Chapter 12

# Introduction to Feeding Normal Dogs

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*"What dogs? These are my children, little people with fur who make my heart open a little wider."*
*Oprah Winfrey*

## CLINICAL IMPORTANCE

Much has changed in our perception and use of dogs over the past half century. Our society has moved from an agrarian phase into a postindustrial phase with a concomitant shift of the human population into urban settings. Dogs have, by necessity, made the shift to urban living along with us and in doing so we have discovered their remarkable adaptability and versatility.

Dogs have found a job in virtually every niche of society. Dogs have been useful in law enforcement, as nursing home companions, in the military, in drug enforcement, as paraplegic assistants and in search and rescue. The human-animal bond has become a commonly taught subject in veterinary schools, which testifies to the importance of animals, including dogs, for our mental and physical well-being. The Centers for Disease Control and Prevention (CDC) describe some of the health benefits of pet ownership, including decreased blood pressure, cholesterol levels, triglyceride levels and feelings of loneliness and increased opportunities for exercise, outdoor activities and socialization (2006). Many organizations support the health benefits of pet ownership including the American Veterinary Medical Association, The Delta Society and the National Institutes of Health; these organizations and others have issued statements or provided information supporting the health benefits of pet ownership. According to this national poll of working Americans 18 years of age and over, nearly one in five U.S. companies allow pets at work. A majority of those polled believe pets at work provide benefits such as relieving stress, improving relationships with coworkers, making for a happier workforce and creating a happier work environment (CDC, 2006). Another health benefit for both dogs and people is related to exercise and weight loss. When overweight people and overweight pets exercise together, they both have lower dropout rates from their weight-loss programs (Jewell et al, 2004).

The emphasis on dogs as valued members of society (**Box 12-1**) has driven the development of canine nutrition towards the same goals we strive for in human nutrition: long life, high quality life and enhanced performance.

### Demographics

Globally, pet ownership has increased, possibly due to reduced human birth rates, changing family structure and aging populations (Anonymous, 1997). Regardless of a pet's size or species, pet owners consider their pet to be a family member. One survey indicated that 63% of the U.S. population own pets. There are nearly 75 million dogs in the U.S. Furthermore, 45% of U.S. households own dogs; this equates to approximately 1.7 dogs per household (AAMA, 2007). **Table 12-1** lists countries with the most prevalent dog ownership. Breed popularity varies from year to year and from region to region; however, some breeds always appear to be more desired than others (**Table 12-2**). Worldwide, mixed-breed and crossbred dogs are most popular.

### Box 12-1. People Treat their Dogs like Family Members.

A majority of American households (62%) own at least one pet, but virtually everyone, more than nine in 10, considers his or her pet a member of the family. Here are some other interesting facts about dog ownership.

- 70% of owners said they give their dogs presents at Christmas.
- 22% of owners celebrate their dogs' birthday by giving a special treat, making a special meal, giving their dog a cake, ice cream, a new toy, a new bone, singing happy birthday, throwing a birthday party with other dogs, taking their dog to a favorite place or taking photographs.
- More than 50% of American dog owners are more attached to their pets than to at least one other person; 36% say they are more attached to their dog than their best friend and 12% say they are more attached to their dog than their spouse.
- 25% of owners let their dog sleep either on top of or in their bed.

The Bibliography for **Box 12-1** can be found at www.markmorris.org.

**Table 12-1.** Comparisons of dog populations in selected countries.*

| Country | Pet dog population |
|---|---|
| USA | 61,080,000 |
| Brazil | 30,051,000 |
| China | 22,908,000 |
| Japan | 9,600,000 |
| Russia | 9,600,000 |
| South Africa | 9,100,000 |
| France | 8,150,000 |
| Italy | 7,600,000 |
| Poland | 7,520,000 |
| Thailand | 6,900,000 |

*Source: Infobase Pvt. Ltd.

**Table 12-2.** Ten most popular dog breeds registered by the American Kennel Club in 1996 compared with their popularity in 2005.

| | 1996* | | 2005** | |
|---|---|---|---|---|
| Breed | Rank | Number | Rank | Number |
| Labrador retriever | 1 | 149,505 | 1 | 137,867 |
| Rottweiler | 2 | 89,867 | 16 | 15,916 |
| German shepherd dog | 3 | 79,076 | 4 | 45,014 |
| Golden retriever | 4 | 68,993 | 2 | 48,509 |
| Beagle | 5 | 56,946 | 5 | 42,592 |
| Poodle | 6 | 56,803 | 8 | 31,638 |
| Dachshund | 7 | 48,426 | 6 | 38,566 |
| Cocker spaniel | 8 | 45,305 | 15 | 16,343 |
| Yorkshire terrier | 9 | 40,216 | 3 | 47,238 |
| Pomeranian | 10 | 39,712 | 14 | 19,511 |

*Adapted from U.S. Pet Ownership & Demographics Sourcebook. Schaumburg, IL: Center for Information Management, American Veterinary Medical Association, 1997; 32-35.
**American Kennel Club Registration Statistics, 2005.

The terms "mixed breed" and "crossbred" have slightly different meanings. Mixed-breed dogs' ancestry might not be discernable, whereas breeders often plan crossbreeding by mating two different purebred dogs.

Coinciding with increasing numbers of pets, from 2001 to 2006, sales of commercial pet foods increased 5.4% in the U.S. and more than 10% worldwide. In the U.S., the trend is for less pet food to be sold through grocery stores and more through specialty and mass merchandisers. Packaged dry dog foods are almost universally fed by dog owners (95% of dog owners) compared to canned food use (34% of dog owners) (Packaged Facts, 2006). This highly competitive market and increased demand, coupled with the importance of nutrition to the health and performance of dogs, make it necessary for practicing veterinarians to understand not only the basics, but also the subtleties of canine nutrition to make knowledgeable recommendations to clients about optimal feeding programs.

## Species Diversity

The modern domestic canine species encompasses a vast number of breeds each with its own genetic idiosyncrasies (Fogle, 1997). Using genomic techniques (microsatellite genotyping), the genetic similarities of 85 modern breeds were organized into four distinct groups. The breeds in each of the four groups had similar geographic origins, morphology or role in human activities (Parker et al, 2004). The variety of dog breeds has arisen out of selection efforts by people to produce animals with specific traits that may enhance performance, show or behavioral characteristics (**Table 12-3**). The result is a species that displays a wide variety of morphology; head shape, size, coat characteristics (color, length, etc.) and musculoskeletal structure. By selecting for these traits, we have probably unknowingly selected for variations in metabolism and nutrient usage as has been evidenced in other species. Our knowledge about breed variation in metabolism and nutrient requirements is growing. Furthermore, nutrigenomic technologies create a potential for an even better understanding of breed-specific nutrition (Chapter 4). Nutrigenomics is currently applied to many species including people (Swanson et al, 2003). Because dogs are good models for certain human diseases, the outcome will be an increasing body of knowledge about metabolism and nutrition of the diverse canid species. A common unifying theme is dogs are omnivores.

# DOGS AS OMNIVORES

The word carnivore can be used to indicate either a taxonomic classification or a type of feeding behavior. The order Carnivora is quite diverse (**Table 12-4**) and consists of 12 families containing more than 260 species. Omnivorous and carnivorous feeding behaviors are most common among members of the order Carnivora; however, the order also includes species that are herbivores (e.g., pandas) (Corbet and Hill, 1986; Morris and Rogers, 1983, 1989).

## Eating Behavior

Several researchers have examined the eating habits of wolves (*Canis lupus*), the nearest ancestors of our domestic dogs, and close relatives such as coyotes (*Canis latrans*). Both are opportunistic predators and scavengers, hunting and eating what is available regionally (Sheldon, 1992). Coyotes eat carrion and hunt rodents, other small mammals, birds, amphibians and other species (Sheldon, 1992; Landry and Van Kruiningen, 1979). Additionally, they have been reported to consume droppings of herbivorous prey; domestic dogs also will readily consume herbivore feces (Lewis et al, 1987). Regional ungulates such as buffalo, deer, elk, moose, wildebeest, antelope and zebra are the natural prey of wolves (Sheldon, 1992; Landry and Van Kruiningen, 1979). Viscera are typically consumed; therefore, partially digested vegetable material is a normal part of the wolf's diet (Beaver, 1981). Both coyotes and wolves also eat plant matter such as fruits, berries, persimmons, mushrooms and melons (Sheldon, 1992; Landry and Van Kruiningen, 1979; Röhrs, 1987). Similarly, dogs are opportunistic eaters and have developed anatomic and physiologic characteristics that permit digestion and usage of a varied diet.

## Anatomy and Physiology

### *Oral Cavity*

The oral cavity functions to decrease the physical size of food for introduction into the rest of the alimentary tract. Decreasing the physical size of food creates particles small enough to pass through the esophagus and increases the surface area of the food, which enhances enzymatic digestion in the stomach and small intestine. Dogs have cutting canine teeth for ripping and tearing and molar teeth with large occlusal tables for crushing, which are associated teleologically with the capacity to use plant material (**Figure 12-1**) (Morris and Rogers, 1989). Dogs may fix large pieces of food with their paws to tear off small pieces with their cutting canine teeth, after which the food particle is advanced to the back of the oral cavity where it may be crushed by the molar teeth and mixed with saliva before being swallowed (Meyer, 1990).

### *Stomach*

Wild canids typically eat large meals, usually infrequently, due to intermittent food availability. Dogs may consume their daily energy requirement in one or two large rapidly ingested meals (Ruckebusch et al, 1991). This eating pattern means that the stomach must be able to expand markedly. On average, a medium-sized, adult domestic dog has the capacity to ingest 30 to 35 g of dry matter per kg body weight per day (Meyer, 1990a; Meyer et al, 1980). However, the canine stomach can adjust, within limits, to accommodate the amount of food ingested and can hold 1 to 9 liters depending on the breed (Schummer and Nickel, 1960).

### *Small and Large Intestine*

The characteristics of the canine small intestine are consistent with those of animals that digest an omnivorous diet (Morris and Rogers, 1989). The small intestine composes approximately 23% of the total gastrointestinal (GI) volume of dogs (Ruckebusch et al, 1991) vs. 15% for cats (Wolter, 1982). The ratio of GI tract length to total body length is 6:1 for dogs, 4:1 for cats, 10:1 for rabbits and as high as 20:1 for some herbivores (Morris and Rogers, 1989; Meyer, 1990; Wolter, 1982). This anatomic relationship is consistent with ingestion of an omnivorous diet with intermediate digestibility (i.e., between low digestible herbaceous forages and highly digestible animal flesh). Dogs digest starch effectively via pancreatic enzymes and mucosal disaccharidases.

**Table 12-3.** Examples of various functions dogs perform in society.

| |
|---|
| Assisting hearing or physically impaired persons |
| Entertainment |
| Guiding blind persons |
| Herding |
| Hunting |
| Military and law enforcement |
| Pets |
| Racing (sprint or endurance) |
| Rescue operations |
| Show and breeding |
| Social interactions |

### *Nutrient Requirements and Metabolism*

Much can be learned about an animal's nutritional requirements simply by analyzing its natural food source. True carnivores, such as cats, are limited to what is available from prey tissues such as skeletal muscle and liver to provide energy and nutrients, including protein, taurine, arginine, arachidonic acid and niacin. Consequently, carnivorous animals (e.g., cats) developed more efficient pathways to use these nutrients, and have lost the ability or have a decreased ability to synthesize them from precursors (Chapter 19). Being omnivorous and feeding on a varied diet of plant and animal tissue, dogs maintained or improved the ability to synthesize nutrients from precursors. These differences lend more evidence to early evolutionary divergence (Martin, 1989) and further support the premise that dogs are omnivores.

**Table 12-5** compares the recommendations for daily nutrient intake of adult dogs to the nutrient content of meat (ground beef). This comparison confirms that an all-meat food would be unbalanced for dogs. Specific aspects of nutritional requirements of dogs are discussed in Chapters 5 and 6 and Chapters 13 through 18.

# LIFESTAGE NUTRITION

Lifestage nutrition is the practice of feeding animals foods designed to meet their optimal nutritional needs at a specific age or physiologic state (e.g., maintenance, reproduction, growth or senior). The concept of lifestage nutrition recognizes that feeding either below or above an optimal nutrient range can negatively affect biologic performance or health (Chapters

**Table 12-4.** Taxonomy and natural feeding behavior of the order Carnivora.*

| **Family** | **Canidae** | **Ursidae** | **Procyonidae** | **Ailuropodidae** | **Mustelidae** | **Viverridae** |
|---|---|---|---|---|---|---|
| Feeding behavior | Omnivores | Omnivores<br>Carnivores | Omnivores | Herbivores | Carnivores<br>Omnivores | Omnivores |
| No. of species | 35 | 7 | 13 | 2 | 63 | 35 |
| Examples | Dogs<br>Jackals<br>Coyotes<br>Foxes<br>Wolves | Bears | Raccoons<br>Coatis<br>Kinkajou<br>Olingos | Pandas | Weasels<br>Polecats<br>Mink<br>Ferrets<br>Martens<br>Wolverine<br>Badgers<br>Skunks<br>Otters | Genets<br>Civets<br>Linsangs |

| **Family** | **Herpestidae** | **Hyaenidae** | **Felidae** | **Otariidae** | **Odobenidae** | **Phocidae** |
|---|---|---|---|---|---|---|
| Feeding behavior | Carnivores<br>Omnivores | Carnivores | Carnivores | Carnivores | Carnivores | Carnivores |
| No. of species | 37 | 4 | 36 | 14 | 1 | 19 |
| Examples | Mongooses<br>Meerkats | Hyenas | Leopards<br>Pumas<br>Cats<br>Ocelots<br>Serval<br>Jaguars<br>Lynxes<br>Bobcats<br>Lions<br>Tigers<br>Cheetahs | Eared seals<br>Sea lions | Walrus | Earless seals |

*Adapted from Corbet GB, Hill JE. A World List of Mammalian Species. New York, NY: Facts on File Publications, 1986; 105-121. Nowak RM, Paradiso JL. Walker's Mammals of the World, 4th ed. Baltimore, MD: The Johns Hopkins University Press, 1983. Ridgway SH, Harrison RJ. Handbook of Marine Mammals. New York, NY: Academic Press Inc, 1981.

**Table 12-5.** Comparison between the recommended daily allowances of selected nutrients for a 10-kg adult dog and the nutrient content of meat (beef).*

| | | | **Regular ground beef** | | |
|---|---|---|---|---|---|
| | **RDA** | | **Amount meeting the DER of a 10-kg dog** | | |
| **Nutrient** | **10-kg dog** | **per 100 g** | **482 g** | **% of RDA** | **Adequacy** |
| Metabolizable energy (kcal) | 650 | 135 | 650 | 100 | Yes |
| Moisture (ml) | 650 | 60 | 289 | 44 | na |
| Protein (g) | 24 | 17 | 82 | 341 | No |
| Fat (g) | ≥8 | 20 | 96 | 1,204 | No |
| Calcium (mg) | 1,000 | 10 | 48 | 5 | No |
| Phosphorus (mg) | 750 | 200 | 963 | 128 | Maybe |
| Ca/P ratio | 1:1-2:1 | 1:20 | 1:20 | na | No |
| Sodium (mg) | 250-500 | 70 | 337 | 100 | Yes |
| Potassium (mg) | 550 | 325 | 1,565 | 285 | No |
| Magnesium (mg) | 150 | 25 | 120 | 80 | Maybe |
| Iron (mg) | 14 | 3.25 | 16 | 112 | Yes |
| Copper (mg) | 1 | 0.05 | 0.2 | 24 | No |
| Zinc (mg) | 10 | 1.5 | 7 | 70 | No |
| Iodine (mg) | 0.15 | 0.003 | 0.014 | 10 | No |

Key: RDA = recommended daily allowance, DER = daily energy requirement, na = not applicable, Yes = meets the optimal recommendations, Maybe = does not meet the optimal recommendations, but is neither deficient nor excessive, No = deficient or excessive.
*Adapted from Gesellschaft für Ernährungsphysiologie Ausschuß für Bedarfsnormen. Energie-und Nährstoffbedarf Nr. 5 Hunde. Frankfurt, Germany: DLG Verlag, 1989. Meyer H, Heckötter E. Futterwerttabellen für Hunde und Katzen. Hannover, Germany: Schlütersche Verlaganstalt und Druckerei, 1986. National Research Council. Nutrient Requirements of Dogs. Washington, DC: National Academy Press, 1985. Randoin L, Le Gallic P, Dupuis Y, et al. Tables de composition des aliments. Institut Scientifique d'Hygiène Alimentaire, 6th ed. Malakoff, France: LT Editions J. Lanore, 1990. Watt BK, Merrill AL. Composition of Foods-Raw, Processed, Prepared. Agriculture Handbook No 8.Washington, DC: Agricultural Research Service, USDA, 1975.

5 and 6). This concept differs markedly from feeding a single product for "all lifestages" (all-purpose foods) in which nutrients are added at levels to meet the highest potential need (usually growth and reproduction). Adult animals at maintenance are always provided nutrients well in excess of their biologic needs when fed all-purpose foods. Because the goals in nutrition are to feed for optimal health, performance and longevity, feeding foods designed to more closely meet individual needs is

preferred. This philosophy is the central tenant to lifestage nutrition and preventive medicine. In addition to providing advice about basic nutritional requirements of their patients, veterinarians should assess and minimize the nutrition-related health risks at each lifestage. For maximal benefit, risk assessment and prevention plans should begin well before the onset of disease.

The value of lifestage feeding is enhanced if risk factor management is incorporated into the feeding practice. In many instances, when the nutritional needs associated with a dog's age and physiologic state are combined with the nutritional goals of disease risk factor reduction, a more narrow, but optimal, range of nutrient recommendations results. For example, essentially all commercial dog foods sold in the U.S. meet or exceed the Association of American Feed Control Officials (AAFCO) minimum nutrient requirements for dog foods. Regulatory agencies such as AAFCO ensure ingredient safety and nutritional adequacy. However, even foods that are nutritionally adequate may have levels of certain nutrients outside a desired range for disease risk factor reduction or optimal performance (these nutrients are nutrients of concern). As mentioned in Chapter 1, besides nutrients of concern, specific food factors such as digestibility and texture can also affect health and modify disease risk. Together, nutrients of concern and specific food factors are referred to as key nutritional factors. The key nutritional factors for commercial foods for different lifestages of healthy dogs will be discussed in Chapters 13 through 18, including those associated with reducing the risk of specific diseases and those involved with optimizing performance during different physiologic states.

Homemade foods, unlike commercial foods, are not regulated. Thus, unless experts in canine nutrition have formulated the recipes from which they are made, there are no assurances that homemade foods will provide adequate nutrition or that the ingredients used to make them are safe for dogs (Chapter 10). However, even if the recipes for homemade foods ensure nutritional adequacy and ingredient safety, key nutritional factors should also be considered, depending on the lifestage of the dog being fed.

**Figure 12-1.** Maxillary dentition and palate of a dog (left). Mandibular dentition and sublingual mucosa of the same dog (right). These photographs demonstrate tooth anatomy associated with an omnivorous eating behavior. The cuspid (canine) teeth are long and cutting and are used for capturing and puncturing prey. The maxillary and mandibular premolar teeth interdigitate and provide a shearing action. The carnassial teeth (upper fourth premolar and lower first molar) have broad occlusal surfaces and are used for grinding and chewing. (Adapted with permission from Harvey CE, Emily PP. Function, formation, and anatomy of oral structures in carnivores. Small Animal Dentistry. St. Louis, MO: Mosby-Year Book Inc, 1993.)

In sequence, the chapters that follow cover Feeding Young Adult Dogs: Before Middle Age, Feeding Mature Adult Dogs: Middle Aged and Older, Feeding Reproducing Dogs, Feeding Nursing and Orphaned Puppies from Birth to Weaning and Feeding Growing Puppies: Postweaning to Adulthood. The next chapter begins with feeding young adult dogs because most dogs are adults, and the nutrient needs of adult dogs serve as a good basis for comparing nutrient needs for other lifestages. Chapter 18 covers recommendations for feeding adult working and sporting dogs for optimal physical and olfactory performance.

## REFERENCES

The references for **Chapter 12** can be found at www.markmorris.org.

Chapter 13

# Feeding Young Adult Dogs: Before Middle Age

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*"If you get to thinking you're a person of some influence, try ordering somebody else's dog around."*
*Will Rogers*

## INTRODUCTION

Depending on breed, dogs one through five to seven years of age are generally considered young adults. They are usually fully grown (about 12 months old for most breeds) but are not yet middle aged. In people, middle age is often considered to coincide with the third quarter of the average lifespan. Other than obesity and periodontal disease, this age range represents a relatively healthy period in a dog's life. Generally, many of the more common mortal diseases are more often diagnosed in middle-aged or older dogs.

The goals of nutritional management for young adult dogs are to maximize longevity and quality of life (disease prevention). A basic premise is that the foods fed should be nutritious; they should provide the recommended allowances of all known required nutrients. Most regulated commercial foods provide all the necessary nutrients in amounts that avoid deficiencies (Chapter 9). However, to meet the feeding goals described above, nutritional recommendations must exceed simply preventing diseases associated with nutrient deficiencies.

Nutritional recommendations for people living in affluent countries include nutrient and food recommendations that help prevent important diseases such as obesity, diabetes mellitus, cardiovascular disease, cancer, Alzheimer's disease and others. Thus, as in people, optimal feeding plans for pet dogs should include recommendations for specific nutrients and non-nutrient food ingredients (key nutritional factors) that influence important canine diseases. **Table 13-1** lists the important health concerns that may be positively affected by proper nutritional management in this age group of dogs. To achieve these feeding goals, besides selecting the best food, the food needs to be properly fed (amounts and methods).

## PATIENT ASSESSMENT

Patient assessment should be a structured process that includes: 1) obtaining accurate and detailed medical and nutritional histories, 2) reviewing the medical record, 3) conducting a physical examination and 4) evaluating results of laboratory and other diagnostic tests. During assessment, the feeding goals should be established and explained, risk factors for nutrition-related diseases considered and key nutritional factors identified.

### History and Physical Examination

Often, in a typical busy clinical setting, the time available to obtain a dietary history and conduct a physical examination is limited. However, a minimum dietary database for all canine patients should be obtained and include: 1) the type of food fed (homemade, commercial, dry, moist, semi-moist, etc.), 2) recipes if homemade food represents the majority of the diet, 3) brand names of commercial foods, if known, 4) names of supplements, treats and snacks and 5) method of feeding (free

**Table 13-1.** Important diseases for adult dogs that have nutritional associations.*

| Disease/ health concern | Incidence/prevalence/ mortality/pet owner concern |
|---|---|
| Dental disease | Most prevalent disease; numerous associated health risks (e.g.kidney disease) |
| Obesity | Approximate 30% prevalence; associated health risks (e.g., diabetes mellitus, musculoskeletal disease); major concern |
| Kidney disease | Second leading cause of non-accidental death; major concern |
| Arthritis | 6% prevalence; primary concern |
| Cancer | Primary cause of death; primary concern |
| Skin/coat problems | Second most common cause of disease (26% prevalence); second most common health concern |

*Adapted from DeBowes LJ, Mosier D, Logan EI. Association of periodontal disease and histologic lesions in multiple organs from 45 dogs. Journal of Veterinary Dentistry 1996; 13: 57-60. Egenvall A, Bonnet BN, Hedhammar A, et al. Mortality in over 350,000 insured Swedish dogs from 1995-2000: II. Breed-specific age and survival patterns and relative risk for causes of death. Acta Veterinaria Scandinavica 2005; 46(3): 121-136. Lund EM, Armstrong PJ, Kirk CA, et al. Health status and population characteristics of dogs and cats examined at private veterinary practices in the United States. Journal of the American Veterinary Medical Association 1999; 214: 1336-1341. Morris Animal Foundation Survey Results, August 12, 2005. Morris Animal Foundation Survey Results, 1998.

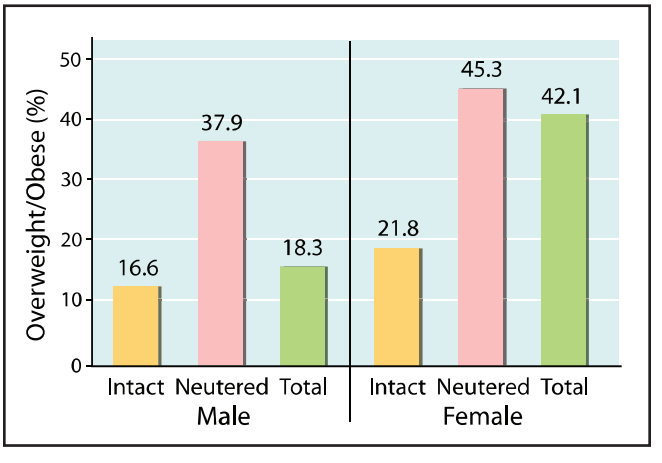


**Figure 13-1.** Percentage of overweight and obese dogs in intact, neutered and total female (3,828) and male (4,109) populations. (Adapted from Edney ATB, Smith PM. Study of obesity in dogs visiting veterinary practices in the United Kingdom. Veterinary Record 1986; 118: 391-396.)

choice, meal feeding, etc.). An extended dietary database includes: 6) quantities fed, 7) recent changes in food type, intake and preferences, 8) access to food for other pets or livestock, 9) who in the family buys food for the pet, 10) who in the family feeds the pet and 11) appetite changes with estimates of magnitude and duration. The general type and level of activity (e.g., house pet, confined to kennel, working dog, etc.) and neuter status should be noted because these factors are important determinants of energy requirements. The dietary history should be expanded if nutrition-related problems such as obesity are identified in the initial evaluation of the patient.

