe, grapes and oranges.

Commercially prepared foods may constitute a significant portion of the diet (i.e., up to 50 to 60%). Treats and other nutritionally imbalanced foods should constitute no more than 10% of the diet.

If commercially prepared foods are used for 50% or more of the diet, additional supplementation is usually unnecessary. Homemade diets of vegetables and fruits should be supplemented. Several recipes have been published (Frye, 1991; Donoghue and Langerberg, 1996). Juveniles should be fed bite-sized foods, once or twice daily. Adults should be fed daily or every other day. These diurnal lizards should be offered food at a time that correlates with their need to bask and thermoregulate to allow efficient digestion of food.

Omnivores

Some of the most common omnivorous lizards presented to veterinary practitioners include bearded dragons (Pogona spp.), blue-tongued skinks (Tiliqua spp.), water dragons (Physignathus spp.) and plated lizards (Gerrhosaurus spp.). In captivity, these omnivores consume prey (often invertebrates) or a meat-based, commercially prepared food mixed with fruits and vegetables.

A commercially prepared food should make up 60 to 75% of the total diet. The remaining portion may include invertebrates such as crickets, mealworms, wax worms, sweepings (insects found by gently sweeping grasses with a net; counsel clients to make sure no pesticides have been used on the grass), earthworms, snails and slugs (especially for skinks). Other prey includes small vertebrates, such as newborn and fuzzy mice, chicks and adult mice and rats. Cooked eggs may also be included as a protein source. Dog food (moist and dry), primate biscuits and trout food can be fed. Cat food is appropriate (up to 50 to 60% of the diet) for blue-tongued and pink-tongued skinks; however, these foods should be fed cautiously to other omnivorous lizards to prevent risks from over-feeding a high-fat diet.

Fresh greens and produce may make up the rest of the diet. Palatable foods include leafy vegetables, squash, carrots, green beans, alfalfa sprouts and thawed frozen mixed vegetables. Fruits should include melon, papaya and oranges.

Nutritionally adequate, commercially prepared foods are available for omnivorous lizards. However, because no long-term feeding trials have been reported, performance of lizards should be monitored to ensure that they are thriving.

In general, the more varied the overall diet, the less supplementation is necessary. If 50% or more of the diet includes dog food, monkey biscuits, cat food or complete omnivore foods, no supplementation is necessary. Otherwise, supplementation of produce and dusting of invertebrates are recommended.

Carnivores

The most common carnivorous lizards kept in captivity are monitors (Varanus spp.), tegus (Tupinambis spp.) and Gila monsters and beaded lizards (Heloderma spp.). These animals eat whole prey items (vertebrate [Figure 71-1] and invertebrate), but some also will eat cooked meat and eggs and commercial pet food. Feeding cooked meat and eggs is recommended to avoid exposure to potential pathogenic bacteria such as Salmonella spp.

Commercially prepared foods are available for monitors and tegus. As with any dietary regimen, reptiles should be monitored for any dietary-related disease. Supplementation is rarely necessary for adult carnivorous lizards if they are eating whole vertebrate prey items or commercially prepared food or a variety of foods. A calcium and vitamin D₃ supplement can be used twice weekly for juveniles fed a diet of newborn mice and insects.

Insectivorous lizards kept in captivity include species of geckos (Gekkonidae and Eublepharidae), old-world chameleons (Chamaeleo spp.), water dragons (Physignathus spp.), anoles

Figure 71-1. Monitor lizards are carnivorous. This large monitor (Varanus giganteus) awaits a large pre-killed rat to be dropped into its enclosure.
Snakes: Serpentes
Snakes that Eat Mammalian and Avian Prey

Most of the snakes seen by private practitioners feed on mammals. Boids (pythons and boas), rat and corn snakes (Elaphe spp.) and gopher, bull and pine snakes (Pituophis spp.) are some of the more common snakes presented to veterinarians. Their diet consists of rats, mice, gerbils, rabbits and young chicks. These prey items should be fed a high-quality, complete ration to provide adequate nutrition for snakes.

Trauma associated with feeding live prey is common. Therefore, training snakes to eat stunned, dead or frozen-thawed prey is preferred. These reptiles are attracted to prey by the smell, the heat radiating from the prey item and by movement. To help encourage snakes to eat dead food, the prey item should be warm when offered. It can also be wiggled with a long pair of forceps. Eventually, even stubborn snakes become accustomed to eating dead prey.

Frozen rodents should be thawed rapidly in very hot water to minimize bacterial intestinal bloom. Caution should be used when feeding chicks or other birds to snakes because of potential exposure to salmonella. Boiling chicks before feeding may reduce the risk.

Some snakes are finicky feeders. For example, ball pythons prefer gerbils (which are found in their native habitat) or brown or black rodents, rather than white laboratory rodents.

Supplementation is unnecessary when feeding whole vertebrate prey. The only exception is with long-term feeding of newborn mice, which may be deficient in calcium. Allowing newborn mice to obtain milk from the mother for a day or two improves their calcium content. Also, dipping newborn mice in liquid calcium supplement increases dietary calcium content. Feeding frozen mice also improves calcium content. Obese rodents and those that have been frozen for more than six months may have reduced vitamin content.

Snakes that are housed together should be separated for feeding to minimize injuries to each other and to help identify which snake has eaten. If two or more snakes attack the same prey, one snake may inadvertently eat or injure the other.

Feeding frequency varies, depending on the species of snake. Generally, young growing snakes should be fed every five to seven days. Mature, adult snakes may be fed weekly, biweekly or even monthly.

Snakes that Eat Reptiles, Amphibians and Fish

Some snakes feed on ectotherms, including amphibians, fish, crayfish and other reptiles. Snakes that eat these prey items include king snakes (Lampropeltis spp.), indigo snakes (Drymarchon spp.), water snakes (Nerodia spp.), hog-nosed snakes (Heterodon spp.), ring-necked snakes (Diadophis spp.) and garter snakes (Thamnophis spp.). The prey should be frozen for

(Anolis spp.), small skinks (Scincidae), monitors (Varanus spp.), girdle-tailed lizards (Cordylus and Pseudocordylus spp.), lacertas (Lacertidae), basilisks (Basiliscus spp.), collared lizards (Crotaphytus spp.), sailfin dragons (Hydroaurus spp.), ameivas (Ameiva spp.) and swifts (Sceloporus spp.). These species thrive on a wide variety of well-fed and well-supplemented insects such as crickets, mealworms, wax-moth larvae, king mealworms, cockroaches and fruit flies (for juveniles). Other insects, when available, include butterworms, grasshoppers, earthworms, flies, fly larvae and sweepings.

Insects can be fed a relatively balanced diet to “gut load” them before they are fed to lizards. A variety of whole diets can be used to feed insects including psittacine pellets, tropical fish flakes and commercial invertebrate “gut loading” foods. Also, insects can be fed vegetables that have a high precursor vitamin A content such as collard greens, kale, romaine and red-leaf lettuce, grated carrots and sweet potatoes (Stahl, 1997). Invertebrates should be dusted with a calcium supplement and a multivitamin supplement before they are fed to the reptile. (See Supplements.) Calcium supplement can be used daily for young growing reptiles and three to four times weekly for adults. Multivitamin supplements (which should contain some preformed vitamin A) should be used less frequently (i.e., once or twice weekly) (Stahl, 1997).

Prey should be of the appropriate size for the lizard. A general guide is for prey length to be less than the width of the lizard’s head. Insects that are too large may bite the lizard or, if swallowed, cause it to regurgitate. Generally, only enough prey to be consumed at one feeding should be offered. Excess numbers of insects may cause stress or injury to the lizard.

Juveniles should be fed daily. Adults can be fed every second or third day.