Body weight, body condition score (BCS) (Chapter 1), oral health and overall appearance of the skin and coat of all adult dogs should be assessed and recorded in the medical record. These parameters are general indicators of nutritional adequacy. An otherwise healthy young adult dog with normal body weight, skin and coat and BCS (2.5/5 to 3.5/5) and no evidence of significant dental disease is unlikely to need further nutritional assessment. However, for purposes of disease prevention, nutritional intervention, such as switching to a food that matches the recommended levels of key nutritional factors, may be warranted. The health concerns listed in **Table 13-1** are discussed in the risk factor review that follows.

## *Gender and Neuter Status*

No controlled studies have been performed to delineate differences in nutritional requirements of intact male vs. intact female dogs. It may be presumed that, like other mammals, intact females require less caloric intake than intact males. If this assumption is true it is probably because of gender-related differences in lean body mass. Lean body mass accounts for nearly all of an animal's resting energy requirement (RER) (Blaxter, 1989). Women require fewer calories than men because of a lower relative amount of lean body mass than men (Pellett, 1990). One study showed that female dogs had an average of 16% more body fat than male dogs (Meyer and Stadtfeld, 1980). Surveys have found a much higher prevalence of overweight and obese conditions in female than male dogs (**Figure 13-1**) (Edney and Smith, 1986; Mason, 1970). These findings suggest that intact female dogs may need fewer calories than intact males.

Obesity occurs twice as often in neutered dogs than in reproductively intact dogs (**Figure 13-1**) (Edney and Smith, 1986). Very little is known, however, about the pathophysiology of this phenomenon. Neutering does not appear to have a marked impact on the resting energy expenditure of female dogs (Anantharaman-Barr, 1990); however, it may significantly increase food intake (Houpt et al, 1979). The increased food intake in neutered bitches is thought to be a consequence of a reduction of appetite-suppressing estrogen activity (Houpt et al, 1979; O'Farrell and Peachey, 1990). A decrease in physical activity is also assumed to occur in many dogs after neutering and may play a more important role in male dogs because of decreased roaming (Hopkins et al, 1976; Lewis, 1978). The daily energy intake should be limited to prevent rapid weight gain in neutered dogs; 1.6 x RER is a good starting point. For some breeds and individual dogs, it may be necessary to lower the energy intake of neutered dogs to 1.2 to 1.4 x RER (Chapters 1 and 5).

## *Breed*

The breed classification should be determined in the initial assessment. Different breeds may be at risk for specific diseases or metabolic alterations that require nutritional management. As an example, certain canine breeds appear to be predisposed

to obesity (Chapter 27). In addition, daily energy requirement (DER) differences have been delineated among different breeds, possibly because of differences in lean body mass, temperament and activity level. As examples, Newfoundland dogs have energy requirements about 20% less than average (Kienzle and Rainbird, 1991), whereas Great Danes and Dalmatians may have energy requirements up to 60% higher than average (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Zentek and Meyer, 1992; Männer, 1990). Careful attention to specific local lineage and personal clinical impressions of breed differences may prove useful in food recommendations.

### *Activity Level*

Activity significantly influences the energy requirements of individual dogs and should be taken into account when estimating energy requirements. For example, standing requires 40% more energy than lying down (Meyer, 1983). DER may range from RER for sedentary dogs to almost 15 x RER for endurance athletes under extreme conditions (Hinchcliff et al, 1997). A consistently higher level of physical activity probably would result in a relative increase in lean body mass, which would result in an increase in energy use, even at rest (Blaxter, 1989). However, because the activity of individual dogs often cannot be defined precisely, feeding recommendations should initially be conservative to avoid overfeeding and the risk of obesity. Food intake should be adapted as needed to maintain optimal body weight. Chapter 18 presents more information about the influence of specific nutrients on athletic performance (**Box 13-1**).

#### SEDENTARY DOGS

Estimations for DER include enough energy to support spontaneous activity, such as eating, sleeping, going outside and up to three hours of play and exercise per day. However, most pet dogs are minimally active (NRC, 2006). Approximately 19% of owners never play with their dogs and 22% take their

## Box 13-1. Special Nutritional Considerations for Stressed Dogs.

### STRESS

Police dogs, sentry dogs and other working dogs may refuse to eat, lose weight, develop diarrhea or become reluctant to work for inapparent reasons. Physiologically induced weight loss is most common in sentry dogs, in which a combination of mental stress, weather extremes and activity may result in loss of up to 10% of body weight during a six-hour tour of duty. Stress stimulates release of cortisol and induces a discharge of catecholamines. Besides stimulating alertness, catecholamines may depress food intake in stressed animals by activating the β-adrenergic and dopaminergic receptors in the lateral hypothalamus. This is obvious in highly stressed sentry dogs that may be reluctant to eat the volume of food they need to meet energy requirements. Dogs in various stressful situations demonstrate the same behavior. Some show dogs and racing greyhounds eat sparingly when the owner/handler prepares to depart to a show or a competition. A decrease in food intake, a slight increase in energy requirement and the catabolic effect of cortisol justify feeding a food with increased fat content (at least about 15% dry matter [DM]) and a protein level of about 25% DM. This recommendation does not compensate for energy spent for activity in addition to the stress (e.g., long-distance performances in which fat must be further increased to meet additional energy requirements).

Changing environments such as boarding or hospitalization may influence food intake due to stress. Dogs may develop diarrhea or refuse to eat when boarded. Practitioners commonly see dogs that refuse to eat in the hospital, but readily eat at home.

### EFFECTS OF THE SHOW CIRCUIT

The success of a show dog is determined by genetics, general health, socialization, training and nutrition. Therefore, the preparation of a show dog starts with the correct choice of parents, sound breeding practices and correct rearing of puppies. Good nutrition allows for optimal expression of inherited qualities of a dog. Nutrition of a show dog involves feeding for correct development of skeleton and dentition, and maintenance of long-term health. More specific to show dogs are the nutritional needs for optimal condition of skin and coat, and the support of stress.

Preparation for the show may require particular attention. Skin health and correct color, length and glossiness of hair are important for adult show dogs. The first requirement for a shiny coat is good overall health and nutrition throughout the year. See Chapter 32 for more information about the nutritional effects on skin and coat.

Some show dogs may be finicky eaters, so they may need to be fed a more concentrated, palatable food, containing 25 to 30% DM protein and ≥15% DM fat. During a show, dogs don't spend much energy for physical activity; the primary increase is probably due to stress. Generally, a food that supports the health of skin and coat will provide all the nutrients needed to counteract stress.

### EFFECTS OF MULTI-DOG HOUSEHOLDS

Individually housed dogs with limited exercise may have daily energy requirements (DER) as low as 90 to 95 kcal (375 to 400 kJ) metabolizable energy (ME)/$BW_{kg}^{0.75}$, or 1.3 x resting energy requirement (RER). When housed in kennels with other dogs in situations where much mutual interaction occurs, DER may increase to 130 to 140 kcal (545 to 585 kJ) ME/$BW_{kg}^{0.75}$, or 1.9 to 2.0 x RER or more.

In the U.S., more than a third of dog-owning families have more than one dog and many families own more than one species. Some dogs may increase their interest in food when a new pet is introduced to a household, whereas others may refuse to eat for a day or two. Jealousy may arise over food, bones or toys, or over space in the bed. Dogs may defend their food bowl and raise the hair on their crest, withers and back or growl. Free-choice feeding may have a quieting effect in kennels or multiple-dog households, and less dominant dogs may have a better chance to get their share of the food provided. In some cases, dogs need to be fed in separate places. However, those situations are often created by the owner's intervention in the pecking order.

The Bibliography for **Box 13-1** can be found at www.markmorris.org.

**Table 13-2.** Influence of age on daily energy requirements of active pet dogs.*

| Age (years) | Typical DER ranges** kcal ME/$BW_{kg}^{0.75}$ | kJ ME/$BW_{kg}^{0.75}$ | x RER |
|---|---|---|---|
| 1-2 | 120-140 | 500-585 | 1.7-2.0 |
| 3-7 | 100-130 | 420-550 | 1.4-1.9 |
| >7 | 80-120 | 335-500 | 1.1-1.7 |

Key: DER = daily energy requirement, ME = metabolizable energy, RER = resting energy requirement, kcal = kilocalories, kJ = kilojoules.
*Most pet dogs are minimally active and have a DER of approximately 95 kcal/$BW_{kg}^{0.75}$ or 1.2 to 1.4 x RER.
**The energy requirements indicated in this table are only starting points and should be adapted for individual dogs.

dogs out for exercise fewer than three hours per week (Slater et al, 1995). Solitary dogs are less active than dogs housed as a group (Hubrecht et al, 1992). In one study, large dogs (Labrador retrievers) were active for half as many hours per day as small dogs (Manchester terriers) (Patil and Bisby, 2002). An association was also reported between increasing age and declining activity; older dogs spent less time running and more time walking (Head et al, 1997; Siwak et al, 2002).

## ACTIVE AND SPORTING DOGS

Dogs and horses are often regarded as the elite athletes of domesticated mammals (Rose and Bloomberg, 1989). Greyhounds are sprint athletes and can reach average speeds of 56 to 60 km/hour (35 to 37.5 miles/hour) over typical race distances (Tompkins and Heasman, 1988). Sled dogs are endurance athletes and can maintain a trot of about 16 km/hour (10 miles/hour) for 10 to 14 hours per day for several consecutive days (Grandjean and Paragon, 1992). Energy requirements of dogs performing work between the two extremes (i.e., sedentary and sled dogs) need to be tailored to the individual. Chapter 18 describes how to feed active working and sporting dogs.

### *Age*

Age-related changes occur between the onset of adulthood and five to seven years of age. The prevalence of dental disease, obesity, cancer, arthritis and kidney disease generally increases over this time span (Chapters 27, 30, 34, 37, 47). The cumulative effects of oxidative damage can result in beta-amyloid deposition in the brain as early as five to seven years of age, predisposing to cognitive dysfunction (Chapter 35). Furthermore, apart from reproduction and imposed activity during work or sport, age may be the single most important factor that influences the DER of most adult dogs (**Table 13-2**) (Finke, 1994).

### *Environment*

The influence of the environment should not be neglected when evaluating energy and nutrient requirements. Temperature, humidity, type of housing, level of stress and the degree of acclimatization should be considered with respect to breed and lifestage nutrient requirements of dogs (**Box 13-1**). Animal factors including insulative characteristics of skin and coat (i.e., subcutaneous fat, hair length and coat density) and differences in stature, behavior and activity interact and affect DER.

Dogs can tolerate extreme cold. Adult dogs can maintain normal body temperature in ambient temperatures as low as -46 to -50°C (-51 to -58°F) for four to 27 hours and six out of seven dogs maintained normal body temperatures at -75 to -79°C (-103 to -110°F) for three to five hours (Hume and Egdahl, 1959). One study found that an ambient temperature of -160°C (-256°F) was necessary to make a dog hypothermic after one hour (Giaja, 1938). When kept outside in cold weather, dogs may need 10 to 90% more energy than during optimal weather conditions (Meyer, 1983; Durrer and Hannon, 1962). Heat losses are minimal at a temperature called the lower critical temperature (Blaxter, 1989a). This is the environmental temperature at which dogs reach their minimum metabolic rate. It is breed specific and is lower when the thermic insulation (i.e., coat density and length) is greater (Zentek and Meyer, 1992; Meyer, 1983, 1990; Männer, 1991; Kleiber, 1975). The lower critical temperature is estimated at 15 to 20°C (59 to 68°F) for longhaired breeds, 20 to 25°C (68 to 77°F) for shorthaired breeds and may be as low as 10 to 15°C (50 to 59°F) for arctic breeds (Männer, 1990, 1991; Kleiber, 1975; Meyer, 1990).

Energy use by dogs in cold environments is similar to energy use during endurance exercise (Minaire et al, 1973). In part, skeletal muscle is involved in shivering and non-shivering thermogenesis (NRC, 2006). As with endurance exercise, muscle glycogen stores may limit the ability to withstand cold (Minaire et al, 1973). Thus, high-fat foods are probably well suited for cold-acclimatized dogs in a cold environment. No published studies currently exist about the influence of changing the relative proportions of the nutrient composition of a food for improved resistance to cold in dogs. But for long-term exposure to cold, the amount of food fed should be increased to ensure increased energy availability.

Compared to cold ambient temperatures, a relatively smaller amount of energy is expended to dissipate heat at temperatures above the thermoneutral zone; however, increased amounts of water are required (**Box 13-2**). Adult dogs tolerated high ambient temperatures up to 56°C (133°F) for three hours or more in dry air (Adolph, 1947) but became poikilothermic at 33°C (91°F) or higher in moist air after one hour (Lozinsky, 1924). The metabolic rate increased by 10% in adult dogs when ambient temperatures were 35°C (95°F) (Minaire et al, 1973).

Housing conditions may influence energy and water requirements by modifying the immediate environment. Many housing options are possible; however, any shelter with temperatures closer to the thermoneutral zone will decrease energy requirements in cold environments and water requirements in hot environments (i.e., protection from wind chill, excess sun, etc.). Conversely, housing that moves dogs farther away from the thermoneutral zone will have the opposite effects (e.g., closed spaces in hot humid conditions, damp shady shelters in cold weather). The number of dogs in a shel-

## Box 13-2. Nutrients Used for Body Cooling.

When ambient temperature exceeds a dog's thermoneutral zone, water and energy are used for heat loss. The ability of dogs (and people) to withstand extremely high ambient temperatures is well demonstrated by a study conducted in 1775 by Blagden. It was reported that Blagden, and a dog in a basket (to protect its feet from being burned), entered a room kept at a 126ºC (259ºF) and remained there for 45 minutes. A steak he took with him was cooked; however, he and the dog were unaffected.

Bodies cool by radiation, conduction, convection and vaporization of water. As the ambient temperature increases, the conditions for heat loss by radiation, conduction and convection become increasingly unfavorable. When the ambient temperature exceeds the dog's body temperature, the dog's entire metabolic heat production and the heat received from the environment by conduction, convection and radiation must be removed by evaporation of water to maintain normal body temperature.

Vaporization of water can occur via insensible perspiration, respiration, panting and sweating. Dogs have few sweat glands and thus must pant to evaporate additional water for cooling. Panting is facilitated by the elastic properties of the thorax and respiratory system. Depending on the size of the dog, the respiratory apparatus oscillates to a natural frequency (the resonant frequency of the chest is proportional to the square root of the body mass). The amount of cooling is regulated by the duration of panting. If not for resonant elasticity, the increased muscular effort of breathing would generate more heat than the total heat that could be dissipated by panting. As a result of these elastic properties, however, panting requires only a small amount of energy.

The amount of heat lost via vaporization of water is approximately 580 kcal (2,426 kJ)/kg water. In hot desert-like conditions, in which the heat gained from the environment can be 10 times the metabolic heat production, the water required for cooling a 15-kg dog may equal 2.5% of its body mass per hour. At this rate, if uncompensated for evaporative water loss, a dog could experience a 10% reduction of its total body water within 2.5 hours. Thus, from a nutritional perspective, dogs in hot environments may have a significant increase in water requirement with only a small increase in energy needs to maintain normal body temperature.

The Bibliography for **Box 13-2** can be found at www.markmorris.org.

ter may also affect the adequacy of the housing; increased numbers of dogs will increase the temperature in the local environment (Blaxter, 1989a; Kleiber, 1975).

Regarding environmental factors, and unrelated to the nutritional needs of dogs, pet food manufacturers develop products to address owner conveniences and concerns. This practice led to the development of specific pet food flavor varieties, kibble shapes, colors and sizes and packaging improvements. In the U.S., products have been introduced for pets that spend the majority of their lives indoors or in high population density urban settings. As an example, these products address the desire by pet owners for a very small stool volume, which makes cleanup easier. In addition, pets fed highly digestible, calorically dense foods eat less, resulting in less food carried home by the owner. Such trends, however, are not new to urban high population density countries such as Japan.

## Laboratory and Other Clinical Information

Healthy young adult dogs require few laboratory and other diagnostic tests as part of routine assessment. The most common extended database includes a fecal examination for intestinal parasites, tests for heartworm infection and fundic examination. For dogs older than five years, a urinalysis performed on a fresh urine specimen collected after an all-night fast is added. A complete blood count, serum biochemistry profile and urinalysis should be obtained for ill dogs and those with suspected abnormal nutrition.

## Key Nutritional Factors

**Table 13-3** summarizes key nutritional factors for young adult dogs. The following section describes these key nutritional factors in more detail. Calcium is also a nutrient of concern for young adult dogs, especially when they are fed homemade foods (**Box 13-3**).

**Table 13-3.** Key nutritional factors for foods for young adult dogs.

| Factors | Recommended food levels* | |
|---|---|---|
| | Normal weight and body condition | Inactive/ obese prone |
| Water | Free access | Free access |
| Energy density (kcal ME/g) | 3.5-4.5 | 3.0-3.5 |
| Energy density (kJ ME/g) | 14.6-18.8 | 12.5-14.6 |
| Fat and essential fatty acids (%) | 10-20 | 7-10 |
| Crude fiber (%)** | ≤5 | ≥10 |
| Protein (%) | 15-30 | 15-30 |
| Phosphorus (%) | 0.4-0.8 | 0.4-0.8 |
| Sodium (%) | 0.2-0.4 | 0.2-0.4 |
| Chloride (%) | 1.5 x Na | 1.5 x Na |
| Antioxidants (amount/kg food) | | |
| Vitamin E (IU) | ≥400 | ≥400 |
| Vitamin C (mg) | ≥100 | ≥100 |
| Selenium (mg) | 0.5-1.3 | 0.5-1.3 |
| Food texture (VOHC Seal of Acceptance) | Plaque | Plaque |

Key: DM = dry matter, kcal = kilocalories, kJ = kilojoules, ME = metabolizable energy, VOHC = Veterinary Oral Health Council Seal of Acceptance (Chapter 47).
*Dry matter basis. Concentrations presume an energy density of 4.0 kcal/g. Levels should be corrected for foods with higher energy densities.
**Crude fiber measurements underestimate total dietary fiber levels in food.

**Box 13-3. Nutritional Factors of Concern for Homemade Foods Intended for Adult Dogs.**

In addition to the key nutritional factors for commercial foods for adult dogs (See Key Nutritional Factors discussion.), calcium is also a nutritional factor of concern for homemade foods for adult dogs.

Commercial foods may contain inadequate, adequate and sometimes excessive amounts of calcium and/or phosphorus and; therefore, should not be supplemented. However, calcium is often deficient and phosphorus may be excessive in homemade foods, especially when most of the diet comes from meat and leftovers from the table (Table 12-5). Existing commercial multiple vitamin-mineral mixes (powders, tablets, etc.) are seldom designed to correct imbalances encountered in homemade foods. When formulating homemade foods, it is better to correct calcium-phosphorus imbalances by adding mineral sources such as calcium carbonate or dicalcium phosphate, both of which are usually available from drug stores (Chapter 10).

## *Water*

Water accounts for approximately 56% of an adult dog's body weight (73% of lean body mass) (Stadtfeld, 1978). The body has a limited capacity to store water, and although healthy dogs can replenish a water deficit of up to 8% of body weight in a few minutes (Anderson, 1982), water deprivation will result in death more quickly than withholding any other nutrient (NRC, 1985). Therefore, it can be argued that water is the most important nutrient.

Total water intake (i.e., drinking and water from food) is influenced by several factors such as environment, physiologic state, activity, disease processes and food composition. Total water intake increases almost linearly with increasing salt levels in food (Anderson, 1982; Burger et al, 1980). Switching from a moist to a dry food and vice versa markedly affects the amount of water taken with the food; however, dogs compensate well for this difference by changing the quantity of water they drink, thus keeping their total daily water intake constant (Burger et al, 1980). Generally, dogs self-regulate water intake according to physiologic need. Healthy adult dogs need roughly the equivalent of their energy requirement in kcal metabolizable energy (ME)/day, expressed in ml/day (Lewis et al, 1987). Dogs should be offered free access to water at rest and before, during and after exercise (NRC, 2006). During warm weather, enough water should be available to compensate for evaporation by panting (Anderson, 1982) **Box 13-2**.

## *Energy*

Domestic canids are the most diverse mammalian species in body weight and size. Therefore, energy requirements are not linearly correlated with kg body weight, but are more closely related to metabolic weight ($BW_{kg}^{0.75}$) (Meyer, 1986; NRC, 2006). DER recommendations of adult, non-athletic, non-reproducing dogs have varied from 85 kcal (355 kJ) $ME/BW_{kg}^{0.75}$ to more than 220 kcal (920 kJ) $ME/BW_{kg}^{0.75}$ (Zentek and Meyer, 1992; Männer et al, 1987; Heusner, 1991). This range may confuse dog owners, but it is not surprising considering that breed, neuter status, age, daily activity, environmental temperature and insulative characteristics of the integument markedly influence the DER of a particular dog (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Männer, 1990, 1991; Meyer, 1983; NRC, 2006; Gesellschaft, 1989; Burger, 1994; Finke, 1991). Graphically, the DER for a population of dogs results in a bell-shaped curve; therefore, the energy intake of individual dogs may vary by about 50% above or below the average requirements, even within the same age group (Chapter 1). The RER, however, is not markedly influenced by these factors, and is similar for all dogs, independent of breed or age. RER is approximately 70 kcal (293 kJ)/$BW_{kg}^{0.75}$ (NRC, 2006; Kleiber, 1975) (Chapter 1). A simple linear formula can also be used to estimate RER for dogs weighing more than two kg: $RER_{kcal}$ is approximately (30 x $BW_{kg}$) + 70 (Lewis et al, 1987). To convert from kcal to kJ, multiply kcal by 4.184. Table 5-2 provides RER values for dogs with body weights from 1.5 to 70 kg.

Because DER is the sum of RER plus all the above influences, it is better to use RER as the basis for calculating energy requirements of adult dogs and to assign different multipliers to account for differences in activity, age and environmental influences. When assigning multipliers to RER, it is important to account for neuter status because this variable can be an important factor in determining DER of household dogs. Neutered dogs may have a lower DER than intact counterparts. Surveys have shown that the prevalence of obesity increases progressively and peaks in middle-aged dogs (Armstrong and Lund, 1996; Kronfeld et al, 1991). Thus, prevention of obesity should be an important goal of feeding programs for young adult dogs. Animals benefit more from an appropriate weight-maintenance program than treatment for obesity (Chapter 27).

Three groups of adult dogs can be distinguished based on DER: 1) one to two years old, 2) three to seven years old and 3) more than seven years old (**Table 13-2**) (Rainbird and Kienzle, 1990; Kienzle and Rainbird, 1991; Finke, 1991, 1994). The differences in DER probably reflect an age-related decrease in activity and lean body mass.

Most pet dogs are minimally active and may have a DER that approaches their RER. Such dogs fed caloric intakes recommended for maintenance (1.6 x RER) will be overfed and are likely to become overweight. A recommendation of 1.2 to 1.4 x RER (85 to 98 kcal [355 to 410 kJ] $ME/BW_{kg}^{0.75}$/day) is a good starting point for feeding sedentary dogs (Männer, 1990, 1991; Männer et al, 1987; Heusner, 1991; NRC, 2006).

A good starting point for estimating the DER of more active adult dogs would be 1.6 x RER (115 kcal [480 kJ] $ME/BW_{kg}^{0.75}$). Such dogs between two and seven years of age would probably have a DER between 1.4 to 1.9 x RER (100 to 130 kcal [420 to 550 kJ] $ME/BW_{kg}^{0.75}$) with the higher number used in the lower age group and the lower number applied to the higher age group (**Table 13-2**). All initial estimates of

energy needs must subsequently be evaluated by body condition assessment and adjusted as needed for individual dogs. It has been estimated that sled dogs may require more than 10,000 kcal/day (41.8 MJ/day) (up to 15 x RER) to maintain body weight under racing conditions (Hinchcliff et al, 1997). Active young adult dogs should be fed a food with an energy density range of 3.5 to 4.5 kcal/g dry matter (DM). The energy density range of foods for inactive/obese prone dogs should be lower (3.0 to 3.5 kcal/g DM).

### *Fat and Essential Fatty Acids*

Fats are an excellent source of energy, but the real requirement for fat is to supply essential fatty acids (EFAs). In addition, fat serves as a carrier for the absorption of fat-soluble vitamins (i.e., A, D, E and K). Linoleic and α-linolenic acids are considered essential because dogs lack the enzymes to synthesize them (Watkins, 1997). Linoleic acid (18:22n-6) is the parent fatty acid of the omega-6 (n-6 series), as is α-linolenic acid for the omega-3 (n-3) series. EFAs have structural functions in cell membranes and are precursors of eicosanoids such as prostaglandins, thromboxanes and leukotrienes (NRC, 1985a; Lands, 1991). Linoleic acid deficiency results in two primary skin defects: hyperproliferation and increased permeability to water (Ziboh and Miller, 1990). The epidermal water barrier consists of lamellae of lipids (sphingolipids) in the stratum corneum of the epidermis. Linoleic acid is incorporated into the ceramide-portion of sphingolipids where it provides the specific characteristics needed for barrier function (Ziboh and Miller, 1990). Additionally, linoleic acid plays a role in fertility (Lands, 1991). Ensuring an adequate intake of EFAs is key to maintaining normal skin and coat quality.