Occasionally, larger and adult species of insectivorous lizards can be fed newborn, fuzzy or adult mice. The mice should make up no more than about 25% of the diet.

Several small lizard species, such as anoles and day geckos, readily accept fruit-flavored baby foods and yogurt. Basilisks, sailfin dragons and water dragons may accept a small amount of fruit. These soft foods provide a convenient medium for supplementation of calcium, vitamins and trace minerals.

Fresh water should always be available for lizards. Large soaking bowls should be available for some species, such as water dragons and water monitors, Nile and Dumeril’s monitors, sailfin lizards and basilisks. Misting the environment daily may help increase humidity for tropical species. Chameleons and some smaller species of lizards (e.g., anoles) usually won’t drink from standing water. It is usually necessary to visually stimulate these lizards with drip systems, air bubbling systems or by misting the trees and plants in their environment to encourage drinking. These reptiles can also be placed on a clothes-drying rack or large plant, such as a Ficus spp., and placed under a spray of water in a shower, in order to simulate a rain shower and encourage drinking.

Some of the desert species (e.g., Uromastyx lizards and chuckwallas) need only small water bowls for drinking; however, they may benefit from being soaked in a warm water bath once or twice weekly. Water sources may harbor bacteria so bowls must be kept meticulously clean. Routine disinfection is recommended. Vitamin-mineral supplements should not be added to water sources because they may reduce palatability and result in increased bacterial populations.
Insect-eating snakes typically seen by veterinarians include green snakes (Ophiodrya spp.), worm snakes (Carphophis spp.), ring-necked snakes (Diadophis spp.), brown snakes (Storeria spp.) and other primarily fossorial snakes. Additionally, some ectothermic snakes eat insects, especially as juveniles.

A variety of insects should be offered, including crickets, mealworms, earthworms, nightcrawlers and wax-moth larvae. Insects should be fed a complete diet before they are fed to snakes. Insects should be dusted with a calcium and vitamin supplement weekly. Some of the larger snakes in this group may be weaned onto pinkie mice for added nutrition. Pinkies can be supplemented by dipping them into a liquid calcium supplement.

Many of these snakes also feed on very small amphibians, such as salamanders, tadpoles and frogs. As with feeding ectothermic snakes, cold-blooded prey items should be frozen for at least three days to minimize parasitic infections.

For all snakes, fresh water should be provided at all times. Water bowls should be cleaned and disinfected regularly. A water container that is large enough for soaking should be provided. Vitamin-mineral supplements should not be added to the water. Palatability may be reduced and bacteria in the water may feed on the supplements resulting in a bacterial bloom.

**Turtles and Tortoises: Chelonia**

**Carnivores**

The most common carnivorous turtles seen by veterinarians are water turtles, such as snapping turtles (Chelydra spp.), mata mata turtles (Chelys spp.) and alligator snapping turtles (Macroclytus spp.). These turtles usually eat only while in water. They can be fed in their regular aquatic environment or, better yet, in a separate water-filled tank. This practice decreases the amount of fecal material and decaying food in their aquarium, thereby reducing water quality problems.

Most aquatic turtles are fed commercial turtle or fish pellets. Trout food comes in several sized pellets. Large pellets tend to float well and are attractive to large turtles, whereas the smaller pellets tend to sink quickly but are readily accepted by juveniles and small turtles. Trout food may be difficult for reptile owners to find because it is usually only available by special order from feed stores. It is typically sold only in 50-lb bags. Veterinarians who see a large number of reptiles may want to purchase the food, separate it into smaller amounts (store it in a freezer) and make it available to clients who own turtles.