Whether omega-3 fatty acids are essential is less certain because of the inability of omega-3 fatty acids to support all of the physiologic functions that are supported by omega-6 fatty acids (Lands, 1991). Nevertheless, a source of dietary omega-3 fatty acids is recommended (Watkins, 1997). The minimum recommended allowance for dietary eicosapentaenoic plus docosahexaenoic acids is 0.044% DM (NRC, 2006). Omega-3 fatty acids may moderate excessively vigorous actions of omega-6-derived eicosanoids (Lands, 1991) and are of value in the management of certain diseases (Chapters 30, 32, 34, 37). The minimum recommended allowance for dietary fat in foods for normal, healthy adult dogs is 8.5%, with at least 1% of the food as linoleic acid (DM) (NRC, 2006). Depending on the type/source of fat, increasing the amount of fat in foods increases palatability and EFA levels; however, energy content also increases. The recommended range of fat for foods intended for young adult dogs is 10 to 20% (DM). Lower levels of dietary fat are recommended for obese-prone adult dogs (7 to 10% DM).

### *Fiber*

The levels of dietary fat and fiber are important determinants of a food's energy density. Fat provides more than twice as much energy on a weight basis than carbohydrate or protein. High-fat foods have increased energy density; conversely, low-fat foods have decreased energy density. Fiber is a poor source of energy for dogs; thus, as the fiber content of foods increases, energy density decreases. Dietary fiber reduces the energy density of the food and helps promote satiety (Chapters 5 and 27). Inclusion of fiber in foods may therefore help maintain ideal body weight in dogs fed free choice. In pet foods, fiber is listed as crude fiber, which is an imprecise measure because most soluble fiber is omitted. A better measure would be total dietary fiber; however, regulations only permit declaration of crude fiber because no method for determination of total dietary fiber is yet officially recognized for pet foods. It is difficult to determine the optimal concentration of crude fiber in a complete food for dogs; however, up to 5% DM seems adequate. Obese-prone dogs may benefit from at least 10% DM crude fiber and DM fat should be restricted to between 7 to 10%. Foods that are low in fat and high in fiber tend to have the lowest energy density and are recommended for obese-prone dogs.

### *Protein*

The amount of protein in commercial foods for healthy dogs varies widely (15 to 60% DM). After the amino acid requirements are met for an individual animal, addition of more protein provides no known physiologic benefit. This fact often runs contrary to the popular belief that more protein is better. Also, the addition of extra protein in commercial dog foods is sometimes marketed as necessary for carnivores and misrepresents the fact that dogs are omnivores. Excess dietary protein, above the amino acid requirement, is not stored as protein, but rather is deaminated by the liver. Subsequently, the kidneys excrete the by-products of protein catabolism and the remaining keto acid analogues are used for energy or stored as fat, or as glycogen in some cases.

The subject of whether excess dietary protein contributes to the progression of subclinical kidney disease has yet to be resolved (Chapter 37). Studies in people suggest that protein restriction may help slow progression of kidney disease (Mitch et al, 1998; NKF, 1998). In addition to any potential aggravating effects excess dietary protein may have on subclinical kidney disease, foods high in protein also tend to contain high levels of phosphorus. As mentioned above, excess dietary phosphorus accelerates the progression of kidney disease in dogs. Minimum protein requirements for healthy adult dogs eating high-quality protein have been determined using nitrogen balance and endogenous nitrogen excretion. A more reliable estimate based on endogenous nitrogen excretion equates to a minimum requirement of 1.7 g metabolizable protein/$BW_{kg}^{0.75}$ for an ideal protein (NRC, 1985a; Kendall et al, 1982; Schaeffer et al, 1989). When protein of average quality is used (biologic value of about 70), the minimum requirements are increased to 2.1 to 2.5 g digestible protein/$BW_{kg}^{0.75}$ (Gesellschaft, 1989b).

The minimum crude protein content of food depends on digestibility and quality. For example, if the digestibility of an average quality protein is 75%, then about 12% DM crude protein is adequate. Foods containing less than 12% DM crude protein must be of higher biologic value. Biologic value becomes less important for healthy adult dogs if foods contain crude pro-

tein levels greater than 12%. A daily protein intake for adult maintenance of 4.3 to 5.0 g digestible protein/$BW_{kg}^{0.75}$ (biologic value = 70) or 4.0 to 6.5 g digestible protein/100 kcal ME is recommended (Gesellschaft, 1989b). The minimum recommended allowance for DM crude protein is 10% for a commercial food with an energy density of 4 kcal/g DM (NRC, 2006). Foods formulated to meet the lower limits in crude protein must also have the recommended allowances for essential amino acids. Thus, the recommended range of DM crude protein for foods for young adult dogs is between 15 to 30%.

### *Phosphorus*

Minimum requirements for phosphorus for adult dogs are not very different from those established for other mammals. Commercial foods contain adequate and sometimes excessive amounts of phosphorus and, therefore, should not be supplemented.

Based on endogenous losses, a daily intake of 75 mg phosphorus/kg body weight is adequate (Gesellschaft, 1989a). At an energy density of 3.5 kcal (14.6 kJ)/g DM this corresponds to an average content of about 0.4 to 0.6% DM phosphorus. These levels are adequate, but not excessive; daily intakes 20 to 30% less are still sufficient (Gesellschaft, 1989a). Therefore, it is unnecessary to feed foods with higher levels of phosphorus, or to add calcium-phosphorus supplements to commercial foods. Moreover, higher phosphorus levels are contraindicated for a substantial part of the dog population; up to 25% of the young adult dog population may already be affected by subclinical kidney disease (Oehlert and Oehlert, 1976; Rouse and Lewis, 1975; Shirota et al, 1979). One clinical study revealed that 22.4% of all dogs over five years of age examined at a European veterinary teaching hospital for a variety of reasons had abnormally elevated kidney function tests (Leibetseder and Neufeld, 1991). Excess dietary phosphorus can accelerate progression of chronic renal disease (Brown et al, 1991), whereas phosphorus restriction may slow the progression of chronic renal disease and improve long-term survival (Brown et al, 1991; Finco et al, 1992). It is therefore prudent to feed foods that contain adequate but not excessive amounts of phosphorus (Chapter 37 contains more information about how excess dietary phosphorus affects progression of kidney disease).

The minimum recommended allowance for phosphorus in foods for adult dogs is 0.3% (DM); this recommendation is appropriate for foods with an energy density of 4 kcal/g (DM) (NRC, 2006). The recommended range of phosphorus for foods intended for young adult dogs is 0.4 to 0.8% (DM) when the energy density ranges from 3.5 to 4.5 kcal/g DM.

### *Sodium and Chloride*

Essential hypertension is not considered a common problem in dogs; therefore, higher intakes of dietary sodium and chloride have not been considered harmful in young, healthy dogs (Bodey and Mitchell, 1996; Bovée, 1990). However, one study suggested that up to 10% of apparently healthy dogs may have high blood pressure (Remillard et al, 1991).

High sodium and chloride intake is contraindicated in dogs with certain diseases that may have a hypertensive component such as obesity, renal disease and some endocrinopathies (Anderson and Fisher, 1968; Cowgill and Kallet, 1986; Rocchini et al, 1987; Littman, 1990; Ross, 1992). Uncontrolled high blood pressure may lead to kidney, brain, eye, heart and cardiovascular damage (Cowgill and Kallet, 1986; Littman, 1990). Dietary sodium chloride restriction is the first step in, and an important part of, antihypertensive therapy (Cowgill and Kallet, 1986; Littman, 1990; Ross, 1992).

It is prudent to meet but not greatly exceed sodium and chloride requirements when selecting foods for adult dogs. The best estimate for a minimum requirement of sodium is about 4 mg/kg body weight/day (Morris et al, 1976). Generally, 25 to 50 mg/kg body weight/day (Gesellschaft, 1989a) is recommended for adult maintenance; these levels are six to 12 times more than the minimum. The minimum recommended allowance for sodium content of commercial foods is 0.08% (DM); this allowance is for foods with an energy density of 4 kcal/g (DM) (NRC, 2006). For risk factor management, the recommended range for dietary sodium is 0.2 to 0.4% (DM), which is more than adequate. Sodium levels in commercial foods for adult dogs range from 0.11 to 2.2% DM and are higher in moist foods than in dry foods. In the absence of studies establishing chloride requirements in dogs, a value 1.5 times the sodium requirement is recommended.

### *Antioxidants*

The consequences of prolonged oxidative stress (i.e., free radical damage) to cell membranes, proteins and DNA may contribute to and/or exacerbate a wide variety of degenerative diseases. A partial list includes cancer, diabetes mellitus, kidney/urinary tract disease, heart disease, liver disease, inflammatory bowel disease and cognitive dysfunction (Ames et al, 1993; Kesavulu et al, 2000; Ha and Le, 2000; Thamilselvan et al, 2000; Freeman et al, 1999; Cheng et al, 1999; Center, 1999; Knight, 1999). The consequences of free radical damage to cells and tissues have also been associated with the effects of aging (Harman, 1956).

The body synthesizes many antioxidant enzyme systems and compounds but relies on food for others. Commonly supplemented food-source antioxidants include vitamins E and C, β-carotene and other carotenoids, selenium and thiols. Fruits and vegetables are good sources of flavonoids, polyphenols and anthocyanidins. The following discussion focuses on vitamins E and C and selenium as antioxidant key nutritional factors because: 1) they are biologically important, 2) they act synergistically (e.g., vitamin C regenerates vitamin E after it has reacted with a free radical), 3) they are safe and 4) information about inclusion levels in pet foods is usually available. For improved antioxidant performance, foods for mature dogs should contain at least 400 IU vitamin E/kg (DM) (Jewell et al, 2000), at least 100 mg vitamin C/kg (DM) and 0.5 to 1.3 mg selenium/kg (DM).

#### VITAMIN E

Vitamin E is the main lipid-soluble antioxidant present in

plasma, erythrocytes and tissues (NRC, 2006). It is transported in plasma proteins and partitions into membranes and fat storage sites where it is one of the most effective antioxidants for protecting polyunsaturated fatty acids from oxidation. It functions as a chain-breaking antioxidant that prevents propagation of free radical damage of biologic membranes. Vitamin E inhibits lipid peroxidation by scavenging lipid peroxyl radicals much faster than these radicals can react with adjacent fatty acids or with membrane proteins (Gutteridge and Halliwell, 1994). Vitamin E plays a dominant role in defending against oxidative damage in cells.

The requirement for vitamin E for foods (DM) for adult dogs is 30 mg/kg (NRC, 2006). Research indicates that a level of vitamin E much higher than the requirement confers specific biologic benefits. One antioxidant biomarker study in dogs indicated that for improved antioxidant performance, dog foods should contain at least 500 IU vitamin E/kg (DM) (Jewell et al, 2000). Besides helping to prevent chronic diseases associated with oxidative stress, increasing dietary intake of vitamin E up to 2,010 mg/kg food (DM) in older dogs improved immune function (Hayes et al, 1969; Hall et al, 2003; Meydani et al, 1998). Furthermore, increased vitamin E intake is also directly related to increased vitamin E content of skin in dogs (Jewell et al, 2002). The skin is uniquely challenged by oxidants due to its role as a barrier. It is exposed to air pollutants, ultraviolet radiation and oxidants released as a result of normal metabolism, parasites and aerobic microbes. An upper limit of 1,000 to 2,000 IU/kg food (DM) has been suggested for dogs (AAFCO, 2007; NRC, 1985). In one study that demonstrated improved immune function associated with ingestion of 2,010 IU vitamin E/kg food (DM) (Hall et al, 2003), dogs had no safety issues at this intake level for one year.[a] A prudent recommendation is that foods for young adult dogs should contain at least 400 IU vitamin E/kg (DM).

### VITAMIN C

Vitamin C is the most powerful reducing agent available to cells. As such, it is important for regenerating oxidized vitamin E. Besides regenerating vitamin E, vitamin C: 1) regenerates glutathione and flavonoids, 2) quenches free radicals both intra- and extracellularly, 3) protects against free radical-mediated protein inactivation associated with oxidative bursts of neutrophils, 4) maintains transition metals in reduced form and 5) may quench free radical intermediates of carcinogen metabolism.

Dogs can synthesize required amounts of vitamin C (Innes, 1931; Naismith, 1958; Chatterjee et al, 1975) and they can rapidly absorb supplemental vitamin C (Wang et al, 2001). However, in vitro studies indicated that dogs (and cats) have from one-quarter to one-tenth the ability to synthesize vitamin C as other mammals (Chatterjee et al, 1975). Whether or not this translates to a reduced ability in vivo is unknown. In conjunction with the recommended levels of vitamin E, above, for improved antioxidant performance, foods for adult dogs should contain at least 100 mg of vitamin C/kg (DM).

Excessive supplementation of vitamin C should be avoided. In people, high levels of oral vitamin C increased urine oxalate excretion and stone risk (Massey et al, 2005). Vitamin C supplementation to cats resulted in a small, progressive reduction of urinary pH (Kienzel and Maiwald, 1998). However, moderate supplementation of foods for healthy adult cats with vitamin C (193 mg/kg of food, DM) did not increase the risk of oxalate production in urine (Yu and Gross, 2005).

### SELENIUM

Glutathione peroxidase is a selenium-containing antioxidant enzyme that defends tissues against oxidative stress by catalyzing the reduction of $H_2O_2$ and organic hydroperoxides and by sparing vitamin E. The minimum requirements for selenium in foods for dogs and cats are 0.10 and 0.13 mg/kg (DM), respectively (Wedekind et al, 2002, 2003, 2003a). Animal studies and clinical intervention trials in people have shown selenium to be anticarcinogenic at levels much higher (five to 10 times) than human recommended allowances or minimal requirements (Combs, 2001; Neve, 2002). Several mechanisms have been proposed for this effect, including enhanced antioxidant activity via glutathione peroxidase (Neve, 2002). Therefore, for increased antioxidant benefits, the recommended range of selenium for adult dog foods is 0.5 to 1.3 mg/kg (DM). There are no data to base a safe upper limit of selenium for dogs, but for regulatory purposes, a maximum standard of 2.0 mg/kg (DM) has been set for dog foods in the U.S. (AAFCO, 2007).

## *Food Texture*

Periodontal disease is the most common health problem of adult dogs (Harvey et al, 1994) and may predispose affected animals to systemic complications (DeBowes et al, 1996). Periodontal disease can be prevented in many dogs with routine veterinary care and frequent plaque control at home. Feeding recommendations for oral health commonly include feeding a dry pet food (Golden et al, 1982). However, typical dry dog foods contribute little dental cleansing and the general statement that dry foods provide significant oral cleansing should be regarded with skepticism. Research has demonstrated that maintenance dog foods with specific textural properties and processing techniques can significantly reduce plaque accumulation and maintain gingival health. If the labels of such foods carry the Veterinary Oral Health Council (VOHC) seal, they have been successfully tested according to specific protocols and shown to be clinically effective in reducing accumulation of plaque (Chapter 47).

# FEEDING PLAN

## Assess and Select the Food

After the nutritional status of the dog has been assessed and the key nutritional factors and their target levels determined, the adequacy of the food is assessed. The steps for assessing foods for normal adult dogs are to: 1) ensure that the nutritional adequacy of the food has been assured by a credible regulatory agency such as the Association of American Feed Control Officials (AAFCO) for foods sold in the U.S., 2) compare the

**Table 13-4.** Selected commercial foods for young to middle-aged adult dogs compared to recommended levels of key nutritional factors.*

| Dry foods | Energy density (kcal/cup)** | Energy density (kcal ME/g) | Fat (%) | Fiber (%) | Protein (%) | P (%) | Na (%) | Vit E (IU/kg) | Vit C (mg/kg) | Se (mg/kg) | VOHC plaque (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Recommended levels (normal body condition)** | **-** | **3.5-4.5** | **10-20** | **≤5** | **15-30** | **0.4-0.8** | **0.2-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Lamb Meal & Rice Recipe | 364 | 4.0 | 16.0 | 2.5 | 23.0 | 0.67 | 0.29 | 582 | 174 | 0.54 | No |
| Hill's Science Diet Oral Care Adult | 273 | 3.8 | 15.5 | 10.1 | 25.1 | 0.65 | 0.24 | 564 | 175 | 0.62 | Yes |
| Iams Adult Lamb Meal & Rice Formula | 330 | 4.0 | 14.2 | 4.2 | 25.1 | 1.6 | 0.65 | 123 | 52 | 0.37 | No |
| Iams Chunks | 381 | 4.4 | 17.8 | 2.9 | 29.8 | 1.1 | 0.6 | 103 | 43 | 0.27 | No |
| Iams Eukanuba Medium Breed Adult | 404 | 4.7 | 17.9 | 2.1 | 27.8 | 1.16 | 0.55 | na | na | na | No |
| Iams ProActive Health Chunks | 374 | 4.0 | 17.0 | 1.9 | 28.9 | 1.21 | 0.58 | na | na | na | No |
| Medi-Cal Dental Formula | 290 | na | 12.7 | 5.3 | 19.7 | 0.9 | 0.4 | na | na | na | No |
| Medi-Cal Preventive Formula | 340 | na | 16.3 | 2.7 | 23.9 | 0.8 | 0.4 | na | na | na | No |
| Nutro Natural Choice Dental Care Lamb Meal and Rice | 287 | 3.7 | 15.4 | 4.4 | 23.6 | 1.54 | 0.22 | 275 | 71 | 1.65 | No |
| Nutro Natural Choice Lamb Meal and Rice | 342 | 3.8 | 14.3 | 2.2 | 24.2 | 1.54 | 0.33 | 220 | 66 | 0.77 | No |
| Purina Dog Chow | 430 | 4.2 | 11.4 | 5.1 | 23.9 | 0.91 | 0.42 | 144 | na | 0.64 | No |
| Purina ONE Total Nutrition Lamb & Rice Formula | 451 | 4.7 | 20.1 | 1.8 | 30.5 | 1.09 | 0.52 | na | na | na | No |
| Purina Pro Plan Chicken & Rice Formula | 489 | 4.8 | 16.9 | 3.4 | 33.8 | 1.22 | 0.46 | na | na | na | No |
| Royal Canin MINI Adult 27 | 352 | 4.3 | 17.4 | 1.6 | 29.3 | 0.87 | 0.43 | 717 | 326 | 0.22 | No |
| Royal Canin MINI Dental Hygiene 24 | 320 | 4.2 | 15.4 | 1.8 | 26.4 | 0.77 | 0.33 | 659 | 330 | 0.21 | No |
| Waltham Pedigree Small Crunchy Bites | 290 | 3.8 | 13.7 | 2.0 | 26.0 | 1.55 | 0.65 | 256 | 80 | na | No |
| **Moist foods** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)** | **Fat (%)** | **Fiber (%)** | **Protein (%)** | **P (%)** | **Na (%)** | **Vit E (IU/kg)** | **Vit C (mg/kg)** | **Se (mg/kg)** | **VOHC plaque (Yes/No)** |
| **Recommended levels (normal body condition)** | **-** | **3.5-4.5** | **10-20** | **≤5** | **15-30** | **0.4-0.8** | **0.2-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Adult Advanced Savory Chicken Entrée | 345/13 oz. | 3.9 | 17.1 | 1.3 | 26.7 | 0.67 | 0.25 | 200 | na | 1.00 | No |
| Medi-Cal Preventive Formula | 435/396 g | na | 20.1 | 3.3 | 23.8 | 0.7 | 0.3 | na | na | na | No |
| Purina Pro Plan Adult Chicken & Rice Entrée Classic | 426/13 oz. | 4.9 | 36.6 | 0.9 | 40.4 | 1.36 | 0.47 | na | na | na | No |

food's key nutritional factor content with the recommended levels (**Tables 13-3** and **13-4**).

Whether or not commercial foods for healthy pets have been AAFCO approved can usually be determined from the nutritional adequacy statement on the product's label (Chapter 9). Although it is important to ensure nutritional adequacy, AAFCO approval does not ensure the food will be effective in preventing long-term health problems. Thus, in addition to having AAFCO approval, the food should be evaluated to ensure the key nutritional factors are at appropriate levels for delivering the feeding goal of promoting long-term health.

**Table 13-4** compares the key nutritional factor recommendations for foods for young adult dogs to the key nutritional factor profiles of selected commercial foods sold in the U.S. and Canada. The manufacturer should be contacted if the food in question cannot be found in **Table 13-4.** Manufacturers' addresses, websites and toll-free phone numbers are listed on pet food labels.

Comparing a food's key nutritional factor content with the key nutritional factor target levels will help identify any significant discrepancies in the food being fed. This comparison is fundamental to determining whether or not to feed a different food. The current food should be changed if significant differences are seen between the recommended key nutritional factor levels and those in the food currently fed.

Commercial treats, snacks and table food should also be included in the food assessment step because they are part of the total food intake of an animal and, if misused, may create

**Table 13-4 (cont.)** Selected commercial foods for young to middle-aged adult dogs compared to recommended levels of key nutritional factors.*

| Dry foods | Energy density (kcal/cup)** | Energy density (kcal ME/g) | Fat (%) | Fiber (%) | Protein (%) | P (%) | Na (%) | Vit E (IU/kg) | Vit C (mg/kg) | Se (mg/kg) | VOHC plaque (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Recommended levels (inactive/obese prone)** | **-** | **3.0-3.5** | **7-10** | **≥10** | **15-30** | **0.4-0.8** | **0.2-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Light Adult | 295 | 3.3 | 8.8 | 14.6 | 24.5 | 0.58 | 0.23 | 586 | 276 | 0.45 | No |
| Iams Eukanuba Medium Breed Weight Control | 275 | 4.2 | 10.5 | 1.9 | 21.3 | 0.76 | 0.50 | 206 | 42 | 0.34 | No |
| Iams Weight Control | 328 | 4.2 | 12.5 | 2.8 | 22.2 | 0.85 | 0.37 | 103 | 44 | 0.35 | No |
| Medi-Cal Weight Control/Mature | 320 | na | 8.5 | 4.0 | 19.5 | 0.8 | 0.2 | na | na | na | No |
| Nutro Natural Choice Lite | 244 | 3.4 | 7.2 | 4.4 | 16.7 | 1.22 | 0.33 | 161 | 67 | 0.44 | No |
| Purina Pro Plan Chicken & Rice Weight Management | 337 | 3.7 | 10.2 | 2.7 | 30.5 | 1.06 | 0.27 | 503 | na | 0.33 | No |
| Royal Canin MINI Weight Care 30 | 326 | 3.8 | 12.0 | 6.2 | 32.6 | 0.82 | 0.33 | 652 | 326 | 0.16 | No |
| **Moist foods** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)** | **Fat (%)** | **Fiber (%)** | **Protein (%)** | **P (%)** | **Na (%)** | **Vit E (IU/kg)** | **Vit C (mg/kg)** | **Se (mg/kg)** | **VOHC plaque (Yes/No)** |
| **Recommended levels (inactive/obese prone)** | **-** | **3.0-3.5** | **7-10** | **≥10** | **15-30** | **0.4-0.8** | **0.2-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Light Adult | 322 kcal/13 oz. | 3.4 | 8.6 | 9.7 | 19.5 | 0.51 | 0.31 | 385 | na | 0.78 | No |
| Medi-Cal Weight Control/Mature | 370 kcal/396 g | na | 10 | 5.5 | 21.5 | 0.6 | 0.3 | na | na | na | No |

Key: ME = metabolizable energy, Fiber = crude fiber, P = phosphorus, Na = sodium, Se = selenium, VOHC = Veterinary Oral Health Council, na = information not available from manufacturer, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.

an imbalance in an otherwise balanced feeding plan. Excessive feeding of treats and snacks may markedly affect the cumulative nutritional profile (**Box 13-4**). The impact of snacks on daily nutrient intake depends on two factors: 1) the nutrient profile of the snack and 2) the number provided daily. Thus, if snacks are fed, it is prudent to recommend those that best match the nutritional profile recommended for a particular lifestage. However, meeting nutrient requirements is not the primary goal of feeding treats; consequently, many commercial treats are not complete and balanced. A few treats are complete and balanced and are approved by AAFCO, or some other credible regulatory agency. Similarly, most table foods are not nutritionally complete and balanced and may contain high levels of fat or minerals. If snacks are fed, it is simplest to recommend that they be commercial treats that, if possible, match the nutritional profile recommended for a particular lifestage (see product label). Generally, any snacks should not be fed excessively (<10% of the total diet on a volume, weight or calorie basis). Otherwise, the nutritional composition of the snack and food should be combined and assessed as the entire diet.

## Assess and Determine the Feeding Method

The feeding method includes the amount fed and how it is fed (free choice vs. some type of restricted feeding). It may not always be necessary to change the feeding method when managing healthy adult dogs in optimal body condition. However, a thorough evaluation includes verification that an appropriate feeding method is being used. In addition, current or future risk factors such as obesity should be considered when evaluating the current method. Current feeding methods should have been obtained when the history was taken.

Nutrient requirements of dogs and intake of appropriate levels of key nutritional factors are met, not only by the amount of nutrients in the food, but also by how much food is fed. If the dog in question has an ideal BCS (2.5/5 to 3.5/5), the amount being fed is probably appropriate. The amount fed can be estimated either by calculation (Chapter 1) or by referring to feeding guides on product labels. Such calculated amounts and feeding guides represent population averages and, likely, may need to be adjusted for individual dogs. If possible, owners should check the dog's body weight and/or be taught to regularly evaluate their dog's BCS. If these measurements indicate a trend of increasing or decreasing body weight or BCS, pet owners should be counseled to change the amount fed by 10% increments.