Fish (e.g., goldfish, minnows and guppies) are also fed to aquatic turtles and are available as feeder fish from pet stores. Smelt, mackerel and other oily fish should be fed in limited quantities because their high polyunsaturated fatty acid content may lead to vitamin E deficiency and steatitis. Also, fish may contain thiaminases. Feeding wild-caught fish should also be discouraged because they may be intermediate hosts for reptile parasites. Amphibians (e.g., tadpoles and frogs) can also be fed but they too are safest if captive-born. Crayfish are not recommended because they may harbor the bacterium *B. chitonovora*, which has been implicated in shell diseases of turtles (Boyer and Boyer, 1992).

Other food items include earthworms, snails, slugs, beetles, grasshoppers, moths, crickets, mealworms, giant mealworms, wax worms and other insects. Wild-caught prey should be free of insecticides and pesticides.

Carnivorous turtles may occasionally consume leafy vegetables or fruits, which can be fed as treats. Vitamin-mineral supplementation is not necessary if turtles eat a variety of commercial foods. Cuttlebone may be added as a calcium supplement for juveniles.

**Omnivorous Aquatic Turtles**

The most common omnivorous water turtles seen by veterinarians are red-eared sliders (*Trachemys* spp.), painted turtles (*Chrysemys* spp.), Reeves turtles (*Chinemys* spp.), diamondback terrapins (*Malaclemys* spp.), map turtles (*Graptemys* spp.) and river cooters (*Pseudemys* spp.). Many omnivorous water turtles are primarily carnivores as juveniles and become more herbivorous as they age. The carnivorous portion of the diet is the same as described for carnivorous water turtles and should make up between 75 and 100% of the diet for juveniles and about 50% of the diet for adults. A wide variety of vegetables should be
offered to round out the diet. Generally, vegetables that float are preferable because turtles can nibble on them throughout the day. Favorites include greens such as romaine lettuce, collard greens, endive, Swiss chard and kale. Fruits tend to disintegrate in water. Supplementation of the diet is usually unnecessary if the diet is varied and includes commercial foods.

**Box Turtles**

Some of the most popular box turtles include the eastern box turtle (*Terrapene carolina carolina*), the ornate box turtle (*Terrapene ornata ornata*), the three-toed box turtle (*Terrapene carolina triunguis*) and Asian box turtles (*Cuora spp.*).

Box turtles are primarily omnivorous, although some species such as Asiatic box turtles are more carnivorous. Box turtles tend to eat more animal protein as juveniles and become more omnivorous as they mature. The carnivorous portion of the diet is similar to that described for water turtles and should include a wide variety of invertebrates such as earthworms, slugs, mealworms and wax worms.

Commercial box turtle foods, low-fat dog food, trout food, primate biscuits and small amounts of cat food add variety and nutritional balance to the diet. Fruits and vegetables will be more readily accepted as box turtles mature, but should be offered at all ages (Figure 71-3). Box turtles seem most interested in eating red, orange and yellow foods. They tend to favor strawberries, tomatoes, raspberries and blueberries. These fruits can be used to entice turtles to eat. Red food dye can be used to convince stubborn animals to try different and more balanced foods.

Water for box turtles should always be available in a shallow, heavy bowl or dish to allow the turtle to enter the water without spilling the contents. Additionally, box turtles should be soaked in a warm water bath once or twice weekly for approximately 30 minutes. Vitamins and mineral supplements should not be placed in water sources because they may reduce palatability and may increase bacterial growth.

**Herbivorous Tortoises**

The most common tortoises seen by veterinarians are California desert tortoises (*Gopherus agassizii*), leopard tortoises (*Geochelone pardalis*), South American red-footed tortoises (*Geochelone carbonaria*), yellow-footed tortoises (*Geochelone denticulata*), Greek tortoises (*Testudo graeca*), hingeback tortoises (*Kinixys spp.*) and gopher tortoises (*Gopherus polyphemus*). Most tortoises are strictly herbivorous, although a few accept meat-based foods. All use hindgut fermentation.