Besides establishing how much food is being fed, another part of feeding method assessment is to determine how the food is offered (i.e., when, where, by whom and how often). An

## Box 13-4. Impact of Treats on Daily Nutrient Intake.

From 60 to 86% of owners regularly give their dogs commercial treats. If table foods are considered, 90% or more of dogs receive treats, snacks and biscuits as a supplement to their regular food. People like to give treats and snacks for emotional reasons, to change their pet's behavior or to improve and maintain oral health. Because several daily treats will have a marked effect on a dog's cumulative nutritional intake, specific questions about treats should be asked when taking the dietary history. Specific recommendations about treats should be provided when prescribing a food regimen for diseased or healthy dogs. This information is critical when managing specific problems such as developmental orthopedic disease in growing large- and giant-breed dogs, adverse reactions to food, obesity, urolithiasis, diabetes mellitus, heart failure and renal disease.

The impact of snacks on a dog's daily nutrient intake depends on two factors: 1) the nutrient profile of the treat and 2) the number of treats provided daily. It is best to recommend a treat that matches the nutritional profile preferred for a given lifestage or disease. Snacks provide energy; a handful of dog snacks, for example, can easily be equivalent to 40% of a small dog's daily energy requirement (DER) or 10% of a large-breed dog's DER. Therefore, the owner must compensate for the additional energy by feeding less of the dog's usual food. This recommendation is especially important for dogs in which a small snack can have a marked impact (i.e., toy- and small-breed dogs). The following two examples illustrate the impact of treats on daily nutrient intake.

A six-year-old, neutered male miniature pinscher weighing 4.5 kg is fed two commercial biscuit treats per day, in addition to its regular food. Each biscuit provides 15 kcal (62.8 kJ), so the dog receives a total of 30 kcal (125.5 kJ) per day from the treats. The dog's DER is about 330 kcal (1,381 kJ). Therefore, the treats provide almost 10% of the dog's DER. If the dog's DER is being met with the regular food, then the treats may contribute to long-term excess energy intake and obesity.

A five-month-old, 20-kg, female German shepherd dog is given a commercial treat marketed as a snack with "real marrow bone." Calcium is not declared on the guaranteed or typical analysis of the treat label. The owner gives the dog 10 treats daily as part of a training program. This number of treats is within the feeding guidelines on the label. However, analysis shows that each treat contains 426 mg of calcium. Consuming 10 treats daily increases the dog's daily calcium intake by more than 80% compared with feeding a commercial food formulated for large-breed puppies. This feeding practice increases the risk of developmental orthopedic disease (Chapter 33). To facilitate learning, dogs do not need to receive edible reinforcement every time and the pieces can be very small. If praise is paired with treats, praise alone will rapidly become sufficient reinforcement for the desired behavior.

The Bibliography for **Box 13-4** can be found at www.markmorris.org.

**Table 13-5.** Advantages and disadvantages of various feeding methods for dogs.

| Method | Advantages | Disadvantages |
|---|---|---|
| Free-choice feeding | Less labor intensive<br>Less knowledge required<br>Quieting effect in a kennel<br>Less dominant dogs have a better chance to get their share | Less control over food intake<br>Predisposes to obesity<br>Less monitoring of individual changes in food intake |
| Meal-restricted feeding | Better control of food dose<br>Early detection of altered appetite<br>Better control of body weight | Intermediate labor intensive<br>Most knowledge required for food dose calculation |
| Time-restricted feeding | Intermediate control of food dose<br>Some monitoring of appetite possible | Inaccurate control of food intake<br>Risk of obesity similar to free choice<br>Most labor intensive |

important determinant of food intake in domestic dogs is the owner's and other family members' involvement because these factors usually control the amounts and types of food fed (Rabot, 1993; Mugford and Thorne, 1980; Houpt and Smith, 1981; Houpt, 1991). Studies show that owners typically feed their dogs one (26 to 77% of owners) to two (19 to 50% of owners) meals per day (Slater et al, 1995; Mugford and Thorne, 1980; Campbell, 1986). Often, pet owners overestimate needs and feed too much (Rabot, 1993). Furthermore, despite widespread concern about obesity among pet owners, most people do not recognize overweight/obesity in their own dog (Singh et al, 2002). Pet dogs may eat several small meals daily when fed a commercial dry food free choice and still maintain an ideal body weight (Mugford and Thorne, 1980). However, relatively inactive dogs fed a highly palatable, energy-dense food free choice are at increased risk for obesity (Houpt, 1991). Most pet dogs are relatively inactive (NRC, 2006).

Both free choice and restricted feeding methods (time restricted or food restricted) have advantages and disadvantages. Although free-choice feeding is most popular, it can lead to the most problems. As an alternative, meal-restricted feeding is simple and more precise in delivering the required

## Box 13-5. Alternative Eating Behaviors.

### RESPONSE TO FOOD VARIETY

Dogs may display preferences for specific types of foods according to taste and texture. However, the notion that dogs require a variety of flavors or taste in their meals is incorrect and may be detrimental in some instances. Dogs prefer novel foods or flavors to familiar foods; therefore, feeding a variety of novel foods free choice may lead to overeating and obesity. Dogs may correct for excessive energy intake by decreasing or refusing food intake the next day(s). Reduction of food intake to maintain weight following engorgement may erroneously be interpreted as a dislike of the current food instead of an auto-regulatory mechanism to achieve the previous set-point weight.

### GARBAGE EATING

Garbage eating is probably normal behavior. Many dogs prefer food in an advanced stage of decomposition. However, garbage eating is oftentimes unhealthy. Ingestion of garbage may cause brief, mild gastroenteritis or more serious intoxication (Chapter 11). Because the etiology is complex and may involve bacterial toxins, mycotoxins and by-products from putrefaction or decomposition, the clinical signs vary widely from vomiting, diarrhea, abdominal pain, weakness, incoordination and dyspnea, to shock, coma and death. Scavenging dogs may eat less of their regular meal; therefore, garbage eating may be mistaken for anorexia at home.

Spraying garbage bags with a dog repellent usually will not stop the problem. Preventing access to garbage is the obvious best solution.

### GRASS EATING

Owners often ask why dogs eat grass. Plant and grass eating is normal behavior. Herbivores are the natural prey for wolves and most other canids. The viscera of prey are often eaten first and contain partially digested vegetable material. Because dogs' ancestors and close relatives in the wild regularly ingest plant material, some investigators have suggested that domestic dogs must also eat grass. Probably the better explanation is that, to date, no one knows for sure why dogs eat plants or grass, but they may simply like the way plants taste or prefer the texture. Plant chlorophyll can bind mycotoxins, such as those found in moldy grains, decreasing their absorption.

### BEGGING FOR FOOD

Begging for food may be fun when dogs sit up or perform other tricks; however, the behavior can become annoying when whining, barking, persistent nudging and scratching take over. Begging for food was one of the most common complaints addressed in a study involving more than 1,400 owners and was perceived as a problem in one-third of the dogs. Additionally, begging may encourage owners to feed more of the dog's regular food. Begging tends to increase with age and may indicate that most owners don't realize that they reinforce begging by continuing to offer tidbits to their begging pet. Treats reinforce begging. Also, the fact that begging for food is directly proportional to the number of people in the family may be related to an increase in the number of tidbits fed.

Treatment consists of ignoring behaviors such as begging, barking and whining. Owners should be prepared for a prolonged period of such behaviors before begging subsides completely. Intermittent reinforcement of begging when these behaviors become problematic can be more powerful than continuous rewarding, even though the owner may have refused to provide snacks in the interim. It may also help to keep the dog out of the kitchen and dining areas when preparing and eating food and to feed the dog before or after the family has eaten.

### PICA

Pica is defined as perverted appetite with craving for and ingestion of non-food items. The etiology of true pica is unknown. Suggested causes include mineral deficiencies, permanent anxiety and psychological disturbances. A few cases of pica have been noted in relation to zinc intoxication and hepatic encephalopathy. Pica is common in dogs with exocrine pancreatic insufficiency, probably as a manifestation of polyphagia, and perhaps as a consequence of some specific nutritional deficiency. Sometimes, coprophagy and garbage eating are mistakenly considered forms of pica.

Pica can be treated with aversion therapy by offering a counter attraction at the moment the dog begins to eat foreign material and by punishment if there is no response. Outdoors, the dog should be kept on a leash or even muzzled. Most treatments for pica are unrewarding. Physically preventing the animal from engaging in pica is sometimes the only solution.

### COPROPHAGY

Coprophagy is defined as eating feces and may involve consumption of the animal's own stools or the feces of other animals. Coprophagy is probably widespread among pet dogs and is probably more disturbing to owners than it is harmful to dogs. Bitches normally eat the feces of their puppies during the first three weeks of lactation. Feral dogs and dogs in rural areas have access to and consume large-animal feces, which is considered normal behavior. In many cases, however, coprophagy is a behavioral problem and the etiology is unknown. Coprophagy can also be related to certain diseases.

**Table 1** lists behavioral and metabolic disorders that may be associated with coprophagy. The risk of transmitting parasitic diseases is probably the most important health reason for managing coprophagy; however, the associated halitosis is of primary concern to owners. The dog's motivation must be reduced to correct coprophagy. Several measures have been proposed.

Punishment may deter the dog's behavior, but may violate the confidence between owner and pet. Punishment may also aggravate the coprophagic behavior. Thus, a good balance has to be found. Walking the dog on a leash and keeping it away from feces after the dog defecates is helpful.

*Box 13-5 continued*

Repulsive substances can be used to create aversion for feces. Many different products have been recommended including spices (e.g., pepper, sambal, hot pepper sauce), quinine, strong perfumes and specific products such as cythioate, meat tenderizers and For-Bid.[a] Adding repulsive substances to feces can be time-consuming and has questionable efficacy.

Food changes to deter coprophagy have been recommended; however, most of these recommendations lack substantiation. Using foods with increased fiber levels has been reported to help. Free-choice feeding has also been recommended, whereas a strict schedule of two meals per day and avoiding all tidbits or table foods has worked for others.

**ENDNOTE**

a. Alpar Laboratories Inc., La Grange, IL, USA.

The Bibliography for **Box 13-5** can be found at www.markmorris.org.

**Table 1.** Factors associated with coprophagy.

| |
|---|
| **Behavior** |
| Confinement in a kennel leading to stress or competitive behavior |
| Confinement leading to boredom with all exploratory effort focused on feces |
| Reaction to punishment during housetraining |
| Strong dominance or extreme submissive attitude towards the owner |
| To attract the owner's attention |
| Young animals with a natural interest in feces |
| **Gastrointestinal disorders** |
| Malassimilation |
| Parasitic infections |
| Polyphagia due to diabetes mellitus or Cushing's syndrome |
| **Food** |
| Overfeeding |
| Poorly digestible food |

**Table 13-6.** Feeding plan summary for young adult dogs.

1. Select a food or foods with the best levels of key nutritional factors (**Table 13-4**); for foods not in **Table 13-4**, contact the manufacturer for key nutritional factor content.
2. The selected food should also be approved or meet requirements established by a credible regulatory agency (e.g., AAFCO).
3. Determine the preferred feeding method (**Table 13-5**); when the correct amount of food is fed, meal-restricted feeding is least likely to result in obesity.
4. For food-restricted meal feeding, estimate the initial quantity of food based on DER calculation (DER ÷ food energy density).
5. Body condition and other assessment criteria will determine the DER. DER is calculated by multiplying RER by an appropriate factor (Table 5-2). Remember, DER calculations should be used as guidelines, starting points and estimates for individual dogs and not as absolute requirements.
   - Neutered adult = 1.6 x RER
   - Intact adult = 1.8 x RER
   - Inactive/obese-prone adult = 1.2 to 1.4 x RER (Most pet dogs are relatively inactive)
   - Working adult = 2.0 to 8.0 x RER (Chapter 18)
6. Monitor body weight, body condition and general health. These parameters are used to refine the amount to feed.

Key: AAFCO = Association of American Feed Control Officials, DER = daily energy requirement, RER = resting energy requirement.

amount of food. Time-restricted feeding is less effective for controlling the amount of food consumed and is more labor intensive. **Table 13-5** provides a brief review of these feeding methods. See Chapter 1 for a more in-depth discussion of feeding methods.

If a food change is in order and/or the amount fed needs to be modified, knowledge of the presence of other pets in the home, which family member is responsible for selecting and purchasing the dog's food and who feeds the dog regularly are helpful for evaluating the feasibility of new dietary recommendations and improving compliance. Most healthy adult dogs adapt well to new foods. However, it is good practice to allow for a transition period to avoid digestive upsets. This is particularly true when switching from lower fat foods to higher fat foods or when changing forms of food (e.g., changing from dry to moist food). The new food should be increased and old food decreased in progressive amounts over a three- to seven-day period until the changeover is completed (Nott et al, 1993) (Chapter 1).

Dogs may eat an insufficient amount or completely refuse new food, especially if the new food is lower in palatability as may be required for health concerns (e.g., lower fat content). Investigation of food refusal may reveal problems with owner compliance rather than a finicky appetite. The following guidelines may be useful when a food change must be made: 1) Explain clearly to the owners why a change in food is necessary or preferable. 2) Justify your recommendation to the owners (i.e., food profile vs. specific needs of the dog). 3) As a general rule, start with one or two meals per day, always presented at the same time. Uneaten food should be removed after 15 to 20 minutes. 4) Don't give treats or table foods between meals for the first few days. If a small snack is given, it should be given immediately (i.e., within seconds) after the new food is eaten. Most dogs will accept the new food within a few days. **Table 13-6** summarizes the feeding plan recommendations discussed above.

Finally, owners are often concerned about alternative eating behaviors displayed by their dogs. In fact, these behaviors may be more offensive to the owner than detrimental to the dog. Alternative eating behaviors may be of nutritional or non-nutritional origin, and some may indicate underlying disease (**Box 13-5**).

## REASSESSMENT

Owners should be encouraged to weigh their dog every month, and should be trained to observe their dog and adapt the food intake according to its needs. Dogs whose nutrition is well managed are usually alert, have an ideal BCS (2.5/5 to 3.5/5) with a stable, normal body weight and a healthy coat. Stools should be firm, well formed and medium to dark brown.

Reassessment by a veterinarian should take place regularly. Healthy dogs should be reassessed every six to 12 months. Because few if any homemade recipes have been tested according to prescribed feeding protocols, dogs should be reassessed more frequently if homemade food is a significant part of their caloric intake. Reassessment should take place immediately if clinical signs arise indicating that the current feeding regimen is inappropriate, or if the dog's needs change (e.g., reproduction or change in activity).

If expected results are not obtained, the owner should also be questioned in detail about compliance with the feeding regimen or the possibility that the dog has access to other food sources.

## ENDNOTE

a. Jewell DE. Hill's Science and Technology Center, Topeka, KS. Personal communication (data on file). March 30, 2007.

## REFERENCES

The references for **Chapter 13** can be found at www.markmorris.org.

## CASE 13-1

### Feeding a Young Basset Hound after an Ovariohysterectomy

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### Patient Assessment

A 12-month-old female basset hound was admitted for an ovariohysterectomy. The owners had observed no problems since purchasing the dog from a pet store eight months before. Physical examination revealed a normal 20-kg dog (body condition score [BCS] 3/5) except for excessive accumulation of waxy debris in both ears. Results of preanesthetic blood work were normal. The ovariohysterectomy was performed with no complications. The owners returned to pick up the dog the next day.

### Assess the Food and Feeding Method

The dog was fed a commercial specialty brand growth formula (Science Diet Lamb Meal & Rice Formula Canine Growth[a]) that the owners purchased from the pet store where they obtained the dog. The owners had been following the feeding directions on the pet food label. They were currently feeding one can of the growth formula in the morning (520 kcal, 2.18 MJ) and two cups (200 g) of the dry formulation of the same brand in the evening (780 kcal, 3.26 MJ). The dog's appetite had been good. The owners also gave the dog two commercial treats each day (Science Diet Canine Growth Treats[a]) (19 kcal [79 kJ] per treat).

### Questions

1. What are the key nutritional factors to consider in developing a feeding plan for this young neutered adult dog?
2. What response should be given when the owners ask whether the ovariohysterectomy will change the feeding recommendations for their dog?
3. Outline a specific feeding plan for this patient including an appropriate food and feeding method.

### Answers and Discussion

1. Key nutritional factors for young adult dogs include water, energy, phosphorus, calcium, protein, sodium, chloride, fat and essential fatty acids, antioxidants and food texture. In general, water requirements are met by allowing free access to a source of potable water. Energy, fat and fiber are important because prevention of obesity is an important goal of feeding adult dogs. Phosphorus, calcium, sodium and chloride requirements should be met but not greatly exceeded. Essential fatty acids are important for maintenance of normal skin and coat, a primary concern of many dog owners. Food texture is important in controlling periodontal disease, the most common health problem of adult dogs. Antioxidants may help prevent certain diseases.
2. Gonadectomy increases the risk of obesity in dogs. Neutered female dogs are about twice as likely to be overweight as intact female dogs. A similar trend occurs in castrated male dogs. Gonadectomy predisposes dogs to weight gain and eventual obesity

for several reasons. Daily energy requirement (DER) may decrease because of metabolic changes associated with gonadectomy. Furthermore, studies have demonstrated that neutered female dogs eat more food and gain more weight than sham-operated females fed identical food. Thus, removal of the metabolic effects of estrogens and androgens by gonadectomy may lead to increased food consumption when the animal's energy requirement is simultaneously lower due to decreased metabolic rate and physical activity. These are important considerations when creating a feeding plan for young neutered adult dogs.

3. Basset hounds are predisposed to obesity. Gonadectomy and the breed predisposition to obesity make obesity prevention a primary goal in developing a feeding plan for this patient. This dog has also reached adulthood; therefore, the levels of nutrients found in growth-type formulas are unnecessary.

   The food should be changed from a growth formula to an adult maintenance formula. In general, adult maintenance formulas of the same brand contain less energy, fat, phosphorus, calcium, sodium and chloride than growth formulas. These lower levels of nutrients exceed the minimum nutrient requirements of adult dogs while avoiding the higher nutrient levels found in growth or all-purpose type formulas. This dog's optimal BCS suggests that it is eating an appropriate amount of food. However, gonadectomy and other metabolic changes associated with maturity will probably decrease the DER. The estimated DER would be 1.4 to 1.6 x resting energy requirement (RER) (940 to 1,070 kcal, 3.93 to 4.48 MJ). The dog is currently consuming 1,300 kcal (5.44 MJ) or 2 x RER. The feeding method will be dictated somewhat by whether moist, dry, semi-moist or homemade foods are fed. The owners are currently meal feeding a combination of moist and dry foods; this feeding method can be continued with the new food.

## Progress Notes

The dog was discharged to the owners' care with instructions to limit exercise for several days, examine the suture line daily for signs of swelling or inflammation and return for suture removal in 10 to 14 days. The owners were shown how to clean the ears and an otic cleaning solution was dispensed.

The owners were interested in continuing to feed a combination of moist and dry food. They were instructed to purchase the same brand adult maintenance food (Science Diet Lamb Meal & Rice Formula Canine Maintenance[a]) and gradually mix the new food with the old food until the moist and dry growth formulas were completely gone. A combination of the adult maintenance food consisting of one large (418 g) can of moist food in the morning (420 kcal, 1.76 MJ) and 1 2/3 cups (165 g) of dry food in the evening (610 kcal, 2.59 MJ) would provide approximately 1.6 x RER for the dog's current weight of 20 kg. Two treats per day were also continued; however, the owners were encouraged to use the adult maintenance formula of the same treat (18 kcal [75 kJ] per treat).

Prevention of obesity was emphasized to the owners because of the risk factors discussed earlier. They were given an instruction sheet that outlined how to score the dog's body condition and encouraged to weigh the dog monthly. They were instructed to call the practice if the dog appeared to be gaining weight or if the dog's BCS increased. Periodontal disease, veterinary oral care and routine home oral care were also discussed.

## Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA. Science Diet Lamb Meal & Rice Formula Canine Growth and Science Diet Lamb Meal & Rice Formula Canine Maintenance are currently marketed as Science Diet Lamb Meal & Rice Recipe Puppy and Science Diet Lamb Meal & Rice Recipe Adult.

## Bibliography

Anantharaman-Barr G. The effect of ovariohysterectomy on energy metabolism in dogs (research abstract). Friskies Veterinary International 1990; 2: 19-20.

Chapter 14

# Feeding Mature Adult Dogs: Middle Aged and Older

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*"Old dogs, like old shoes, are comfortable. They might be a bit out of shape and a little worn around the edges, but they fit well."*
*Bonnie Wilcox 'Old Dogs, Old Friends'*

## INTRODUCTION

For a number of reasons, the mature segment (six to eight years of age and older) of the pet dog population is growing. More than 35% of dogs in the U.S. are at least seven years old and, in Europe, the number of dogs older than seven years increased by about 50% from 1983 to 1995 (Lund et al, 1999; Kraft, 1998). In this chapter, mature dogs include dogs that are middle aged and older. In people, middle age is often considered as being approximately the third quarter of the average lifespan.

Aging increases vulnerability (Mosier, 1989; Hayflick, 1994). Aging isn't a disease; however, morbidity increases with age because normal changes make animals more vulnerable to diseases (Hayflick, 1994). The influence of nutrition on vulnerability to chronic or acute disease is difficult to evaluate, and has not been explored thoroughly in dogs. In people and companion animals, nutrition may be one of the more important aspects of geriatric care because delay or elimination of the two or three leading causes of death would profoundly affect life expectancy (Hayflick, 1994a). In dogs, the three leading nonaccidental causes of death are cancer, kidney disease and heart disease (Bronson, 1982; MacDougall and Barker, 1984; MAF, 1991, 1998). Other diseases and disorders are also common (Table 13-1). Moreover, older animals seldom suffer from a single disease and one problem may markedly influence the course of another (Mosier, 1990).

The overall feeding goals for mature adult dogs are to optimize quality and longevity of life and minimize disease. To understand the specific nutritional needs of mature dogs, it is necessary to know the major effects of aging on canine body systems (**Box 14-1**). Aging is characterized by progressive and, usually, irreversible change (Mosier, 1988), and its rate and manifestations are determined by intrinsic and extrinsic factors, one of which is nutrition. Because aging is progressive, the point in time at which a food change should be made is arbitrary, and in a way philosophical. Dogs often are considered mature or likely to start having diseases associated with aging between seven and one-half and 13.5 years (Goldston, 1989). Smaller dogs tend to live longer than large dogs (**Table 14-1**). The life expectancy of smaller dogs may be more than 20 years. Because dogs are often considered older when they reach half of their life expectancy (Grandjean and Paragon, 1990), a food change should be considered around the age of five years for large- and giant-breed dogs and around seven years for small dogs (Markham and Hodgkins, 1989).

At these ages, dogs may gradually start to gain weight and develop age-related physical and behavioral changes (Armstrong and Lund, 1996; Markham and Hodgkins, 1989; Landsberg and Ruhl, 1997). Clinical signs of cognitive dysfunction and brain pathology associated with aging begin at about seven to eight years of age (Head et al, 2000).[a]

However, veterinarians should not accept the tenant that poor health and old age are synonymous (Goldston, 1989). There is a real opportunity to improve the quality and possibly

### Box 14-1. The Mature Dog.

Aging is the progressive change that occurs after maturity in various organs and leads to decreased ability of an organism to meet environmental demands. This definition underscores two primary aspects of aging. First, aging occurs "after maturity." Although nutrition in young animals will have an affect on longevity and health, changes occurring during growth should not be considered aging. Second, aging results in a "decreased ability to meet the demands of the environment." Although young organisms adapt easily to fluctuations in nutrient intake and quality, mature animals may no longer be able to cope with excesses, borderline deficiencies or changes in nutrient intake and quality. Therefore, foods for mature dogs should meet allowances more rigorously and consistently because of lack of reserve capacity to handle large excesses and deficiencies.

An important feature of aging is that, compared with a group of younger adults, the mature dog population has a "large variation in health status" between individuals. In addition, diseases may be subclinical and not apparent by results of a physical examination; more in depth assessments are necessary, including diagnostic evaluations. Mature animals, therefore, must be evaluated individually rather than as a group and their nutritional needs determined accordingly.

The Bibliography for **Box 14-1** can be found at www.markmorris.org.

**Table 14-1.** Percent survival rates of mature dogs.*

| Age | 10 years | 15 years |
|---|---|---|
| Small-breed dogs | 38% | 7.0% |
| Large-breed dogs | 13% | 0.1% |

*Adapted from Deeb BJ, Wolf NS. Studying longevity and morbidity in giant and small breed dogs. Veterinary Medicine 1994; 89 (Suppl.7): 702-713.

the length of life of mature dogs through nutritional management. An important example is cognitive dysfunction (Chapter 35). Nutritional intervention in combination with mental stimulation can halt and even reverse its progression.

There is considerable interest in the potential benefits of pet nutrition on the part of pet owners. In one survey, 51% of respondents indicated that they were interested in learning about clinical signs and treatments for older pets and 47% were interested in pet nutrition (MAF, 2005).

## PATIENT ASSESSMENT

### History and Physical Examination

A thorough history should be taken and a physical examination performed to identify potential areas of nutritional concern. All of the considerations discussed for young adult dogs in Chapter 13 (i.e., breed, gender and health status) should be considered when developing key nutritional factors for mature dogs. Special attention should be directed to physiologic changes associated with aging and diseases that are more prevalent in mature animals such as renal disease, cancer, degenerative joint disease, cardiac disease, endocrine disorders, periodontal disease, cognitive dysfunction and obesity (Harvey et al, 1994; Alexander and Wood, 1984; Hoskins, 1995; Goldston, 1995; Landsberg and Ruhl, 1997). Many diseases may be subclinical, emphasizing the importance of a thorough evaluation.