The basic diet for most tortoises includes a staple of leafy vegetables, such as collard greens, romaine lettuce, parsley, leaf lettuce, dandelion greens, turnip greens and Swiss chard. Dandelion and clover are excellent forages. These should make up 60 to 70% of the diet. Avoid feeding excessive quantities of produce containing oxalates (e.g., spinach) and goitrogens (e.g., kale). Commercially prepared foods for tortoises and iguanas work well for the other 30 to 40% of the diet because they supply protein, vitamins and minerals not present in vegetables.

Timothy hay, alfalfa hay and pellets and grass clippings may be offered to increase the fiber content of the diet. The remainder of the diet may include small amounts of fruits and vegetables.

For juvenile tortoises, foods should be finely chopped into small, manageable pieces to increase consumption. To minimize ingestion of cage and enclosure substrate, food should be offered on flat trays or plates that juveniles can climb onto. Tortoises are often unable to eat from bowls or raised feeders. Produce should be supplemented with calcium, vitamins and trace minerals. Usually, diets are supplemented twice weekly for hatchlings and once every seven to 10 days for adults. Supplementation may be unnecessary if 50% or more of the tortoise's diet is comprised of commercial food.

Many tortoises will not drink from water bowls, so all tortoises should be soaked in a tub or large bowl of warm water (up to the plastron) for 15 to 20 minutes to encourage drinking and excretion. Generally, tropical species should be soaked twice weekly, whereas desert species may need to be soaked only once a week. Hatchlings should be soaked daily.

**ENDNOTE**


**REFERENCES**

The references for Chapter 71 can be found at www.markmorris.org.
Swollen Eyes and Respiratory Difficulty in a Box Turtle

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Patient Assessment
An adult, female Eastern box turtle (*Terrapene carolina carolina*) weighing 357 g was presented for examination. The turtle had a carapace length of 125 mm, and a plastron length of 121 mm. The turtle had been caught and maintained in captivity for one year. It was kept indoors during the winter in a 20-gallon aquarium with one other female Eastern box turtle. In the late spring, it was placed in an outdoor enclosure. The outside environment contained a small wooded area, weeds, grass and leaves. Open areas in the enclosure allowed exposure to sunlight. One male and two other female box turtles also lived in this outdoor enclosure. The turtle was observed laying a clutch of eggs one month earlier.

The owner presented the turtle because its eyes were swollen and sometimes sealed shut. Congestion was noted and mucus bled from the turtle’s nares. The turtle was anorectic and lethargic.

Physical examination revealed bilaterally swollen eyelids with conjunctivitis and purulent discharge. Visual inspection of the corneas was difficult due to swelling. Mucus was present in both nares, and congestion and mucus were noted in the oral cavity. Increased upper respiratory noises were heard. Skin and shell quality were normal. Body weight was fair.

A culture was taken of the mucus in the nares. A diagnosis of hypovitaminosis A and secondary bacterial conjunctivitis and rhinitis was made based on the historical information and physical examination findings.

Assess the Food and Feeding Method
The turtle’s diet for the previous year consisted of a variety of fruits, such as apples, bananas, strawberries, and earthworms and insects found in the outdoor enclosure. The owner had not used any supplements for several months, but previously had used a multivitamin supplement.

Questions
1. What nutrient problems should be suspected based on the dietary history?
2. What should the initial treatment be for this turtle?
3. What long-term changes should be made in the diet?

Answers and Discussion
1. The current diet was probably deficient in vitamin A and other vitamins and minerals, such as calcium. Earthworms are generally a nutritious dietary item, but the fruits offered provided only trace amounts of calcium and inadequate supplementation was provided. Additionally, not feeding a complete food, such as commercial box turtle, trout or dog food as a part of the diet contributed to the problem.
2. The patient was soaked in a warm water bath for 20 minutes then placed in an incubator at 29°C (85°F) and fluid therapy was initiated (20 ml/kg body weight of lactated Ringer’s solution given epicloelomically). Vitamin A (200 to 300 IU/kg body weight) was given orally. The turtle was started on enrofloxacin (5 mg/kg body weight, q48h) administered into the musculature of the front legs. One or two gentamicin ophthalmic drops were placed in each eye twice daily.
3. The patient’s diet was changed to include foods with higher vitamin A content. A variety of vegetables and fruits, and a commercial box turtle food were provided.