This chapter builds on many of the recommendations in Chapter 13 for feeding young adult dogs. The minimum nutrient requirements of mature dogs are similar to those of young adult dogs. The few studies evaluating the effect of aging on the nutritional needs of dogs have shown minimal changes in nutrient requirements. Therefore, nutritional recommendations for mature dogs are based on risk factor management, extension of learning from other species and prudence. For several of the key nutritional factors for mature dogs, this results in reducing the recommended upper range of some nutrients, compared to that for young adult dogs. The only nutritional modification known to slow aging and increase the lifespan consistently in multiple species is caloric restriction. Reducing caloric intake by 20 to 30% of normal, while meeting essential nutrient needs, slows the aging process and reduces the risk for cancer, renal disease, arthritis and immune-mediated diseases in several animal models (Sheffy and Williams, 1981; Kealy et al, 2002). This level of restriction seems difficult to achieve in the long term but should be considered for incorporation into mainstream nutritional advice. Carefully monitoring food intake and body condition in mature dogs is important because these parameters may indicate underlying disease processes.

### Laboratory and Other Clinical Information

Laboratory analyses become more important in health screening of dogs older than five years. All mature dogs should be screened for renal disease and hypertension. Chronic renal disease is best diagnosed with a urinalysis (i.e., urine specific gravity, urine protein, urine sediment examination) and a serum biochemistry profile, including urea nitrogen, creatinine, electrolyte, calcium and phosphorus measurements (DiBartola, 1995). Additional blood parameters should be evaluated based on historical and physical examination findings. Generally, indirect blood pressure measurements obtained routinely during hospital visits are reasonable estimates of a dog's true blood pressure (Remillard et al, 1991). However, uncooperative, anxious dogs may have elevated blood pressure values in the hospital setting that do not reflect normal values (Littman and Drobatz, 1995). Fundic examination may also detect changes associated with hypertension and other systemic diseases (Littman and Drobatz, 1995). Thoracic radiographs and echocardiography should be performed if a cardiac murmur is detected or if there is a history of coughing or an abnormal respiratory pattern.

### Key Nutritional Factors

Veterinarians should appreciate the diversity in health status of

mature dogs and adapt care and nutrition to the specific needs of each patient (MacDougall and Barker, 1984; Knapp, 1964; Kronfeld, 1983). **Table 14-2** summarizes key nutritional factors for mature dogs. The following section describes these key nutritional factors in more detail. Most of these are the same as for young adult dogs. A more thorough discussion of the overlapping key nutritional factors can be found in the key nutritional factors section in Chapter 13.

**Table 14-2.** Key nutritional factors for foods for mature dogs.

| Factors | Recommended food levels* | |
|---|---|---|
| | Normal weight and body condition | Inactive/ obese prone |
| Water | Free access | Free access |
| Energy density (kcal ME/g) | 3.0-4.0 | 3.0-3.5 |
| Energy density (kJ ME/g) | 12.5-16.7 | 12.5-14.6 |
| Crude fat (%) | 10-15 | 7-10 |
| Crude fiber (%)** | ≥2 | ≥10 |
| Protein (%) | 15-23 | 15-23 |
| Phosphorus (%) | 0.3-0.7 | 0.3-0.7 |
| Sodium (%) | 0.15-0.4 | 0.15-0.4 |
| Chloride (%) | 1.5 x Na | 1.5 x Na |
| Antioxidants (amount/kg food) | | |
| Vitamin E (IU) | 400 | 400 |
| Vitamin C (mg) | ≥100 | ≥100 |
| Selenium (mg) | 0.5-1.3 | 0.5-1.3 |
| Food texture (VOHC Seal of Acceptance) | Reduced plaque accumulation | Reduced plaque accumulation |

Key: kcal = kilocalories, kJ = kilojoules, ME = metabolizable energy, VOHC = Veterinary Oral Health Council Seal of Acceptance (Chapter 47).
*All foods expressed on a dry matter basis unless otherwise noted. If the caloric density of the food is different, the nutrient content in the dry matter must be adapted accordingly (Chapter 1).
**Crude fiber measurements underestimate total dietary fiber levels in food.

## Water

Mature dogs are more prone to dehydration due to possible osmoregulatory disturbances, medications (diuretics) and chronic renal disease, with compromised urine concentrating ability. Therefore, continuous access to a fresh, clean water supply is very important and water intake should be routinely monitored.

## Energy

With increasing age, lean body mass decreases, subcutaneous fat increases, basal metabolic rate gradually declines and body temperature may decrease. As dogs age, they become slower and less active, and their thyroid function may be impaired (Siwak et al, 2000; Armstrong and Lund, 1996; Finke, 1991; MacDougall and Barker, 1984; Mosier, 1990; Meyer, 1990; Sheffy et al, 1985). All these changes result in a 12 to 13% decrease in daily energy requirement by around seven years of age (Chapter 13, Table 13-2) (Kienzle and Rainbird, 1991). For mature dogs, a daily energy intake of 1.4 x resting energy requirement (100 kcal [418 kJ] metabolizable energy/$BW_{kg}^{0.75}$) is a good starting point (Leibetseder, 1989). This amount should be modified if a dog tends to lose or gain weight when fed at the recommended level. Very old dogs are often underweight and may have inadequate energy intake (Armstrong and Lund, 1996; Kronfeld, 1991; Donoghue et al, 1991). Underweight, very elderly people increase body weight when a food of higher caloric density is provided (Olin et al, 1996). Thus, it may be appropriate to feed a more energy-dense food to very old dogs. Because of the potential for mature dogs to have different energy needs, energy densities in foods recommended for this age group may vary from 3.0 to 4.0 kcal (12.6 to 16.7 kJ)/g dry matter (DM).

## Fat

A relatively low fat intake helps prevent obesity in healthy mature dogs. However, some dogs may need different foods at seven years of age than they will at 13 years of age. Very old dogs may have a tendency to lose weight (Armstrong and Lund, 1996; Kronfeld et al, 1991). For these dogs, increasing the fat content of the food increases energy intake, improves palatability and improves protein efficiency (NRC, 1985; Schaeffer et al, 1989).

Research in people has indicated that increased energy intake can correct immunosenescence due to mild protein-energy malnutrition (Morley, 1994). The general condition of elderly people improved significantly by increasing the energy density of the food (Olin et al, 1996). Thus, a good balance should be maintained between preventing obesity and providing sufficient caloric intake.

Generally, fat levels between 7 and 15% DM are recommended for most mature dogs. Fat levels for obese-prone dogs should be between seven to 10%. The fat level should be selected as needed to meet the desired energy density to achieve ideal body weight and condition (body condition score 2.5/5 to 3.5/5). Essential fatty acid requirements should also be met as outlined for young adult dogs.

## Fiber

Mature dogs are prone to develop constipation (Twedt, 1993), which may justify increased fiber intake. Additionally, fiber added to foods for obese-prone mature dogs dilutes calories. Fiber also decreases postprandial glycemic effects in diabetic dogs (Nelson, 1989). Very old dogs that tend to lose weight, however, should be offered a food with increased caloric density. The recommended levels of crude fiber in foods intended for mature dogs are at least 2% (DM).

## Protein

Recommendations for protein intake in mature dogs are controversial, which parallels the debate in people (Pellet, 1990). The decrease in lean body mass, seen with age, together with alterations in protein synthesis and turnover have been the basis for the argument that protein intake in mature dogs should be higher than for younger adults (Grandjean and Paragon, 1990; Kronfeld, 1983; Wannemacher and McCoy, 1966). In contrast, other investigators have recommended reduced protein intake because of the increased prevalence of

renal pathology in dogs older than five years of age (Leibetseder and Neufeld, 1991; Lewis et al, 1987).

As with all lifestages, healthy mature dogs should receive enough protein and energy to avoid protein-energy malnutrition. Improving protein quality, rather than increasing its intake, can provide sufficient protein (Sheffy et al, 1985; Leibetseder, 1989; Mundt, 1989). Additionally, data suggest that mild protein-energy undernutrition in older people plays a role in immunosenescence; however, supplementation with calories returned helper T cells and suppressor cells to values seen in younger people (Morley, 1994). Serum protein concentrations, lymphocyte counts and muscle protein-to-DNA ratios have indicated that foods with 18% DM protein are adequate to maintain immunocompetence in older dogs (Finco et al, 1994). These findings confirmed earlier observations that foods with 16 to 20% DM protein are sufficient to maintain nitrogen balance and protein stores in older dogs (Wannemacher and McCoy, 1966). In addition, alterations in protein metabolism and plasma protein concentrations seen in healthy elderly people are unrelated to daily protein intake, suggesting that other factors play a role (Munro et al, 1987).

High protein intake has not been shown to contribute to the development of kidney disease in healthy animals. However, after kidney function is impaired, protein may play a role in progression of renal disease. In a four-year study with uninephrectomized healthy dogs, investigators recognized no difference in kidney function between dogs receiving a food with 34% DM protein and a food with 18% DM protein (Finco et al, 1994). However, histologic examination revealed an increase in mesangial matrix scores and fibrosis in the high-protein group (Finco et al, 1994). Mesangial proliferation has been described in glomerulonephritis and chronic interstitial nephritis in dogs (Müller-Peddinghaus and Trautwein, 1977a; Spencer and Wright, 1981) and may indicate more rapid renal impairment at a higher protein intake (Finco et al, 1994). Moderately reduced protein intake during early stages of canine renal disease improved the subjects' general condition (Leibetseder and Neufeld, 1991). In conclusion, commercial foods containing 15 to 23% DM protein provide sufficient protein for apparently healthy mature dogs.

### *Phosphorus*

Some degree of clinical or subclinical renal disease is often present in mature dogs; as many as 25% of all dogs may be affected (Oehlert and Oehlert, 1976; Rouse and Lewis, 1975; Shirota et al, 1979; Leibetseder and Neufeld, 1991; Bloom, 1954; Crowell and Finco, 1975; Müller-Peddinghaus and Trautwein, 1977). Excessive phosphorus intake should therefore be avoided (Finco et al, 1992). Researchers have observed that dogs with advanced renal disease had slowed progression and reduced severity of renal disease when phosphorus levels in foods were decreased, thereby improving survival time (Brown et al, 1991; Finco et al, 1992; Lopez-Hilker et al, 1990). The minimum recommended DM allowance of phosphorus for foods for adult dogs is 0.3% (NRC, 2006). Therefore, foods for mature dogs should contain 0.3 to 0.7% DM phosphorus.

### *Sodium and Chloride*

There is no nutritional need for the higher levels of sodium and chloride found in some commercial dog foods, especially considering the increased prevalence of heart and renal disease in mature dogs (Detweiler and Patterson, 1965; Whitney, 1974). High sodium chloride intake may be harmful in diseases that have a hypertensive component. Secondary hypertension is associated with obesity, chronic renal disease and some endocrinopathies, which are frequently seen in mature dogs (Anderson and Fisher, 1968; Cowgill and Kallet, 1986; Rocchini et al, 1987; Littman, 1990; Ross, 1992). Mature dogs with heart disease have decreased ability for eliminating excess dietary sodium (Chapter 36). Kidney disease and certain other diseases with a hypertensive component may be subclinical in their early phases. The minimum recommended allowance for sodium in foods for healthy adult dogs is 0.08 % DM; this recommendation is based on foods with a DM energy density of 4 kcal/g (NRC, 2006). For purposes of risk factor management, the recommended range for dietary sodium in foods for mature dogs is 0.15 to 0.4% DM, which is more than adequate. Some commercial all-purpose foods contain more than 2% DM sodium. Although the chloride requirement of dogs has not been established, a chloride level 1.5 times the sodium requirement is a reasonable recommendation.

### *Antioxidants*

The consequences of prolonged oxidative stress (i.e., free radical damage) to cell membranes, proteins and DNA contribute to and/or exacerbate a wide variety of degenerative diseases including those listed in Table 13-1. In addition to these diseases, cognitive dysfunction was shown to affect 28% of dogs between 11 and 12 years of age and 68% of dogs 15 to 16 years old. Cognitive dysfunction is responsive to certain combinations of antioxidants (Chapter 35).

The consequences of free radical damage to cells and tissues have also been associated with the effects of aging. Although aging is a complex, multifactorial process, one explanation for many of the degenerative changes associated with aging is the free radical theory of aging (Harman, 1956). This theory proposes that free radicals produce cell damage and that age-dependent pathologic alterations may, at least in part, be the cumulative result of these changes.

Many phenomena initiate free radical formation within the body. Although environmental pollutants and radiation are direct and indirect sources of free radicals, the primary source is endogenous from normal oxidative metabolism. However, the body defends itself against the effects of free radicals through a complex network of protective antioxidant compounds.

Antioxidants protect biomolecules by scavenging free radical compounds, minimizing free radical production and binding metal ions that might increase the reactivity of poorly reactive compounds. In addition, many antioxidants exhibit second messenger regulatory function, cell cycle signaling and control of gene expression (Chapter 7). Also, combinations of antioxidants are more effective in relieving oxidative stress than are individual antioxidants.

The following key nutritional factor recommendations focus on the antioxidant vitamins E and C and on selenium as an essential component of the antioxidant enzyme, glutathione peroxidase. These compounds make up the list of antioxidant key nutritional factors because: 1) they are biologically important, 2) they act synergistically (e.g., vitamin C regenerates vitamin E after it has reacted with a free radical), 3) they are safe and 4) information regarding inclusion levels in pet foods is usually available. For improved antioxidant performance, foods for mature dogs should contain at least 400 IU vitamin E/kg (DM) (Jewell et al, 2000), at least 100 mg vitamin C/kg (DM) and 0.5 to 1.3 mg selenium/kg (DM).

### *Food Texture*

Oral disease is the most common health problem in mature dogs and may predispose affected patients to systemic complications (DeBowes et al, 1996). Both veterinary care and home care are important in the treatment and prevention of periodontal disease. Foods designed to reduce the accumulation of dental substrates (e.g., plaque) and help control gingivitis and malodor are an important part of an oral home-care program for mature dogs (Chapter 47). If the labels of such foods carry the Veterinary Oral Health Council (VOHC) seal for plaque control, they have been successfully tested according to specific protocols and shown to be clinically effective in reducing accumulation of plaque. However, with older dogs, it is best if an adequate periodontal management program is in place (veterinarian/client/patient) so that there is sufficient periodontal health to ensure that the patient can chew the product (Chapter 47).

## Other Nutritional Factor

### *Calcium*

Osteoporosis occurs frequently in older people but is not a clinical problem in mature dogs (Weigel and Alexander, 1981). This finding is probably due, in part, to lifetime feeding of calcium-replete commercial foods to most dogs. There should be little concern about calcium deficiency in mature dogs unless unbalanced homemade foods are fed. Foods with 0.4 to 0.8% DM calcium are recommended for mature dogs. The calcium-phosphorus ratio should not be less than 1:1.

# FEEDING PLAN

Mature dogs are more prone to obesity, degenerative joint disease, cardiac disease, renal disease, cognitive dysfunction and metabolic aberrations. They also are usually less active than young adult dogs. The feeding plan should be based on potential risk factors and information attained in the assessment. Because of the larger variation in health among mature dogs, more attention should be paid to individual needs. Nutritional surveillance is more important for mature dogs than for young adult dogs; therefore, the number of veterinary assessments per year should be increased. Goals remain the same as listed in the introduction; however, each patient should be evaluated individually.

## Assess and Select the Food

Assessment of the food for mature dogs is similar to those procedures outlined for young adult dogs in Chapter 13. Compare the current food's key nutritional factor levels with the key nutritional factors reviewed above, identify discrepancies between key nutritional factor levels and current intake and decide whether food changes are required. **Table 14-3** compares key nutritional factor levels in selected commercial foods formulated for mature dogs to the key nutritional factor recommendations. Check with manufacturers for key nutritional factor content of foods not found in **Table 14-3**. Contact information can be found on pet food labels, websites or published information. Also, as with young adult dogs, the pet food label should indicate that the product has been approved by a regulatory agency such as the Association of American Feed Control Officials (AAFCO) (Chapter 9).

Commercial treats, snacks and table food should also be included in the food assessment step. Excessive feeding of treats and snacks may markedly affect the cumulative nutritional profile (Chapter 13, Box 13-4). The impact of snacks on daily nutrient intake depends on two factors: 1) the nutrient profile of the snack and 2) the number provided. Thus, if snacks are fed, it is prudent to recommend those that best match the key nutritional profile recommended for mature dogs. Because meeting nutrient requirements is not the primary goal of feeding treats, many commercial treats are not complete and balanced. However, a few treats are complete and balanced and are approved by AAFCO, or some other credible regulatory agency. Most table foods are not nutritionally complete and balanced and may contain high levels of fat or sodium and other minerals. If snacks are fed, it is simplest to recommend that they be commercial treats that, if possible, match the nutritional profile recommended for a particular lifestage (see product label). Generally, snacks should not be fed in excessive amounts (<10% of the total diet on a volume, weight or calorie basis). Otherwise, the nutritional composition of the snack and food should be combined and assessed.

## Assess and Determine the Feeding Method

It may not be necessary to change the feeding method when managing healthy mature dogs. However, a thorough evaluation includes verification that an appropriate feeding method is being used.

The feeding method should be monitored more closely in mature than in younger dogs. Free-choice feeding should not be used for obese or overweight patients; however, this method may be preferred for thinner, very old animals to allow increased food intake. It is very important to measure food intake of mature dogs; this measurement may be more accurate when dogs are meal fed. Measures to stimulate food intake may be necessary for some very old dogs. Most mature adult dogs adapt well to new foods, but some patients may have difficulty. It is always good practice to allow for a transition period to avoid digestive upsets. This is particularly true when switching from lower to higher fat foods. The new food should be increased and the old food decreased in progressive amounts

**Table 14-3.** Comparison of recommended levels of key nutritional factors for foods for mature adult dogs with levels in selected commercial foods.*

| Dry foods | Energy density (kcal/cup)** | Energy density (kcal ME/g) | Fat (%) | Fiber (%) | Protein (%) | P (%) | Na (%) | Vit E (IU/kg) | Vit C (mg/kg) | Se (mg/kg) | VOHC plaque*** (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Recommended levels (normal body condition)** | **-** | **3.0-4.0** | **10-15** | **≥2** | **15-23** | **0.3-0.7** | **0.15-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Mature Adult 7+ Original | 363 | 4.0 | 15.8 | 4.2 | 19.3 | 0.58 | 0.18 | 700 | 271 | 0.41 | No |
| Hill's Science Diet Oral Care Adult | 273 | 3.8 | 15.5 | 10.1 | 25.1 | 0.65 | 0.24 | 564 | 175 | 0.62 | Yes |
| Iams Eukanuba Medium Breed Senior | 350 | 4.6 | 12.8 | 2.2 | 29.3 | 0.95 | 0.40 | 236 | 83 | na | No |
| Medi-Cal Dental Formula | 280 | na | 12.7 | 5.3 | 19.7 | 0.9 | 0.4 | na | na | na | No |
| Nutro Natural Choice Senior | 267 | 3.8 | 12.1 | 2.2 | 23.1 | 1.21 | 0.27 | 275 | 99 | 0.49 | No |
| Purina ONE Senior Protection Formula | 375 | 4.1 | 14.0 | 3.4 | 32.3 | 1.12 | 0.30 | 1,012 | na | 0.99 | No |
| Purina Pro Plan Chicken & Rice Senior | 408 | 4.2 | 15.6 | 2.3 | 30.4 | 1.14 | 0.44 | na | na | na | No |
| Royal Canin MINI Aging Care 27 | 378 | 4.3 | 17.4 | 1.7 | 29.3 | 0.71 | 0.33 | 717 | 326 | 0.22 | No |
| **Moist foods** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)** | **Fat (%)** | **Fiber (%)** | **Protein (%)** | **P (%)** | **Na (%)** | **Vit E (IU/kg)** | **Vit C (mg/kg)** | **Se (mg/kg)** | **VOHC plaque*** (Yes/No)** |
| **Recommended levels (normal body condition)** | **-** | **3.0-4.0** | **10-15** | **≥2** | **15-23** | **0.3-0.7** | **0.15-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Gourmet Beef Entrée Mature Adult 7+ | 164/5.8 oz. 368/13 oz. | 4.0 | 14.4 | 1.6 | 18.8 | 0.52 | 0.16 | 316 | na | 0.70 | No |
| Hill's Science Diet Gourmet Turkey Entrée Mature Adult 7+ | 369/13 oz. | 4.1 | 12.8 | 2.1 | 19.4 | 0.62 | 0.17 | 426 | na | 0.83 | No |
| Hill's Science Diet Savory Chicken Entrée Mature Adult 7+ | 155/5.8 oz. 347/13 oz. | 3.8 | 13.1 | 1.6 | 18.4 | 0.57 | 0.16 | 520 | na | 0.82 | No |
| **Dry foods†** | **Energy density (kcal/cup)**** | **Energy density (kcal ME/g)** | **Fat (%)** | **Fiber (%)** | **Protein (%)** | **P (%)** | **Na (%)** | **Vit E (IU/kg)** | **Vit C (mg/kg)** | **Se (mg/kg)** | **VOHC plaque*** (Yes/No)** |
| **Recommended levels (inactive/obese prone)** | **-** | **3.0-3.5** | **7-10** | **≥10** | **15-23** | **0.3-0.7** | **0.15-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Light Adult | 295 | 3.3 | 8.8 | 14.6 | 24.5 | 0.58 | 0.23 | 586 | 276 | 0.45 | No |
| Iams Eukanuba Medium Breed Weight Control | 275 | 4.2 | 10.5 | 1.9 | 21.3 | 0.76 | 0.50 | 206 | 42 | 0.34 | No |
| Iams Weight Control | 328 | 4.2 | 12.5 | 2.8 | 22.2 | 0.85 | 0.37 | 103 | 44 | 0.35 | No |
| Medi-Cal Weight Control/Mature | 320 | na | 8.5 | 4.0 | 19.5 | 0.8 | 0.2 | na | na | na | No |
| Nutro Natural Choice Lite | 244 | 3.4 | 7.2 | 4.4 | 16.7 | 1.22 | 0.33 | 161 | 67 | 0.44 | No |
| Purina Pro Plan Chicken & Rice Weight Management | 337 | 3.7 | 10.2 | 2.7 | 30.5 | 1.06 | 0.27 | 503 | na | 0.33 | No |
| Royal Canin MINI Weight Care 30 | 326 | 3.8 | 12.0 | 6.2 | 32.6 | 0.82 | 0.33 | 652 | 326 | 0.16 | No |
| **Moist foods†** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)** | **Fat (%)** | **Fiber (%)** | **Protein (%)** | **P (%)** | **Na (%)** | **Vit E (IU/kg)** | **Vit C (mg/kg)** | **Se (mg/kg)** | **VOHC plaque*** (Yes/No)** |
| **Recommended levels (inactive/obese prone)** | **-** | **3.0-3.5** | **7-10** | **≥10** | **15-23** | **0.3-0.7** | **0.15-0.4** | **≥400** | **≥100** | **0.5-1.3** | **-** |
| Hill's Science Diet Light Adult | 322/13 oz. | 3.4 | 8.6 | 9.7 | 19.5 | 0.51 | 0.31 | 385 | na | 0.78 | No |
| Medi-Cal Weight Control/Mature | 370/396 g | na | 10.0 | 5.5 | 21.5 | 0.6 | 0.3 | na | na | na | No |

Key: ME = metabolizable energy, na = information not published by manufacturer, Fiber = crude fiber, Se = selenium, P = phosphorus, Na = sodium, VOHC = Veterinary Oral Health Council, na = information not available from manufacturer, g = grams.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.
***An adequate periodontal management program should be in place (veterinarian/client/patient) to ensure that there is sufficient periodontal health to enable the patient to chew these products.
†The manufacturers of most of the foods listed for inactive/obese-prone dogs recommend these foods for young adults.

over a three- to seven-day period until the changeover is completed (Nott et al, 1993) (Chapter 1). **Table 14-4** summarizes feeding recommendations for mature adult dogs.

## REASSESSMENT

Nutritional status for healthy mature dogs should be assessed at least every six to 12 months. Immediate reassessment should take place if clinical signs arise that indicate the current nutritional regimen is inappropriate or if the dog's needs change due to altered use.

## ENDNOTE

a. Zicker SC. Hill's Pet Nutrition, Inc., Topeka, KS. U.S. Marketing Research Summary: Omnibus Study on Aging Pets. Data on file. November 2000.

## REFERENCES

The references for **Chapter 14** can be found at www.markmorris.org.

**Table 14-4.** Feeding plan summary for mature dogs.

1. Select a food or foods with levels of key nutritional factors listed in **Table 14-3**; for foods not in this table, contact the manufacturer for levels of key nutritional factors in the food in question.
2. The selected food should also be approved or meet requirements established by a credible regulatory agency (e.g., AAFCO).
3. Body condition and other assessment criteria will determine the DER. DER is calculated by multiplying RER by an appropriate factor (Table 5-2). Remember, DER calculations should be used as guidelines, starting points and estimates for individual dogs and not as absolute requirements.
   Dogs in ideal body condition =
   3.0 to 4.0 kcal (12.5 to 16.7 kJ ) ME/g DM
   Inactive/obese-prone dogs =
   3.0 to 3.5 kcal (12.5 to 14.6 kJ) ME/g DM
4. Determine the preferred feeding method (Table 13-5); when the correct amount of food is fed; meal-restricted feeding is least likely to result in obesity.
5. For food-restricted meal feeding, estimate the initial quantity of food based on DER calculation (DER ÷ food energy density). Food energy density can be obtained from **Table 14-3** or from the manufacturer.
6. Monitor body weight, body condition and general health. These parameters are used to refine the amount to feed.

Key: AAFCO = Association of American Feed Control Officials, DER = daily energy requirement, RER = resting energy requirement, ME = metabolizable energy, DM = dry matter.