Progress Notes
The following day, the box turtle was soaked in a warm water bath for 15 minutes. Afterward, purulent material was gently removed from the periorcular tissues with an eye rinse. Gentamicin ophthalmic drops were placed in both eyes. The patient was then tube fed an enteral diet placed directly into the stomach with a curved metal feeding tube. The following day, the enrofloxacin, gentamicin drops and the warm water bath were repeated.

The turtle was sent home with a two-week course of parenteral enrofloxacin and gentamicin drops. The owner was instructed to apply a vitamin A eye preparation to the eyes daily for 14 days and soak the turtle daily for 15 to 20 minutes. Changes in the diet were recommended and the owner was encouraged to offer food immediately following the soaks.
At a follow-up visit two weeks later, the owner said the turtle had begun to eat well and was much more active. Upon physical examination, the eyes were open and markedly less swollen (**Figure 1**) and no nasal discharge was present. Culture results of the nasal discharge taken earlier revealed *Pseudomonas aeruginosa*. This organism was sensitive to enrofloxacin and gentamicin. The oral dose of vitamin A was repeated, and enrofloxacin, gentamicin and vitamin A drops were continued for another seven days.

**Endnotes**
b. Gentocin Durafilm. Schering-Plough Animal Health, Union, NJ, USA.
c. Dacriose Solution. Ciba Vision Ophthalmics, Atlanta, GA, USA.
d. Ensure Liquid Nutrition. Ross Laboratories, Columbus, OH, USA.
e. Turtle Eye Clear. Tetra Terafauna, Morris Plains, NJ, USA.

**Bibliography**

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**CASE 71-2**

**Lethargy and Bone Swelling in a Green Iguana**
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**Patient Assessment**
An 18-month-old green iguana (*Iguana iguana*) was purchased from a local pet store as a farm-raised juvenile and had been in the owner’s possession for one year. The iguana was examined for anorexia of 10 days’ duration, a swollen mouth and lethargy.

The iguana was housed in a 20-gallon aquarium with indoor/outdoor carpeting, a branch, plastic plant, water bowl and food bowl. A large “hot rock” provided heat. No artificial lighting was provided, but the cage was placed near a window. The iguana was housed alone; the owner had no other reptiles. The iguana had no history of illness and had never been examined by a veterinarian.

The iguana was generally depressed. Its color was a dull yellow-green. At 253 g and 8 inches (snout to vent length) the animal appeared stunted. Under optimal conditions, it should have been three or four times heavier and markedly longer (i.e., 12 to 14 inches). The mandibular bones were severely swollen, the right side significantly more so than the left. Yellow-brown dried material was present along the exposed mandibular mucous membranes. The right forearm, left tibia and right and left femurs were enlarged. The muscle mass over the rear limbs and tailbase was poor. Results of abdominal palpation were normal. The patient exhibited muscle tremors and fasciculations when handled. It was unable to lift its body off the ground to ambulate but would try to slide along the ground.

Radiographs were taken to assess the skeletal system. The right radius and ulna were fractured, but the fractures appeared old (i.e., callous formation). Poor cortical bone density was evident on all long bones and the mandibular and maxillary bones.
A diagnosis of metabolic bone disease was made based on the clinical history, physical examination and radiographic findings.

Assess the Food and Feeding Method
The patient had been raised on a diet of red-tipped and iceberg lettuce, peas, corn, carrots, apples and strawberries. It was fed daily and was offered two or three of these items at a time. The food was always chopped into small pieces and sometimes dusted with a “reptile vitamin.” The owner did not know the name of the supplement, only that it came in a yellow container. The supplement hadn’t been used for months. Fresh water was always available.