## CASE 14-1

### Feeding a Mature Miniature Pinscher

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### Patient Assessment

An eight-year-old intact male miniature pinscher was examined as part of a routine health maintenance program. The owners saw a magazine article recently promoting preventive health programs for mature dogs. They realized that their dog was aging but had not noticed any specific problems.

The dog weighed 4.5 kg and had an optimal body condition score (BCS 3/5). Physical examination was normal except for a slightly enlarged prostate gland, mild periodontal disease and a grade II/VI holosystolic cardiac murmur loudest over the mitral valve. Results of a complete blood count, serum biochemistry profile, urinalysis and ocular fundic examination were normal. Thoracic radiographs were normal with no evidence of cardiomegaly or pulmonary disease.

### Assess the Food and Feeding Method

The dog was fed several different kinds of commercial moist grocery brand dog foods and commercial jerky-type dog treats. Ice cream was also fed regularly. The owners were somewhat concerned because the dog did not seem to be eating as much as it did previously.

## Questions

1. What are the key nutritional factors that should be considered in this patient?
2. Outline a feeding plan (foods and feeding method) for this dog.
3. How should the owner's concern about the reduction in appetite be addressed?

## Answers and Discussion

1. Key nutritional factors for mature dogs include water, energy, fat, fiber, protein, phosphorus, sodium, chloride, antioxidants and food texture. Chronic progressive renal disease is a leading cause of morbidity and mortality in mature dogs. However, classic diagnostic tests such as the serum biochemistry profile and urinalysis that were performed for this dog will not detect renal disease until it is advanced. Although not definitively proven, dogs with subclinical renal disease may benefit from foods that avoid excess levels of phosphorus, protein, sodium and chloride. Clean water should also be available at all times. In general, fat levels between 7 and 15% dry matter (DM) are recommended for most mature dogs. Fat levels and energy density of the food should be adjusted based on the body condition of the patient. Obese-prone mature dogs may benefit from lower fat, less energy-dense foods whereas very old dogs often lose weight and need higher fat, more energy-dense foods. Increased levels of dietary fiber may be important for obese-prone mature dogs and those with constipation. Oral disease is the most common health problem of mature dogs; more than two-thirds of mature dogs suffer from significant periodontal disease. Both veterinary care and home care are important in treatment and prevention of periodontal disease. Foods formulated to decrease the accumulation of dental plaque and help control gingivitis and malodor are an important part of the oral home-care program for mature dogs.
2. Commercial moist grocery brand dog foods may contain excessive levels of phosphorus, fat, energy, protein, sodium and chloride. Jerky-type commercial treats also contain excessive levels of protein, fat, sodium and chloride. Mature healthy dogs may benefit from commercial foods for "senior" or "geriatric" dogs and treats that contain lower yet adequate levels of these nutrients. Excessive levels of dietary sodium and chloride should also be avoided in mature dogs with evidence of cardiac disease. Ice cream should also be discontinued as a regular treat or offered in smaller amounts. Moist foods do not provide textural characteristics that prevent the accumulation of dental plaque. Dental foods formulated to improve oral health are available and would be appropriate for this patient. The dog's body condition suggests that the current caloric intake is appropriate and should be maintained if a new food is selected. The estimated daily energy requirement (DER) should be 1.6 to 1.8 x resting energy requirement (RER) (330 to 370 kcal, 1,390 to 1,550 kJ). The feeding method will be dictated somewhat by whether a moist, dry, semi-moist or homemade food is fed. Moist and homemade foods should be fed once or twice daily as discrete meals, whereas dry or semi-moist food may be fed free choice and left out for prolonged periods.
3. The optimal BCS suggests that the dog is eating an appropriate amount of food. There may be several reasons why the owners expressed concern about the amount of moist food eaten by the dog. The moist foods currently fed are probably high in fat and energy dense; as little as one-half to two-thirds of a standard 400- to 450-g can will meet this dog's DER. The addition of jerky-type treats and ice cream would also decrease the amount of food the dog needed. Mature dogs may not be as active as they were earlier in life, which decreases their energy requirements. Periodontal disease was recognized during the physical examination and significant oral pain will discourage eating in some patients. Finally, an underlying disease may be contributing to partial anorexia despite the normal diagnostic results. All these factors should be explained to the owners and they should be encouraged to monitor food intake and body condition closely.

## Progress Notes

The food was changed to a commercial moist specialty brand food formulated for mature dogs (Science Diet Mature Adult 7+ Canine[a]). The dog was fed three-fourths of a large can per day. The commercial jerky-type treats and ice cream were discontinued and replaced with a dry treat formulated for mature dogs. The dog was given two treats per day. A thorough oral examination including dental prophylaxis and polishing was recommended.

## Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA.

Chapter 15

# Feeding Reproducing Dogs

Jacques Debraekeleer
Kathy L. Gross
Steven C. Zicker

*"Acquiring a dog may be the only opportunity a human ever has to choose a relative."*
*Mordecai Siegal*

## INTRODUCTION

The objectives of a good reproductive feeding program are to optimize: 1) conception, 2) number of puppies per litter, 3) the ability of the bitch to deliver and 4) viability of prenatal and neonatal puppies (Grandjean and Paragon, 1986). Appropriate feeding and management will increase the likelihood of successful reproductive performance, whereas improper or inadequate nutrition can negatively affect reproductive performance in bitches (**Table 15-1**).

Females undergo the greatest extremes in nutrient requirements when the entire reproductive cycle is considered. Estrus, pregnancy and lactation are each associated with specific nutrient concerns that must be addressed. The concerns change with intrinsic physiologic alterations and may be influenced by environmental and other extrinsic factors. Males also need adequate nutrition to achieve optimal performance and conception rates.

Experienced breeders seem to have knowledge about nutritional programs for reproducing dogs based primarily on personal experience, augmented to varying degrees by scientific information. To be effective, veterinarians and their health care teams should have a good understanding of appropriate and practical nutritional programs for reproduction and the neonatal period. These programs should be based on up-to-date, science-based information about the nutritional demands of estrus, gestation and lactation.

## PATIENT ASSESSMENT

### Estrus and Mating

Optimal nutrition for reproducing animals should precede mating and conception (Sheffy, 1978). As a rule, only healthy dogs in a good nutritional state (body condition score [BCS] 2.5/5 to 3.5/5) should be used for breeding because effects of malnutrition before breeding are often unnoticed until puppies are born (**Table 15-1**). A BCS of 2/5 may be acceptable for a house pet that is only bred for an exceptional occasion (Donoghue, 1992). Obese bitches may have a lower ovulation rate, smaller litter size and insufficient milk production (Meyer, 1990). Obesity may also cause silent heat, prolonged interestrous intervals and anestrus. Therefore, to optimize fertility, overweight bitches should lose weight before breeding (Grandjean and Paragon, 1986). A good history and general physical examination should precede breeding to document and correct problems that may interfere with successful breeding.

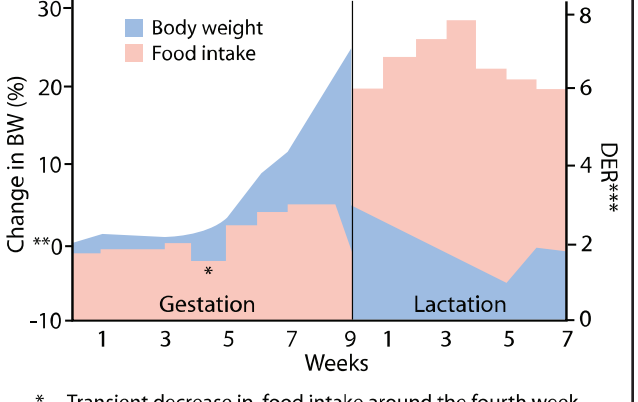
### Pregnancy

Gestation in dogs averages 63 days and is typically divided into 21-day trimesters. Assessment includes a detailed dietary history, a physical examination and pertinent laboratory analyses. During the physical examination, particular attention should be given to body weight, body condition and vaginal discharges. Ultrasound of the abdomen can provide additional information. Adequately fed bitches gain about 15 to 25% more than

**Table 15-1.** Effects of improper nutrition on reproductive performance and health in bitches.*

| Factors | Reproductive and health consequences |
|---|---|
| **Underfeeding** | Small litter size |
| | Low birth weight |
| | Increased neonatal morbidity and mortality |
| | Decreased milk yield |
| | Decreased immunity and decreased response to vaccination |
| | Decreased fertility later |
| | Hair loss and weight loss in bitches |
| **Obesity** | Decreased ovulation |
| | Decreased fertility |
| | Silent heat |
| | Prolonged interestrous interval |
| | Anestrus |
| | Smaller litters |
| **Malnutrition*** | |
| Protein deficiency | Low birth weight |
| | Increased neonatal morbidity and mortality |
| | Decreased neonatal immunity |
| Carbohydrate-free food | Low birth weight |
| | Increased neonatal morbidity and mortality |
| | Increased numbers of stillbirths |
| Zinc deficiency | Fetal resorption |
| | Smaller litters |
| Iron deficiency | Decreased immunity and response to vaccination |
| Pyridoxine and biotin deficiency | Decreased immunity and response to vaccination |
| Hypervitaminosis A | Congenital abnormalities |
| | Smaller litters |
| Hypervitaminosis D | Soft-tissue calcification |

*Malnutrition is uncommon when balanced commercial foods are fed, but may occur if homemade foods are not properly formulated.




* Transient decrease in food intake around the fourth week after conception is indicative of pregnancy.
** Prebreeding body weight
*** Daily energy requirement. Numbers are multiples of resting energy requirement.

**Figure 15-1.** Typical changes in body weight and food intake of a bitch during gestation and lactation. A bitch only weighs 5 to 10% above pre-breeding weight after parturition, and should not lose more than 5% of its body weight during the first month of lactation. Food intake may drop precipitously during the last days of gestation.

their pre-breeding weight before whelping (**Table 15-2** and **Figure 15-1**) (Meyer, 1990; Gesellshaft, 1989; Leibetseder, 1989). After parturition, bitches should weigh about 5 to 10% more than their pre-breeding weight. This weight gain corresponds with development of mammary tissue, extracellular water and some gain in extragenital tissue (Meyer, 1990; Gesellshaft, 1989; Leibetseder, 1989; Mosier, 1978). Retention of more than 10% above pre-breeding weight may adversely affect whelping. Furthermore, unlike cats, dogs do not need to maintain a body fat reserve to provide energy for the subsequent lactation because they can increase their food intake during lactation (Meyer, 1990; Grandjean and Paragon, 1986).

Laboratory analyses can include a complete blood count, serum protein, glucose, calcium, phosphorus and potassium concentrations and culture of vaginal discharges, if present. During pregnancy, red blood cell counts, hematocrit values and red cell volume may decrease because of plasma volume expansion, and may reach their lowest level during the second week of lactation (Concannon et al, 1989; Wallace and Davidson, 1995; Meyer et al, 1985). In most bitches, serum albumin and calcium concentrations also decrease during gestation (Meyer et al, 1985; Kaneko, 1989). Urea nitrogen concentrations may be below the normal range just before parturition; however, this finding should not be alarming, because levels return to normal during the first weeks of lactation (Meyer et al, 1985).

Malnutrition, due to inadequate and/or excessive intake of nutrients, may affect pregnancy and lactation (**Table 15-1**). Fertilized eggs may die at an early stage resulting in embryo loss. Alternatively, fetuses may develop incorrectly, die and be resorbed, expelled before term (abortion) or carried to full term (stillbirth) (McDonald et al, 1995). Embryo loss and in utero resorption are manifested by smaller litter size. Malnutrition during pregnancy is also a cause of low birth weight puppies that are particularly prone to hypoglycemia, sepsis, pneumonia and hemorrhage and have reduced survival (Mosier, 1978, 1978a; Schroeder and Smith, 1994).

Obesity at the end of pregnancy may increase dystocia, prolong labor and therefore predispose puppies to hypoxia and hypoglycemia. Studies indicate that obesity in pregnant women is the most important factor predisposing to preterm parturition and increases perinatal mortality sixfold (Prentice and Goldberg, 1996). Obesity in pregnant women increases the risk of congenital central nervous system defects (e.g., neural tube defects) and low birth weight infants (Prentice and Goldberg, 1996). Rats that were obese during gestation and lactation had inadequate milk production and were unable to maintain their litters. Surviving pups were significantly smaller than normal. These findings occurred irrespective of whether rats were underfed or overfed during lactation (Rasmussen, 1992).

## Lactation

Successful lactation depends on body condition before breeding, and adequate nutrition throughout gestation and lactation. During lactation, nutrient requirements are directly related to milk production, which in turn depends primarily on the num-

ber of suckling puppies. A bitch's nutrient requirement during lactation is greater than at any other adult lifestage and equal to or higher, in some cases, than for growth. Only extreme exercise (Chapter 18) is more energy demanding. The superior ability of bitches to produce milk is illustrated by the following examples. A German shepherd bitch, with six puppies, may produce about 1.7 liters of milk/day during the third and fourth week of lactation (Rüsse, 1961). Beagles with five to seven puppies are able to produce an average of 964 ml of milk/day (7.6% of body weight) at three weeks postpartum, and 1,054 ml/day (8.3% of body weight) at four weeks (Oftedal, 1984). In contrast, a woman produces about 750 ml/day during a three-month lactation (Pellet, 1990). Peak milk production of bitches equates to that of dairy cows, which produce about 7.3% of body weight during peak lactation (exceptional cows can peak at 11% or higher) (Rothbauer, 1994). Additionally, bitch's milk contains more than twice the protein and fat of cow's milk (**Table 15-3**) and more protein than goat's milk. More nutrient-dense milk is necessary to support the more rapid growth rate (as a percent of birth weight) of puppies vs. that of calves, kids and children (**Table 15-4**). A physical examination and anamnesis should be performed as described for gestation, above.

During the first week of lactation, milk production is approximately 2.7% of body weight. Thereafter, milk production steadily increases and peaks during the third and fourth week of lactation and has been estimated to be as much as 8% of a bitch's body weight (Ontko and Phillips, 1958; Rüsse, 1961; Oftedal, 1984; Meyer et al, 1985; Zentek and Meyer, 1992; Scantlebury et al, 2000; NRC, 2006).

After the first two to five days of lactation, the composition of the milk is stable and the bitch's nutrient requirements are primarily determined by the quantity of milk produced (Meyer et al, 1985; Rüsse, 1961; Oftedal, 1984; Mundt et al, 1981). During peak lactation, the quantity of milk produced depends primarily on the number of nursing puppies (Meyer et al, 1985; Ontko and Phillips, 1958). The puppies' intake of solid food begins to increase around the fifth week, after which milk production progressively declines (Gesellshaft, 1989). Therefore, the stage of lactation and the number of nursing puppies primarily determine the bitch's protein and energy requirements for lactation.

Urea nitrogen levels may be decreased just before parturition; however, values normalize during the first few weeks of lactation. Serum total protein concentrations should be within the normal physiologic range (6.0 to 6.5 g/dl) and remain stable during lactation (Meyer et al, 1985). A decrease in total protein may indicate undernutrition. Serum calcium concentrations may temporarily decrease during Weeks 3 and 4 of lactation, whereas inorganic phosphorus concentrations should be normal or slightly increased (Meyer et al, 1985).

## Key Nutritional Factors

Compared with maintenance for young adult dogs, there are no special nutritional requirements for bitches during estrus (Grandjean and Paragon, 1986). As for maintenance, breeding bitches should be fed to be in ideal body condition (2.5/5 to

**Table 15-2.** Distribution of the accretion of the bitch's body weight (BW) at the end of gestation.*

| Tissues | % of pre-breeding BW |
|---|---|
| Fetal mass | 12 |
| Placenta | 3 |
| Growth of uterus, mammary tissue and amniotic fluid | 3 |
| Extragenital accretion of tissue and extracellular water | 7 |
| Total accretion | 25 |

*Adapted from Meyer H. Praktische Fütterung. In: Ernährung des Hundes, 2nd ed. Stuttgart, Germany: E Ulmer Verlag, 1990; 162-223. Gesellschaft für Ernährungsphysiologie. Grunddaten für die Berechnung des Energie- und Nährstoffbedarfs. Ausschuß für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie Energie- Nährstoffbedarf/Energy and Nutrient Requirements, No. 5 Hunde/Dogs. Frankfurt/Main, Germany: DLG Verlag, 1989; 9-31.

**Table 15-3.** Nutrient comparison (% as fed) between bitch's milk and cow's milk.*

| Nutrients | Canine milk | Bovine milk |
|---|---|---|
| **Total protein** | 7.5 | 3.3 |
| Arginine | 0.42 | 0.13 |
| Isoleucine | 0.38 | 0.21 |
| Leucine | 0.98 | 0.36 |
| Lysine | 0.37 | 0.27 |
| Valine | 0.46 | 0.18 |
| **Total fat** | 9.5 | 3.5 |
| Linoleic acid (C18:2) | 11.7 | 2.5 |
| **Lactose** | 3.4 | 5.0 |
| **Gross energy** (kcal/100 g) | 146 | 74 |

*Adapted from Meyer H, Kienzle E, Dammers C. Milchmenge und Milchzusammensetzung bei und Hündin sowie Futteraufnahme und Gewichtsenwicklung ante und post partum. Fortschritte in der Tierphysiologie und Tierernährung (Advances in Animal Physiology and Animal Nutrition) 1985; Suppl. No. 16: 51-72. Swaisgood HE. Protein and amino acid composition of bovine milk. In: Jensen RG, ed. Handbook of Milk Composition. San Diego, CA: Academic Press Inc, 1995; 464-468.

**Table 15-4.** Composition of mammals' milk as related to growth rate of young mammals.*

| Species | Days required to double birth weight | Protein (%) | Fat (%) | Calcium (%) | Phosphorus (%) |
|---|---|---|---|---|---|
| Man | 180 | 1.6 | 3.75 | 0.03 | 0.014 |
| Horse | 60 | 2.0 | 1.4 | 0.10 | 0.07 |
| Cow | 47 | 3.3 | 3.7 | 0.12 | 0.10 |
| Goat | 22 | 2.9 | 3.8 | na | na |
| Sheep | 15 | 4.1 | 7.3 | 0.19 | 0.10 |
| Pig | 14 | 6.0 | 8.0 | 0.21 | 0.15 |
| Cat | 9.5 | 7.5 | 8.6 | 0.18 | 0.16 |
| Dog | 9 | 7.5 | 9.5 | 0.24 | 0.18 |
| Rabbit | 6 | 11.5 | 15.0 | 0.61 | 0.38 |

Key: na = not available.
*As-fed basis.

**Table 15-5.** Key nutritional factors for reproducing dogs.

| Factors | Recommended levels in food (DM) | |
|---|---|---|
| | Mating* | Gestation/lactation |
| Water | Fresh water should always be available | Fresh water should always be available |
| Energy density | 3.5-4.5 (kcal ME/g)** | ≥4.0 |
| Energy density | 14.6-18.8 (kJ ME/g)** | ≥16.7 |
| Crude protein (%) | 15-30 | 25-35 |
| Crude fat (%) | 10-20 | ≥20 |
| DHA (%) | - | ≥0.02 |
| Digestible carbohydrate (%) | ≥23 | ≥23 |
| Calcium (%) | 0.5-1.0 | 1.0-1.7 |
| Phosphorus (%) | 0.4-0.7 | 0.7-1.3 |
| Ca:P ratio | 1:1-1.5:1 | 1:1-2:1 |
| Digestibility | Foods with higher energy density are more likely to have higher digestiblity | Foods with higher energy density are more likely to have higher digestibility |

Key: DM = dry matter, ME = metabolizable energy, kcal = kilocalories, kJ = kilojoules, DHA = docosahexaenoic acid.
*Foods for most breeding males and females are usually similar to those for young and middle-aged adults (Table 13-4).
**If the caloric density of the food is different, the nutrient content in the DM must be adapted accordingly.

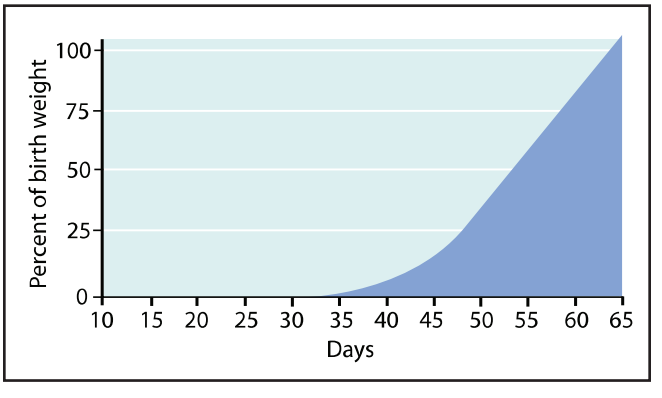



**Figure 15-2.** The development of fetal mass during pregnancy in beagle dogs. Only 2% of total fetal mass is developed at 35 days of pregnancy and 5.5% at 40 days. After Day 40, fetal tissue growth becomes exponential. (Adapted from Gesellschaft für Ernährungsphysiologie. Empfehlungen für die Versorgung mit Energie. Ausschuß für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie Energieund Nährstoffbedarf/Energy and Nutrient Requirements, No. 5 Hunde/Dogs. Frankfurt/Main, Germany: DLG Verlag, 1989; 32-44. Leibetseder J. Ernährung der Zuchthündin und der Junghunde. Der Praktischer Tierarzt 1989; 70: 12-20.)

3.5/5). Like breeding females, most sires do not have special nutritional needs beyond maintenance requirements for young adults and do well when fed foods for young adult dogs (Chapter 13). However, intact males and females may require more energy than their neutered counterparts to maintain ideal body condition (BCS 2.5/5 to 3.5/5).

**Table 15-5** summarizes key nutritional factors for breeding males and females and for pregnant and lactating bitches. The following section describes these key nutritional factors in more detail.

## *Water*

Although often overlooked, water is the first nutrient needed for lactation. Water is needed in large quantities to produce milk and aids in thermoregulation. Water requirements in ml are roughly equal to energy requirements in kcal. A 35-kg bitch nursing a large litter may require five to six liters of water per day at peak lactation. Therefore, it is critical that clean, fresh water be available at all times during gestation and lactation.

## *Energy*

Only 2% of total fetal mass is developed at 35 days of pregnancy and 5.5% at 40 days (**Figure 15-2**). Therefore, during the first two-thirds of gestation, energy requirements are not different from those of young adult dogs (Gesellshaft, 1989a; Ontko and Phillips, 1958). However, during this period bitches should be adequately fed and not allowed to lose weight or body condition. After Day 40, fetal tissue grows exponentially (Gesellshaft, 1989a; Leibetseder, 1989); energy needs correspondingly increase markedly during Week 5 and peak between Weeks 6 and 8 of gestation (Meyer, 1990; Ontko and Phillips, 1958; Romsos et al, 1981). Energy requirements for gestation peak at about 30% above adult maintenance for bitches with smaller litters, whereas energy needs for bitches with larger litters can increase by 50 to 60% (**Table 15-6**) (Meyer, 1990; Romsos et al, 1981; Meyer et al, 1985a).

Although energy needs are highest during Weeks 6 to 8 of gestation, food intake is limited by abdominal fullness as a result of the gravid uterus. Giant breeds may have difficulty ingesting enough food and maintaining body weight even before the last week of gestation (Zentek and Meyer, 1992). Food intake may decrease precipitously just before whelping with some bitches becoming completely anorectic (Romsos et al, 1981; Meyer et al, 1985). Enough energy should be provided to bitches during the earlier weeks of gestation, otherwise bitches may be underweight during mid and late gestation and have difficulty maintaining body condition and milk production after whelping (Bebiak et al, 1987). As mentioned above, bitches should not be allowed to lose body condition during the earlier weeks of gestation. Thus, during gestation, particularly during the last few weeks, the food should be high in energy density (≥4.0 kcal/g [≥16.7 kJ/g]) to provide adequate energy, especially for large-breed bitches.

After whelping, the bitch's energy requirement steadily increases and peaks between three and five weeks (Leibetseder, 1989; Ontko and Phillips, 1958) at a level two to four times higher than the daily energy requirement (DER) for non-lactating adults (Grandjean and Paragon, 1986; Bebiak et al, 1987; Meyer et al, 1985). The energy requirement returns to maintenance levels about eight weeks after whelping (Ontko and Phillips, 1958). Bitches are capable of increasing food intake

during lactation (Meyer et al, 1980, 1985); however, the energy density of the food is usually the limiting factor for meeting DER of lactating dogs (Lewis et al, 1987). If foods with low energy density are fed (<3.5 kcal [<14.6 kJ]/g), the bitch may not be physically able to consume enough food and may lose weight, have decreased milk production and display signs of severe exhaustion (Meyer et al, 1985). These signs are most pronounced in giant-breed dogs with large litters (Zentek and Meyer, 1992). Therefore, for these bitches, foods should provide at least 4 kcal metabolizable energy [ME] (16.7 kJ)/g dry matter (DM).

Energy requirements for lactating bitches can be subdivided into energy for maintenance and energy used for milk production. The DER for lactating bitches, without allotment for milk production, is slightly higher than that for average adults because of stress and increased activity associated with caring for puppies. Energy requirements have been estimated to be approximately 145 kcal (600 kJ) digestible energy/$BW_{kg}^{0.75}$ or about 2.1 x resting energy requirement (RER) (Meyer et al, 1985). This is compared to 132 kcal (550 kJ) ME/$BW_{kg}^{0.75}$ for maintenance of active dogs (NRC, 2006) or about 1.9 x RER. The energy used for milk production, by week of lactation, can be estimated using the method described in **Table 15-7**. **Table 15-8** provides a method for calculating milk production.