Questions
1. What nutrient problems should be suspected based on the dietary history?
2. What is the initial treatment for metabolic bone disease?
3. What should be the long-term feeding plan?
4. What other husbandry recommendations should be made?

Answers and Discussion
1. The iguana was fed a diet low in calcium and high in phosphorus, with poor and inconsistent calcium and vitamin supplementation. The iguana was not exposed to natural sunlight or ultraviolet light, probably leading to vitamin D₃ deficiency. Sunlight through a glass window does not provide ultraviolet exposure. Other nutrient deficiencies are likely, too.
2. Initially the patient was placed in an incubator at approximately 31°C (88°F). Warm lactated Ringer’s solution was given intracoelomically (20 ml/kg body weight). Eight hours later, vitamin D (1,000 IU vitamin D/kg body weight, intramuscularly) and a calcium-containing solution (0.5 ml/kg body weight, subcutaneously) were given. The iguana was kept overnight in the incubator. The following day, fluid therapy was repeated and an enteral nutritional product was administered orally (50% of metabolic requirement, e.g., 5.5 kcal [23 kJ] or 5.5 ml of the liquid enteral product) using a 14-Fr. red rubber urinary catheter. The iguana was started on an oral calcium supplement (1 mg/kg body weight).
3. The iguana’s diet was changed to include a wider variety of calcium-rich vegetables. Supplementation included calcium carbonate sprinkled onto the greens, and once weekly sprinkling of a vitamin D₃-containing product onto the greens. Recommendations included placing a full-spectrum fluorescent bulb within 12 to 18 inches of the patient.
4. Iguanas are diurnal basking lizards and must be provided with radiant heat. A temperature gradient should be provided in their environment. The upper end of the temperature range should be 31 to 35°C (88 to 95°F). A “hot rock” does not provide adequate heat for an iguana. A clamp lamp with an incandescent light bulb was placed at one end of the aquarium to keep the hot end of the cage between 31 and 33.5°C (88 and 92°F). In addition, a hide box was provided to help minimize stress and branches were removed to prevent falls until the patient’s bones strengthened.

Progress Notes
The iguana’s owner was instructed to slowly feed the enteral nutritional product with a syringe (5 to 10 kcal [21 to 42 kJ] daily in small divided doses). The patient was also soaked daily in a warm water bath. The iguana was given the oral calcium supplement (1 ml/kg body weight, b.i.d.) for 30 days.

The iguana returned in one week for a follow-up examination. The owner reported that the iguana was readily accepting the enteral nutritional product and was more alert and active. Upon physical examination, the mandible seemed firmer and the patient was much more responsive. Calcitonin was administered intramuscularly (50 IU/kg body weight). The patient’s diet was switched from the enteral product to moistened commercial iguana food. Small meatball-shaped pellets were fed (four to five pieces were fed one or two times daily, depending on the iguana’s appetite). Additionally, two tablespoons of chopped dark green leafy vegetables (e.g., collard greens, kale, romaine lettuce) were offered daily. Oral calcium was continued.

The iguana returned weekly for calcitonin injections and a second injection of vitamin D. Three weeks later, a follow-up examination revealed stronger, firmer mandibular and maxillary bones and reduced swelling and increased strength in the long bones. The iguana was able to lift its body off the ground to ambulate. It was eating commercial food vigorously and also eating some of the greens. The owner reported that the iguana was spending time basking and had become more active. The oral calcium supplement was reduced to once daily dosing.

A recheck one month later revealed that the iguana was able to move normally (Figure 1). The mandibular and maxillary bones were firm and the patient’s appetite was dramatically improved. Rechecks were recommended at three-month intervals over the next year to prevent relapses.