Other methods for determining energy requirements of lactating bitches have also been reported but each has limitations (Debraekeleer et al, 2000). Regardless, the body condition of bitches should be evaluated and food adjustments made as necessary to maintain a BCS on the high end of the ideal range

**Table 15-6.** Practical recommendations for energy intake during gestation.*

| Week of gestation | Total DER | |
|---|---|---|
| - | kcal ME/day** | kJ ME/day** |
| 1-4 | DER*** | DER*** |
| 5 | DER + 18 kcal ME/kg BW | DER + 75 kJ ME/kg BW |
| 6-8 | DER + 36 kcal ME/kg BW | DER + 150 kJ ME/kg BW |
| 9 | DER + 18 kcal ME/kg BW | DER + 75 kJ ME/kg BW |

Key: DER = daily energy requirement, kcal = kilocalories, kJ = kilojoules, ME = metabolizable energy, BW = body weight, RER = resting energy requirement.
*Adapted from Gesellschaft für Ernährungsphysiologie. Empfehlungen für die Versorgung mit Energie. Ausschuß für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie Energie- und Nährstoffbedarf/Energy and Nutrient Requirements, No. 5 Hunde/Dogs. Frankfurt/Main, Germany: DLG Verlag, 1989; 32-44.
**Energy requirements during gestation are the sum of the energy needed for normal adult maintenance of a non-pregnant dog plus what is needed for accretion of fetal and maternal tissue. Because accretion of fetal and maternal tissue is minimal during the first 35 days of gestation, the increase in energy requirement only becomes significant after Week 6. However, it is better to increase the food intake progressively during Week 5. This allows the bitch to build reserves for the last week of gestation, when food intake is compromised by abdominal fill.
***During gestation DER is estimated as 1.9 x RER (DER = 132 kcal ME/$BW_{kg}^{0.75}$ or 550 kJ ME/$BW_{kg}^{0.75}$).

**Table 15-7.** Two methods for calculating the total daily energy requirements for lactating bitches.

**Method 1***
The total energy for lactation consists of the bitch's daily energy required for maintenance and the energy required for lactation and uses the formula: ME (kcal) = DER + ($BW_{kg}$ x [24n + 12m] x L), where DER equals the DER for maintenance.

The calculation requires the DER for lactating bitches, without allotment for milk production, which is 145 kcal x $BW_{kg}^{0.75}$ (DER for maintenance of lactating bitches is thought to be higher than for bitches not lactating [see text]).

The calculation also requires the energy needed for lactation, which is based on the bitch's body weight in kg, the week of lactation and the number of puppies in the litter. The week of lactation (L) uses correction factors: Week 1 = 0.75; Week 2 = 0.95; Week 3 = 1.1; Week 4 = 1.2. The number of puppies in the litter is represented by "n" if one to four puppies are in the litter and "m" if the number of puppies in the litter is between five and eight; for fewer than five puppies, m = 0.

These values are inserted into the formula to determine the energy requirement for a lactating bitch:
ME (kcal) = DER + ($BW_{kg}$ x [24n + 12m] x L) where DER is the daily maintenance energy requirement without lactation and $BW_{kg}$ x [24n + 12m] x L represents the energy requirement for lactation.

For example, what would be the total energy requirement for a 20-kg bitch, in the second week of lactation, with a litter of six puppies?

DER (without lactation) = 145 kcal x $20^{0.75}$ = 145 kcal x 9.5 = 1,378 kcal
Number of puppies = 6: n = 4, m = 2
Week of lactation = L = 0.95 (correction factor for Week 2)
Requirement for lactation = 20 x (24 x 4 + 12 x 2) x 0.95 kcal = 2,280 kcal
Total requirement for maintenance and lactation = 1,378 + 2,280 = 3,658 kcal

**Method 2**
A simplified approach exists to determine DER for peak lactation; however, this method does not allow variation due to week of lactation as does Method 1. It uses the $ME_{peak\ lactation}$ (kcal) = 2.1 x $RER_{bitch}$ plus 25% per puppy.

Using the same example, what would be the total energy requirement for a 20-kg bitch, in the second week of lactation, with a litter of six puppies?

DER = 2.1 x 70($20^{0.75}$) = 1,390 kcal
Requirement for lactation = 25%/puppy or 348 kcal x 6 = 2,088 kcal.
*Adapted from NRC, 2006.

**Table 15-8.** Calculation of milk production in bitches.*

**TP (liters) = ($BW_{kg}$ x k) + [(n–4) x (0.1 x $BW_{kg}$)]**
**Peak milk production (Weeks 3 to 4) = TP x 0.04.**
Example = 30-kg bitch with 8 puppies
TP = (30 x 2) + [(8–4) x (0.1 x 30)] = 60 + (4 x 3) = 72 liters milk
Peak milk production (Weeks 3 to 4) = 72 x 0.04 = 2.9 liters/day
Key: TP = total milk production through Day 45 of lactation, n = number of puppies, k = 1.6 for bitches ≤8 kg BW, 1.8 for bitches >8 to <25 kg BW and 2.0 for bitches ≥25 kg BW, BW = bitch's body weight.
*Adapted from Grandjean D, Paragon B-M, Grandjean R. Rationnement alimentaire et prévention chez le chien 1. Le Point Vétérinaire 1986; 18: 519-524.

(BCS 3.5/5). Foods for lactation should provide at least 4.0 kcal ME (16.7 kJ)/g DM (Leibetseder, 1989; Meyer et al, 1985; Grandjean et al, 1987).

## *Protein*

Protein needs during mating are the same as for maintenance for young adult dogs (i.e., 15 to 30% DM) and do not increase substantially during the first two trimesters of gestation. During late gestation, the protein requirement increases from 40 to 70% above maintenance (Gesellshaft, 1989b; Leibetseder, 1989; Meyer et al, 1985a), and follows the increase in energy requirement. Thus, foods for dogs in late gestation should also have increased levels of protein to meet nutrient requirements at the same time that DM intake is limited. The increased protein requirement can be met by providing about 7 g of digestible protein/$BW_{kg}^{0.75}$ (an increase of 30 to 50% vs. recommendations for young adults) (Gesellshaft, 1989b; Meyer et al, 1985a). The food should contain about 4 g digestible protein/100 kcal ME (about 10 g of digestible protein/MJ) (Gesellshaft, 1989b; Meyer and Heckötter, 1986). A food containing 20 to 25% DM crude protein and 4.0 kcal/g DM (16.7 kJ/g) provides this level of protein. The quality of the protein should also be higher to improve vigor of newborn puppies and minimize neonatal mortality (Ontko and Phillips, 1958). Protein deficiency during pregnancy may decrease birth weight, increase mortality during the first 48 hours of life and decrease immunocompetence of offspring (**Table 15-1**) (Ontko and Phillips, 1958).

The requirement for protein appears to increase more than the requirement for energy during lactation (Meyer et al, 1985). Therefore, the protein-energy ratio must be higher in foods for lactation than in foods for adult maintenance. Ratios of 4.8 to 6.8 g digestible protein/100 kcal ME (10.5 to 15 g/MJ digestible energy) have been recommended (Leibetseder, 1989; Meyer et al, 1985; Meyer and Heckötter, 1986). This recommendation corresponds to about 19 to 27% DM digestible protein of an energy-dense food (4.0 kcal [16.7 kJ] ME/g).

The minimum recommended crude protein allowance for foods for gestation and lactation in bitches ranges from 20% (NRC, 2006) to 22% (AAFCO, 2007). For optimal reproductive performance, foods for gestation and lactation should contain between 25 to 35% DM crude protein.

## *Fat and Fatty Acids*

Fat provides essential fatty acids and enhances absorption of fat-soluble vitamins. Increasing fat levels in foods improves digestibility and provides energy, which in turn improves nitrogen retention (Schaeffer et al, 1989). Although young adult maintenance-type foods are appropriate for the first two-thirds of pregnancy in most breeds, a food with an energy density of approximately 4.0 kcal (16.7 kJ) ME/g is recommended for the last third of gestation. Feeding a food containing slightly more than 19% DM fat usually achieves this recommendation; however, this level may need to be altered depending on litter size, body condition of the bitch, food intake of the bitch and other extraneous factors as discussed previously. The minimum recommended allowance for fat in foods intended for late gestation and peak lactation is 8.5% DM (NRC, 2006). The Association of American Feed Control Officials (AAFCO) recommends at least 8% DM fat (2007). However, to ensure optimal reproductive performance, particularly for late gestation and for lactating bitches with fewer than four puppies, at least 20% DM crude fat is recommended. At least 20% DM fat is also recommended for giant-breed bitches throughout gestation and lactation.

Increased fat intake results in better food efficiency during lactation (Siedler and Schweigert, 1954). One study showed that increasing the fat content in the food from 12 to 20% DM might increase the fat content in the milk by 30% (Gross, 1993). Because puppies are born with a very low energy reserve (Stadtfeld, 1978; Meyer et al, 1985a), sufficient energy should always be available via the milk. Increasing concentrations of fat also increase the caloric density of foods and help meet the high energy requirements of bitches during lactation. An increase in fat should be balanced by increasing other nutrients proportionally to match the increased energy density.

Milk fat and fatty acid composition are highly variable components of milk. Perhaps because of the type of food typically consumed by dogs and cattle, fat in bitch's milk contains a high percentage of unsaturated fatty acids and is rich in linoleic acid compared to cow's milk (**Table 15-3**). The type of fat fed and the fatty acid profiles of endogenous fat deposits may affect the fatty acid composition of milk. In one study, the fatty acid composition of bitch's milk reflected that of foods fed during gestation and lactation. Furthermore, the milk of bitches fed foods enriched with α-linolenic acid (ALA) but not docosahexaenoic acid (DHA) was high in ALA. Puppies fed this milk accumulated more plasma phospholipid DHA than the control group (but not as much as puppies fed preformed DHA) (Heinemann et al, 2005). In children, during early growth, DHA supports retinal and auditory development (Pawlosky et al, 1997; Birch et al, 2002; Diau et al, 2003). Furthermore, brain development and learning ability were enhanced in infants supplemented with DHA (Birch et al, 2002; Hoffman et al, 2003). Similar to findings in other species, including fish oil as a source of DHA in puppy foods improved trainability (Kelley et al, 2004). Foods containing long-chain omega-3 (n-3) polyunsaturated fatty acids fed during gestation and lactation improve retinal func-

**Table 15-9.** Comparison of key nutritional factors in selected commercial foods for reproducing (gestation and lactation) bitches to recommended levels.*

| Dry foods | Energy density (kcal/cup)** | Energy density (kcal ME/g) | Protein (%) | Fat (%) | DHA (%) | Carbohydrate (%) | Ca (%) | P (%) | Ca:P |
|---|---|---|---|---|---|---|---|---|---|
| **Recommended levels** | **-** | **≥4.0** | **25-35** | **≥20** | **≥0.02** | **≥23** | **1.0-1.7** | **0.7-1.3** | **1:1-2:1** |
| Hill's Science Diet Nature's Best Chicken & Brown Rice Dinner Puppy | 445 | 4.3 | 30.2 | 22.1 | 0.20 | 37.7 | 1.43 | 1.05 | 1.4:1 |
| Hill's Science Diet Nature's Best Lamb & Brown Rice Dinner Puppy | 442 | 4.2 | 30.1 | 22.1 | 0.17 | 36.5 | 1.5 | 1.1 | 1.4:1 |
| Hill's Science Diet Puppy Healthy Development Original | 384 | 4.2 | 31.8 | 22.9 | 0.22 | 33.2 | 1.59 | 1.21 | 1.3:1 |
| Hill's Science Diet Puppy Lamb Meal & Rice Recipe | 377 | 4.2 | 31.7 | 21.7 | 0.22 | 35.3 | 1.58 | 1.1 | 1.4:1 |
| Iams Smart Puppy | 428 | 4.7 | 32.1 | 19.9 | na | 38.7 | 1.37 | 1.04 | 1.3:1 |
| Medi-Cal Development Formula | 425 | na | 28.4 | 17.5 | 0.09 | na | 1.2 | 1.1 | 1.1:1 |
| Purina ONE Healthy Puppy Formula | 465 | 4.6 | 31.7 | 20.6 | na | 38.4 | 1.61 | 1.11 | 1.5:1 |
| Purina Pro Plan Chicken & Rice Formula Puppy Food | 473 | 4.6 | 31.6 | 20.7 | na | 36.6 | 1.23 | 1.04 | 1.2:1 |
| Purina Puppy Chow | 416 | 4.2 | 30.7 | 13.6 | na | 41.7 | 1.25 | 1.02 | 1.2:1 |
| Royal Canin Veterinary Diet Development Formula | 322 | 4.3 | 28.4 | 17.0 | na | 45.0 | 1.32 | 0.99 | 1.3:1 |
| **Moist foods** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)** | **Protein (%)** | **Fat (%)** | **DHA (%)** | **Carbohydrate (%)** | **Ca (%)** | **P (%)** | **Ca:P** |
| **Recommended levels** | **-** | **≥4.0** | **25-35** | **≥20** | **≥0.02** | **≥23** | **1.0-1.7** | **0.7-1.3** | **1:1-2:1** |
| Hill's Science Diet Puppy Healthy Development Savory Chicken Entrée | 205/5.8 oz. 459/13 oz. | 4.1 | 28.2 | 23.6 | na | 39.2 | 1.33 | 0.96 | 1.4:1 |
| Medi-Cal Development Formula | 445/396 g | na | 32.2 | 14.1 | 0.02 | na | 1.3 | 0.9 | 1.4:1 |
| Royal Canin Veterinary Diet Development Formula | 430/396 g | 4.6 | 31.8 | 19.6 | na | 40.4 | 1.45 | 1.2 | 1.2:1 |

Key: ME = metabolizable energy, Ca = calcium, P = phosphorus, Ca:P = calcium-phosphorus ratio, na = information not available from manufacturer, g = grams, DHA = docosahexaenoic acid.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated. Digestibility: Foods with higher energy density are more likely to have higher digestibility. Foods for most breeding males and females are usually similar to those for young and middle-aged adults (Table 13-4).
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup. To convert to kJ, multiply kcal by 4.184.

tion of young dogs (Bauer et al, 2006, 2006a). Because milk concentrations of DHA parallel dietary intake, it seems prudent to include DHA in foods fed to lactating bitches. Common ingredients such as fish and poultry meal are sources of DHA in foods for reproducing bitches. Foods for late gestation and peak lactation should contain the minimum recommended allowance of DHA plus eicosapentaenoic acid (EPA) of at least 0.05% (DM) (NRC, 2006). Therefore, DHA needs to be at least 40% of the total DHA plus EPA, or 0.02% DM.

### *Carbohydrate*

Technically the term "carbohydrate" includes digestible (soluble) carbohydrates (mono-, di- and polysaccharides such as starch and glycogen) and dietary fiber. This chapter refers to digestible carbohydrates. Feeding a carbohydrate-free food to pregnant bitches may result in weight loss, decreased food intake, reduced birth weight and neonatal survival of the puppies and may increase the risk of stillbirth (**Table 15-1**) (Romsos et al, 1981; Kienzle et al, 1985; Kienzle and Meyer, 1989). Because more than 50% of the energy for fetal development is supplied by glucose (Romsos et al, 1981), bitches have a high metabolic requirement for glucose during the last weeks of gestation. Feeding a carbohydrate-free food to pregnant bitches increases the risk of hypoglycemia and ketosis during late pregnancy. Furthermore, the lactose concentration in the milk may decrease by 40% during peak lactation (Romsos et al, 1981; Kienzle et al, 1985; Kienzle and Meyer, 1989) (**Box 15-1**).

Providing approximately 20% of the energy from carbohydrate is sufficient to prevent the negative side effects of a carbohydrate-free diet (Kienzle et al, 1985; Kienzle and Meyer,

**Box 15-1. Periparturient Hypoglycemia.**

Clinical hypoglycemia (i.e., glucose values <45 mg/dl or 2.5 mmol/l) occurs infrequently in bitches, but when it develops it is usually observed during the last two to three weeks of gestation. Neurologic signs of hypoglycemia predominate, and differentiation from eclampsia is not always easy. Elevated levels of serum ketones (mainly β-hydroxybutyrate) are characteristic in bitches with clinical disease; however, ketonemia may be missed when strips or tablets containing nitroprusside are used to detect ketones. Nitroprusside primarily detects acetone and acetoacetate.

Risk factors that may predispose bitches to this syndrome include: 1) poor body condition during pregnancy, 2) malnutrition and 3) feeding a high-fat, carbohydrate-free food. If a carbohydrate-free food is fed, gluconeogenic precursors such as protein should be increased by at least 50% when energy requirements are moderate and may have to be doubled if the energy requirement of the dam is high.

Treatment of clinical hypoglycemia during pregnancy should consist of intravenous administration of a bolus of 20 to 50% glucose solution, which can be followed by intravenous infusion of a 5% glucose solution at a rate of 2 ml/kg body weight/hour. During or soon after the infusion, a palatable food should be provided that has adequate carbohydrate, protein and calories (**Table 15-5**) and has above average digestibility (**Table 15-9**).

The Bibliography for **Box 15-1** can be found at www.markmorris.org.

1989). If no carbohydrate is given, protein intake must almost be doubled; the food must provide at least 12 to 13 g digestible protein/$BW_{kg}^{0.75}$ (Gesellshaft, 1989b; Kienzle et al, 1985; Kienzle and Meyer, 1989). In a study in which a food that had about 50% DM protein was fed, no problems with hypoglycemia or ketosis resulted and puppies were born healthy (Blaza et al, 1989). These protein levels are very high and may cause soft, foul-smelling stools (Paquin, 1979). Providing approximately 20% of the energy from carbohydrate translates to about 23% DM carbohydrate. Foods for gestation should contain at least 23% DM digestible carbohydrate.

When lactating bitches are fed foods without digestible carbohydrates, the lactose level in the milk may decrease to about 2% vs. the normal range of 3 to 3.5% (Romsos et al, 1981; Kienzle et al, 1985). In one study, increasing the digestible carbohydrate level in the food corrected low lactose levels; however, the same effect was not achieved by increasing protein levels (Kienzle et al, 1985). Therefore, these and other investigators recommend that foods for lactation provide at least 10 to 20% of the energy intake in the form of digestible carbohydrate to support normal lactose production (Leibetseder, 1989; Kienzle et al, 1985). Foods for bitches during lactation should also contain at least 23% DM digestible carbohydrate.

### *Calcium and Phosphorus*

For most breeds, during the first two trimesters of gestation, calcium and phosphorus needs are similar to those for maintenance of young adults (0.5 to 1.0% DM calcium and 0.4 to 0.7% DM phosphorus: Ca-P ratio 1:1 to 1.5:1). During the last part of gestation, requirements for calcium and phosphorus roughly increase by 60% because of rapid skeletal growth of the fetuses (Gesellshaft, 1989c; Meyer et al, 1985a). The minimum recommended allowance for calcium in foods intended for late gestation and peak lactation is 0.8% (DM) (NRC, 2006). The AAFCO minimum allowance is 1% (2007). As occurs with some dairy cows, excessive calcium intake during pregnancy may decrease activity of the parathyroid glands and predispose the bitch to eclampsia during lactation (Smith, 1986; Drazner, 1987). Therefore, it has been recommended for most breeds to feed a food during pregnancy that avoids large excesses of calcium (1.0 to 1.7% DM) and has a calcium-phosphorus ratio of 1.1:1 to 2:1 (**Box 15-2**). The range for phosphorus should be from 0.7 to 1.3% (DM). These amounts are also recommended for giant-breed bitches.

Mineral requirements during lactation are determined by mineral excretion in milk (Meyer, 1982) and thus by the number of nursing puppies. A definite increase in calcium content is seen over the course of lactation; however, the calcium-phosphorus ratio is consistently maintained around 1.3:1 (Meyer et al, 1985). This is reflected by the fact that even without clinical eclampsia, plasma calcium levels tend to decrease during the third and fourth week of lactation (Meyer et al, 1985a). Bitches need two to five times more calcium during peak lactation than for adult maintenance (Meyer, 1982, 1990a) (**Box 15-2**). Depending on the number of puppies, bitches need 250 to 500 mg calcium and 175 to 335 mg of phosphorus/kg body weight per day (Gesellschaft, 1989c). One investigator recommended that a food for lactation contain at least 0.8 to 1.1% calcium and 0.6 to 0.8% phosphorus (Leibetseder, 1989); however, reducing these needs by 10 to 20% will not necessarily lead to disturbances in milk mineral content. The recommended range for calcium during gestation and lactation is 1.0 to 1.7% and the corresponding recommended range for phosphorus is 0.7 to 1.3% (DM), respectively. The calcium-phosphorus ratio should be 1.1:1 to 2:1. Calcium supplementation is not recommended during gestation or lactation when appropriately balanced commercial foods are fed.

### *Digestibility*

Nutrients in foods should be highly available due to the considerable nutritional demands associated with late gestation and lactation. Apparent digestibility is the difference between the amount of food ingested and that excreted in feces. During late gestation, the ability to ingest adequate amounts of food may exceed food intake capacity, especially if the food is poorly digestible. Therefore, it is important to assess digestibility and recommend foods with above average digestibility for the reproductive process.

Digestibility information for commercial foods marketed for reproduction is not readily available. However, energy density is an indirect indicator of digestibility. Foods that have an energy

## Box 15-2. Eclampsia in the Bitch.

Eclampsia is an acute, life-threatening condition due to a sudden decrease in extracellular calcium concentration. Bitches are at highest risk for developing eclampsia (puerperal tetany) during Weeks 2 and 3 of lactation when calcium losses via secretion in milk are highest. Eclampsia is less common during Weeks 1 and 4 of lactation, and is seen rarely in the last two weeks of gestation. Occasionally, bitches may be affected at or just before whelping.

The number of nursing puppies is the most important stimulus for milk production; therefore, it is not surprising that eclampsia is seen commonly in bitches nursing large litters. Typically, affected bitches are primipara, are less than four years of age, are toy-breed dogs and have low body weight-to-litter size ratio. Investigators have suggested that toy breeds may be more predisposed to developing eclampsia than large breeds because toy breeds tend to receive more meat-based homemade foods, which are low in calcium. Serum total calcium and ionized calcium concentrations usually are decreased. Serum total calcium concentration is an insensitive measure of ionized calcium concentration. Ionized calcium is the biologically active form. In-hospital serum chemistry analyzers and point-of-care analyzers allow veterinarians to obtain serum total calcium and ionized calcium concentrations rapidly. Diagnosis of hypocalcemia is based on low serum ionized calcium concentrations. Serum ionized calcium concentrations were <0.8 mmol/l (reference range, 1.13 to 1.33 mmol/l) in a retrospective study of eclampsia in the bitch. Other causes of clinical signs typical of hypocalcemia should be considered if the serum ionized calcium concentration is >0.8 mmol/l.

Although most bitches with eclampsia are hypocalcemic, some may be normocalcemic. Some bitches with hypocalcemia, on the other hand, may not exhibit clinical signs. Typical clinical signs are anxiety, panting, whining, hypersalivation, vomiting, ataxia, stiff gait, muscle tremors, tetany and seizures. Other signs include hyperthermia, tachycardia and death, if the condition is untreated. However, clinical signs vary, based on the degree of hypocalcemia and the time over which it develops.

Lack of clinical signs may indicate that factors other than hypocalcemia determine whether tetany manifests clinically or not. The bitch may have additional serum biochemical abnormalities. Blood glucose should be measured, because hypoglycemia may be present concurrently. Magnesium levels in bitches with eclampsia may be low or normal. The ratio of serum total magnesium to total calcium may be significantly lower in affected bitches than in normal bitches. Hyperkalemia has been reported and some bitches may have abnormal serum phosphorus concentrations (either hypophosphatemia or hyperphosphatemia). Further study is needed about the role of other serum biochemical abnormalities in the clinical signs of eclampsia. The incorporation of magnesium into the treatment and prevention of the disorder should be evaluated.

Hypocalcemia leads to increased neuromuscular irritability resulting in restlessness and whining, stiffness of gait, ataxia and tonic-clonic seizures. Decrease in extracellular calcium ion levels leads to increased permeability of nerve cells (primarily of peripheral nerves) to sodium ions. Neuromuscular irritability is directly proportional to:

$[Na^+] \times [K^+] \div [Ca^{++}] \times [Mg^{++}] \times [H^+]$

Suggested causes of hypocalcemia during the periparturient period include calcium supplementation during pregnancy, poor dietary calcium and loss of calcium through fetal skeletal ossification and lactation. High calcium intake may down-regulate parathyroid gland secretion and impair normal mobilization of calcium from skeletal stores. As demand for calcium increases during late gestation and lactation, calcium homeostasis is unable to maintain critical serum levels.

Slow intravenous infusion (over five to 10 minutes) of 10% calcium gluconate, administered to effect (1 to 2 mg calcium/kg body weight), results in rapid clinical improvement. Heart monitoring (e.g., auscultation, electrocardiography) should be performed during intravenous calcium gluconate infusion. If bradycardia or dysrhythmias develop, the infusion must be slowed or discontinued. In addition, body temperature should be monitored because hypothermia may occur following calcium gluconate administration. To lessen the risk of relapse, calcium may be injected subcutaneously or intramuscularly, in addition to the immediate intravenous infusion. However, subcutaneous injections may cause skin necrosis and should be administered only when other routes are inaccessible. Following correction of acute signs, the bitch should be provided with oral vitamin D and calcium supplementation (e.g., calcium carbonate, 100 mg/kg/day, divided with meals) throughout lactation.