Endnotes
a. Calphosan Solution. Glenwood Inc., Tenafly, NJ, USA.
b. Ensure Liquid Nutrition. Ross Laboratories, Columbus, OH, USA.
c. Neo-Calglucon. Sandoz, East Hanover, NJ, USA.
d. Miacalcin. Schering-Plough, Kenilworth, NJ, USA.
Anorexia and Lethargy in a Green Iguana
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Patient Assessment
A two-year-old female green iguana weighing 1.6 kg was presented for anorexia and lethargy of six days' duration. The owner obtained the iguana 18 months ago. The iguana was housed in a 75-gallon aquarium with another iguana. The aquarium was heated with a heating pad under the tank and a 220-watt infrared heat lamp. Ultraviolet-B light was provided by an artificial light source; however, the owner couldn’t specify how long the source was provided daily.

When examined, the iguana was lethargic, but moved when stimulated. The overall skin coloration was dark and dull. A firm mass was palpated in the caudodorsal coelomic cavity; deep palpation elicited a response from the patient. The patient’s long bones were palpably normal. The mandible was firm and non-compressible.

Abnormal results of a complete blood count and serum biochemistry profile included a heterophilic leukocytosis, hyperproteinemria, marked hyperphosphatemia, hyperuricemia and marked increases in creatine kinase levels and aspartate aminotransferase activity. Radiographs demonstrated bilaterally symmetric soft tissue opacities in the caudodorsal coelomic cavity; these opacities were thought to be the patient’s kidneys. A sonogram revealed enlarged hyperechoic kidneys bilaterally.

Assess the Food and Feeding Method
The iguana’s diet consisted of a variety of vegetables including greens, broccoli and dandelions as well as an unspecified commercial iguana food, which made up approximately 50% of the total diet. Fruit was given occasionally. The owner had been supplementing the diet with a vitamin-mineral supplement twice daily for several months.

Questions
1. What nutritional problems are suggested by the diet? Could any of these explain the iguana’s clinical signs?
2. What is the pathophysiology of the biochemical abnormalities? What is the significance of the abnormalities found by imaging?
3. How can this condition be treated?

Answers and Discussion
1. The owner has been providing large amounts of vitamin D₃ in the form of the vitamin-mineral supplement and the commercially prepared iguana food. Vitamin D₃ is essential for calcium uptake from the intestinal tract; however, it can be toxic when given in large amounts. Either hypervitaminosis D or hypocalcemia could be responsible for the lethargy and anorexia exhibited by the patient.
2. Hyperproteinemria may be due to dehydration. Hyperuricemia and hyperphosphatemia indicate some degree of renal failure. The increase in aspartate aminotransferase activity and elevated creatine kinase value indicate either muscle degeneration and/or hepatic damage. Renomegaly and pain elicited when the kidneys were palpated are signs consistent with nephrosis. The increased opacity in the region of the kidneys seen radiographically and by ultrasound is consistent with mineralization of the renal parenchyma. The combination of these findings is suggestive of renal failure secondary to hypervitaminosis D.
3. Excessive supplementation with vitamin D₃ allows large amounts of calcium to be absorbed from the intestinal tract. The resulting soft tissue mineralization, however, can be widespread and severe. Endstage renal failure is generally unresponsive to treatment; however, diuresis may provide short-term palliative treatment.

Progress Notes
The iguana was diuresed with a mixture of 0.9% saline, 2.5% dextrose and lactated Ringer’s solution administered intracoelomically for two days. Unfortunately, the patient died on Day 3. Results of a necropsy examination revealed moderate tubular nephrosis and severe degeneration with mineralization and necrosis of the heart and skeletal muscles. The final diagnosis was vitamin D toxicosis. Vitamin D₃ and calcium metabolism are still not well elucidated in iguanas and vitamin D₃ requirements have not been established. It is unclear how well vitamin D₃ is absorbed in these animals. The risk of over-supplementation can be avoided by providing exposure to adequate amounts of ultraviolet-B light, thus allowing the body to form its own vitamin D₃ instead of giving oral supplementation.