If possible, puppies should be separated from the bitch for the first 24 hours of treatment and fed canine milk replacer by bottle or orogastric tube feeding. If tetany recurs during the same lactation, the puppies should be weaned. Administration of corticosteroids is contraindicated because they may further decrease plasma calcium levels.

Prevention of eclampsia starts during pregnancy by feeding a balanced food, without excess calcium and with a balanced calcium-phosphorus ratio. Foods with a calcium-phosphorus ratio close to 1:1 have been recommended during pregnancy. Vitamin D therapy (10,000 to 25,000 IU daily) during the last week of gestation has been proposed, just as cows are treated to prevent postparturient paresis. This approach may not be valid for bitches because eclampsia and the highest calcium losses generally do not occur immediately after whelping.

The Bibliography for **Box 15-2** can be found at www.markmorris.org.

density of 4 kcal ME/g (16.7 kJ/g) or higher have more fat and less fiber. Fat is typically highly digestible; fiber is poorly digestible. Thus, high-fat, low-fiber foods are usually more digestible.

## Other Nutritional Factors

In addition to the key nutritional factors for commercial foods discussed above, the following nutritional factors are highlighted because they are of particular concern for homemade foods

intended for reproducing dogs (Chapter 10).

### *Essential Fatty Acids*

Homemade foods with rice and meat as the main ingredients may not provide enough essential fatty acids for lactation, and may need to be supplemented with vegetable oil (Meyer, 1990b).

### *Iron, Zinc and Copper*

Requirements for most trace elements depend on litter size. Hematocrit, hemoglobin and plasma iron values often decrease in bitches near the end of gestation (Meyer et al, 1985a). Iron requirements are particularly high during the last week of gestation, when large quantities are stored in the liver of the fetuses, and mobilized from the bitch's body for colostrum (Meyer et al, 1985a). Colostrum is very rich in iron; however, levels decrease within 48 hours (Meyer et al, 1985a). Iron concentrations are low in mature milk. Because of this, iron requirements increase only slightly during lactation when compared with adult maintenance requirements (Gesellshaft, 1989d). Therefore, neonates must have an iron reserve to overcome the initial three-week nursing period, when milk is the only source of food (Meyer et al, 1985a). Latent iron deficiency may impair neutrophil phagocytic function and cell-mediated immunity, increasing susceptibility to infections (Bhaskaram, 1988). The minimum recommended allowance for iron is 70 mg/kg (DM) (NRC, 2006). Oxides of iron should not be used as an iron source because they are poorly available (NRC, 2006).

During periods when requirements for tissue synthesis are greater than normal (e.g., pregnancy, lactation and growth), animals are particularly susceptible to zinc deficiency. Most commercial foods provide adequate zinc. However, if zinc deficiency does occur during pregnancy, it may lead to fetal resorption or fewer, less viable offspring (Fletcher et al, 1988). The minimum recommended allowance for zinc during gestation/lactation is 96 mg/kg (DM) (NRC, 2006).

Copper is an integral constituent of enzymes that catalyze oxidation reactions and plays an important role in connective tissue formation via lysyl oxidase. It is involved in hematopoiesis because it is a constituent of ferroxidases. It is also a cofactor of superoxide dismutase and thus helps protect against oxidative stress. There are numerous sources of copper but oxides of copper should not be used because they are poorly available (NRC, 2006). The minimum recommended allowance for copper is 12.4 mg/kg DM (NRC, 2006). Copper needs during gestation/lactation increase disproportionately to increased energy needs (Gesellshaft, 1989d).

### *Phenylalanine and Tyrosine*

Tyrosine is not an essential amino acid but is made from phenylalanine. However, tyrosine in adequate amounts spares about half of the need for phenylalanine. Therefore, it is appropriate to consider the amount of phenylalanine required as the sum of phenylalanine plus tyrosine. Although phenylalanine and tyrosine are not thought to be the most limiting amino acids for growth in commercial foods, at least twice as much phenylalanine, or phenylalanine plus tyrosine, is required for maximal black hair color as for growth (NRC, 2006; Biourge and Serheraert, 2002). Other metabolic needs for phenylalanine and tyrosine include protein, thyroid hormone and catecholamine synthesis (NRC, 2006). The minimal recommended DM phenylalanine allowance for foods for bitches during late gestation/peak lactation is 0.83% and 1.23% DM for phenylalanine plus tyrosine (NRC, 2006). About one and one-half to two times this much tyrosine is required to maximize black hair color (NRC, 2006).

## FEEDING PLAN

Generally, recommendations are based on information from populations of dogs at similar stages of reproduction. However, the feeding plan should be tailored to meet the needs of individual dogs based on unique variations in genetics, environment, litter size and health status. Information gleaned from the assessment step (i.e., patient, food and feeding method) sets the stage for developing the feeding plan; specifically which foods to feed and which feeding methods to use in providing the food.

### Assess and Select the Food

Food assessment includes a comparison of the current food's levels of key nutritional factors with those recommended in **Table 15-5**. For convenience, **Table 15-9** compares the key nutritional factor content of selected commercial foods marketed for dogs during reproduction to the key nutritional factor targets determined above. Pet food labels usually lack information about carbohydrate content (other than crude fiber), digestibility, energy density and specific vitamins and minerals. If the food in question is not listed in **Table 15-9**, it may be necessary to contact the manufacturer for information.

The food should also be approved by a credible regulatory agency to ensure it will support gestation and lactation (i.e., AAFCO or equivalent). This information should be listed on the product label. The food assessment step determines the appropriateness of the current food. Food selection involves choosing the food that most closely fits the key nutritional factor recommendations. If a food change is warranted, gradually transition the bitch to the new food over several days as described in Chapter 1.

Oftentimes foods marketed for gestation/lactation are also growth-type foods. Thus, they can be referred to as growth/reproduction-type foods. Generally, foods for non-reproducing sexually intact adult dogs (Table 13-4) will suffice for the first four weeks of gestation (Gesellshaft, 1989a). However, it is probably best to feed a growth/reproduction food throughout gestation, particularly for giant breeds. This recommendation also negates the need for a food change during mid- to late-gestation. Lactation represents an extreme test of a food's nutritional adequacy, because no other physiologic endeavor, other than extreme exercise, requires such a marked increase in energy density and nutrient content (Lewis et al,

1987). The nutrient demands are directly related to the dam's ability to produce milk. Because nutritional requirements for lactation increase markedly over a relatively short period of time, it is very important to provide the correct food. A more appropriate food should be selected if food assessment indicates inadequacies or if lactation performance is suboptimal. Lactating bitches are best fed commercial foods.

Dry foods are more nutrient dense, as fed, and have higher levels of carbohydrates than moist foods. These foods may benefit bitches experiencing weight loss and those spending little time eating. Conversely, moist foods are often higher in fat and provide additional water to support lactation. The added water also improves palatability so bitches may be more likely to eat. Because both food types have advantages, many breeders choose to feed both forms during gestation and lactation.

## Assess and Determine the Feeding Method

### *Breeding Males*

Some males in heavy service may have decreased food consumption and lose weight. If weight loss is a problem in reproducing males, the amount of food provided should be increased or a more energy-dense food should be fed to help maintain body condition, provided other causes of weight loss have been ruled out.

### *Bitches*

For females, it has been recommended to increase food intake by 5 to 10% above maintenance levels at the time of proestrus, and to reduce the amount back to maintenance levels after mating; a practice known as flushing (Sheffy, 1978). The purpose of flushing is to optimize conception and litter size. However, flushing is unnecessary for a bitch in good body condition (Nguyen and Dumon, 1988). Because no specific nutritional differences exist for this particular stage of reproduction, feeding methods recommended for young adult dogs are adequate during estrus (Chapter 13).

If a bitch is underfed before breeding and in poor body condition (BCS <2/5), it may be prudent to postpone mating and bring the bitch into good body condition for the next breeding. If breeding cannot be postponed, the bitch should be fed a growth/reproduction-type food, such as those listed in **Table 15-9**, in sufficient quantities to improve body condition throughout gestation (Meyer, 1990). During estrus, bitches tend to have a depressed appetite; therefore, a 17% decrease in food intake can be expected during peak estrus (Houpt et al, 1979; Bebiak et al, 1987). Occasional vomiting may occur in bitches due to hormonal changes, nervousness, travel and environmental changes associated with mating. To reduce these problems, it may be better to feed small meals or not to feed the bitch at all immediately before or after mating (Bebiak et al, 1987).

During the first two-thirds of gestation, bitches are usually fed the same amount of energy as intact adult dogs (approximately 1.8 x RER). This amount is increased to approximately 3.0 x RER during the last three weeks of gestation. Energy intake may need to be increased further to maintain normal body condition in some dogs, especially larger breeds.

During the third or fourth week of gestation, bitches commonly experience a decrease in appetite that may result in up to a 30% reduction in food intake (Lewis et al, 1987; Bebiak et al, 1987; Schroeder and Smith, 1995). This decrease may be due to the effect of embryo implantation, which starts around 20 days of pregnancy (**Figure 15-1**) (Schroeder and Smith, 1995).

Because overfeeding during gestation may have similar negative effects as underfeeding, it is recommended that small- and medium-sized bitches be meal fed. One or two meals per day will suffice for most bitches during the first half of pregnancy. At least two meals per day should be provided in the last half of pregnancy (Meyer, 1990). Giant breeds may need to be fed free choice (Zentek and Meyer, 1992). Bitches pregnant with a large litter may also need to be fed free choice because of abdominal fill. Restriction of food during gestation may lead to smaller litter size, lower birth weights and may compromise the subsequent lactation (Mosier, 1977).

As with gestation, a lactating bitch's nutrient needs are met by a combination of the nutrient levels in the food and the amount fed. Even if the food has an appropriate nutrient profile, significant undernutrition may result if the bitch is fed an insufficient amount. If the bitch maintains normal body condition (BCS 2.5/5 to 3.5/5) and the puppies are growing at a normal rate, then the amount being fed is probably appropriate. The amount to feed can be estimated either by calculation (Chapter 1) or by referring to feeding guides on product labels. As a rough estimate, bitches should ingest their DER + 25% of their DER for each nursing puppy. During peak lactation, a bitch's energy needs may be three to four times greater than its requirements for adult maintenance.

The amount fed during lactation is usually offered either three times per day or free choice. In practice, it is best to feed bitches free choice during lactation (Lewis et al, 1987), except when the bitch has only one puppy and may have a tendency to gain weight. Free-choice feeding is especially important for lactating bitches with more than four puppies (Meyer et al, 1985). Some bitches are nervous throughout lactation and free-choice feeding will allow them to eat on their schedule. Meal-fed lactating bitches should receive at least three meals daily (Lewis et al, 1987; Leibetseder, 1989). Puppies may begin to eat the bitch's food at three weeks of age; therefore, it is important to allow them access to the food. **Table 15-10** summarizes the feeding plan discussed above for reproducing dogs.

Before and during weaning, restricting the food intake of the bitch may help prevent excessive mammary gland distention and discomfort associated with abrupt weaning. Reducing the amount of food fed to the bitch will help decrease lactation. On Day 1 of the weaning process, separate the bitch from the puppies and withhold food but allow the puppies to eat their weaning food. Reunite the bitch and puppies that night and remove all food. Take the puppies away from the bitch again on Day 2. However, this time they are not returned at the end of the day; and at this point they are considered weaned. Also on Day 2, feed the bitch about one-fourth of the amount fed before breeding. Over the next three to four days, gradually increase

**Table 15-10.** Feeding plan summary for reproducing dogs.

1. For gestating and lactating bitches, use **Table 15-9** to select a food with the appropriate levels of key nutritional factors; for breeding males, use Table 13-4. For foods in neither table, contact manufacturers for key nutritional factor content.
2. The selected food should be approved by a credible regulatory agency (e.g., Association of American Feed Control Officials).
3. Determine an appropriate feeding method (Table 13-5). Free-choice feeding is the preferred method for feeding bitches during late gestation and lactation; food-restricted meal feeding may be best for breeding males.
4. For food-restricted meal feeding, estimate the initial quantity of food based on daily energy requirement (DER) calculation (DER ÷ food energy density).
5. DER is calculated by multiplying resting energy requirement (RER) (Table 5-2) by an appropriate factor. Remember, DER calculations are estimates and should be used as guidelines or starting points for amounts to feed individual dogs and not as absolute requirements; the amount fed should be refined by monitoring body condition score and weight.
   Gestation = 1.8 to 2.0 x RER for the first four weeks, then 2.2 to 3.5 x RER for the last five weeks
   Lactation = 4.0 to 8.0 x RER (peak lactation: 2.1 x RER + 25% per puppy) or use Method 1 (**Table 15-7**)
6. At the end of lactation, bitches should be fed for weaning as described in Box 16-5.
7. Monitor body condition, body weight, general health, reproductive performance and puppy growth rates to adjust the feeding plan.

the amount fed to the bitch until by Day 5 or so, the prebreeding amount (maintenance) is fed. Leaving one or two puppies to nurse will not alleviate mammary gland engorgement in bitches that are still producing a large amount of milk at weaning. This practice continues to stimulate milk production, and therefore prolongs the problem. When it is decided to completely separate the puppies from the bitch, all puppies should be taken away at once. Chapter 16 provides more information regarding weaning.

## REASSESSMENT

In general, breeding dogs should be reassessed before every estrous cycle in which a pregnancy is planned. Breeders should be encouraged to present reproducing bitches for a checkup at least a month before the upcoming estrus. Problems detected by the assessment still may be corrected before breeding. See the young adult section for assessment methods (Chapter 13).

There are two occasions during pregnancy when owners should present a bitch for assessment by a veterinarian. The first time is to confirm pregnancy with ultrasonography between 17 to 20 days after breeding, or by palpation between 25 to 36 days after breeding (Wallace and Davidson, 1995; Yeager and Concannon, 1995). A thorough physical examination should be conducted at the first visit. The owner should be encouraged to present the bitch again one week before parturition, or earlier if an abnormality is found during the first checkup. In addition to another physical examination, the following parameters should be assessed at the second checkup: a complete blood count and serum glucose, calcium and total protein concentrations.

The bitch should receive a veterinary checkup around the third or fourth week of lactation. This evaluation should include a physical examination with special attention given to mammary glands and body condition.

During lactation, owners should be advised to carefully observe the bitch and litter. Although experienced breeders usually are good observers, they still should be reminded to look for signs of impending problems. Owners should consult their veterinarian if the bitch's food intake decreases or an abnormal vaginal discharge develops. Other signs that should prompt veterinary care include hypersalivation, muscle contractions, seizures and/or weakness. Poor quality maternal care is another reason for owners to consult their veterinarian. Rectal temperature and mammary gland health should be evaluated regularly (Wallace and Davidson, 1995).

Body weight gain by puppies during early lactation provides an indication of milk production by the bitch (quantity and quality) and milk intake by puppies. Failure to gain weight for more than one day or continuous vocalization may indicate that the quantity or quality of milk production is insufficient due to mastitis, agalactia or inadequate nutrition.

Body condition scoring is an important tool to assess nutritional adequacy. Breeders can easily be taught how to assess and score body condition. A bitch should not lose more than 5% of body weight during the first month of lactation, and optimal body weight should again be reached within a month after lactation ceases (Grandjean and Paragon, 1986; Wolter, 1982). BCS should be maintained around 3/5 throughout lactation, otherwise adjustments should be made in the food or feeding method, assuming other potential causes of weight loss are ruled out.

## REFERENCES

The references for **Chapter 15** can be found at www.markmorris.org.

## CASE 15-1

### Weight Loss in a Lactating Great Dane Bitch

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### Patient Assessment

A five-year-old Great Dane bitch was examined for weight loss. The dog was in its fourth week of lactation and was nursing 11 puppies. Although most of the puppies grew according to breed expectations, three had slightly lower body weights. Delivery had been uneventful.

Physical examination revealed an underweight dog (body condition score 2/5) with no vaginal discharge or other abnormalities. The bitch currently weighed 59 kg but weighed 65 kg before the pregnancy. The mammary glands were well developed with no signs of inflammation.

A complete blood count and serum biochemistry profile were performed. Serum albumin (2.5 g/dl, normal 2.4 to 3.5 g/dl) and serum calcium (9.0 mg/dl, normal 9 to 11.8 mg/dl) concentrations were low normal. The other biochemical parameters were within normal ranges. The hemoglobin concentration (11.8 g/dl, normal 12 to 18 g/dl), packed cell volume (32%, normal 37 to 55%) and total erythrocyte count (5.13 million/ml, normal 5.5 to 8.5 million/µl) were slightly below normal.

### Assess the Food and Feeding Method

The owners reported that the bitch's appetite was voracious. The dog was fed twice daily; early in the morning before the owners went to work and in the evening when they returned home. The bitch received a commercial grocery brand dry food that the owners had fed for several years. The owners were feeding 15 cups (90 g/cup) twice daily; they commented that this seemed like a large amount of food. One cup of low-fat (2%) milk was poured over the food at each meal.

The manufacturer was contacted and provided the following information about the dry matter (DM) nutrient content of the food: crude protein 19.6%, crude fat 11.4%, carbohydrate (nitrogen-free extract [NFE]) 58.0%, crude fiber 3.45%, ash 7.6%, calcium 1.65%, phosphorus 1.23% and sodium 0.48%. The energy density was 3.4 kcal metabolizable energy (ME) (15.5 kJ)/g of food, as fed.

### Questions

1. How should this patient's laboratory results be interpreted?
2. What are the key nutritional factors for a lactating bitch with a large litter?
3. What are the caloric requirements of the patient?
4. What feeding method should be recommended for this dog?
5. What other management techniques should be used with this bitch and its puppies?

### Answers and Discussion

1. Normal pregnancy and lactation can affect canine hematologic values. Mild decreases in hemoglobin concentration, packed cell volume and total erythrocyte count occur during late gestation and lactation. These values should return to normal within several weeks after lactation ceases. Profound changes in hematologic values in pregnant and lactating bitches signal serious malnutrition and/or concurrent disease. The low normal serum albumin and calcium concentrations in this Great Dane bitch are not of immediate concern but may indicate marginal protein and calcium intake. Serum albumin has a long half-life in dogs (approximately eight days); therefore, serum albumin concentrations may not reflect changes over the last one to two weeks. Bitches with large litters secrete large quantities of calcium into the milk during peak lactation (Weeks 3 and 4 of lactation). Thus, serum calcium concentrations may be low normal to mildly decreased.
2. Key nutritional factors for lactating bitches include water, energy, protein, carbohydrate, fat, calcium, phosphorus and food digestibility. Water is needed in large quantities to produce milk. A 60-kg bitch nursing a large litter may require 10 to 11 liters of water per day during peak lactation. Energy requirements steadily increase after whelping and peak between three and five weeks at levels two to four times higher than the daily energy requirement (DER) of non-lactating young adult dogs. Foods for lactating large-breed dogs should provide at least 18% DM fat and 4.0 to 5.0 kcal ME (16.7 to 21 kJ)/g DM. During lactation, the requirements for calcium and protein increase more rapidly than the energy requirements. Generally, foods containing 25 to

35% DM crude protein and 1.0 to 1.6% DM calcium are adequate. Lactose concentrations in milk decrease when lactating bitches are fed foods without digestible carbohydrates. Food should provide at least 10 to 20% of energy intake in the form of carbohydrate to support normal milk lactose production. Because of the considerable nutritional demands associated with lactation, nutrients in the food should be highly available. Foods with above average digestibility are recommended for lactating dogs.

3. Energy requirements for lactating dogs can be subdivided into energy for maintenance and energy used for milk production. The DER, without allotment for milk production, may be slightly higher than that for average young adult dogs because of stress and increased activity associated with caring for puppies. The maintenance portion of the DER for lactating dogs has been estimated to be approximately 1.9 x resting energy requirement (RER). As a rough estimate, at peak lactation the bitch will need an additional 25% of this amount for each puppy. This amount should be adjusted based on body weight changes and body condition assessment. For this bitch, energy for maintenance at ideal body weight would be approximately 1.9 x RER (65 kg body weight) = 3,000 kcal (12.6 MJ). Energy for peak milk production (11 puppies) would be an additional 8,250 kcal (34.7 MJ). The total DER = 11,250 kcal (47.3 MJ). The bitch was currently being fed approximately 9,180 kcal (38.6 MJ) from the food plus 240 kcal (1 MJ) from the supplemental milk for a total of 9,420 kcal (39.6 MJ) per day. The estimated daily deficit is 1,830 kcal (7.7 MJ) vs. the calculated DER.
4. In general, lactating dogs should be offered food free choice. Meal feeding several times a day may be sufficient for smaller dogs or dogs with small litters.
5. The puppies should be introduced to food as soon as possible. A warm gruel prepared from moist or blended dry commercial foods formulated for canine growth should be used and can be offered several times daily to the puppies. This feeding plan will relieve the physical and nutritional stress on the bitch and begin the transition to solid food for the puppies.

## Progress Notes

The bitch's food was changed to a commercial, dry specialty brand product (Science Diet Puppy Healthy Development Original[a]) that was higher in energy density (3.94 kcal [16.48 kJ]/g as fed) than the current food. This food also had appropriate levels of other key nutritional factors. The food and fresh, clean water were offered free choice and the milk was discontinued. Approximately 24 cups of the growth/lactation food would provide the estimated DER for peak lactation. The owners were also instructed to prepare a warm gruel for the puppies using the moist formulation of the product several times daily.

Three weeks later the owners returned with the bitch and six puppies that had not yet been sold. The puppies had been completely weaned the previous week and were now eating the dry growth formula for large-breed puppies. The bitch weighed 63.5 kg and appeared normal. The owners were encouraged to slowly change the bitch's food back to the original dry food for maintenance of young adult dogs over the next week. The DER was estimated to be 1.8 x RER at an ideal weight of 65 kg, which equals 2,850 kcal (12 MJ) or nine to 10 cups of food per day.

## Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA.

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Chapter 16

# Feeding Nursing and Orphaned Puppies from Birth to Weaning

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*"Happiness is a warm puppy."*
*Charles M. Schulz*

## INTRODUCTION

Compared with the young of other species, newborn puppies are relatively immature at birth. For example, their skeletons have a low degree of mineralization (Meyer and Stadtfeld, 1980; Meyer et al, 1985). Large-breed puppies are less mature than small-breed puppies, which may be one of the reasons why they are more susceptible to malnutrition and developmental orthopedic diseases during the rapid growth phase.

Growing puppies progress through three critical phases in the first 12 months of life, during which nutrition is essential for survival and healthy development.

- A nursing period during which the transition is made from in utero nutrition to postpartum nutrition. This period is largely influenced by the nutrition of the bitch during gestation and early lactation. This chapter focuses on feeding nursing and orphaned puppies.
- A weaning period, which is very stressful due to changes in food and environment. The transition from bitch's milk to solid food for further growth must therefore be handled properly. Because weaning overlaps with the nursing period, it is also covered in this chapter.
- A postweaning period that occurs from two to 12 months of age and is a critical time for development. Proper feeding during this period is especially critical for large- and giant-breed puppies because nutrition has proved to be the most important non-genetic factor for healthy bone development. Chapter 17 covers postweaning feeding of growing puppies.

Before weaning, mortality may be as high as 10 to 30%, with two-thirds of the deaths occurring during the first week of life (Pibot and Jean-Blain, 1989; Lawler and Evans, 1989). Three factors are critical to successful transition from fetal life to the nursing period: 1) the bitch's nutrition during gestation and early lactation, 2) the bitch's behavior and physical health and 3) provision of good neonatal care (husbandry practices) by the owner.

Puppies are considered orphaned if they lack sufficient maternal care for survival from birth to weaning. Several physiologic needs normally provided by the bitch must be met to ensure survival of neonates: heat, humidity, nutrition, immunity, elimination, sanitation, security and social stimulation. A foster bitch or the caregiver must meet these needs for orphaned puppies. Most orphans can be raised successfully with proper care and nutrition.

## Box 16-1. Puppy Behavior from Birth to 12 Weeks of Age.

Three phases of puppy behavior are described during the first 12 weeks of life:

- Neonatal period: From whelping to when the eyes open at about 13 days of age.
- Transition period: From when the eyes open to three weeks of age.
- Socialization period: From three weeks of age to weaning.

**NEONATAL PERIOD**

A newborn puppy has two basic activities: sleeping and nursing. Puppies quickly learn to find the bitch's teats when the bitch lies down for nursing. Nursing should be vigorous and active, and after nursing, the puppy's abdomen should be enlarged. Following nursing, puppies usually return to sleep. Neonates spend more than 80% of their time sleeping. However, a healthy puppy never sleeps deeply and quietly. Involuntary muscle contractions such as jerks and twitches (especially of the facial muscles) and irregular respiration are common. This pattern of activity is called "activated sleep" and should not be mistaken for shivering, a reflex that is not operant until about seven days of age. A puppy sleeping without these movements may be ill and should be observed closely. Puppies start crying when hungry or away from the litter; however, healthy puppies will stop crying soon and sleep again, even without nursing. Weak puppies may also have an enlarged abdomen but are restless and continue to vocalize. Such vocalizing is a constant high-pitched crying and is different from the crying of healthy puppies when they are hungry.

**TRANSITION PERIOD**

Puppies become more responsive to their environment as they become older. They no longer cry consistently when hungry or separated from littermates, but will cry when placed in an unfamiliar environment, even if warm and fed. Puppies begin to respond to visual stimuli when their eyes open. Puppies first start to play fight, clumsily pawing and mouthing at one another during this period. Tail wagging also occurs.

The first teeth may begin to erupt during the third week of life. Puppies lose the need for perineal stimulation to eliminate. Sucking on objects other than the bitch's nipples progressively decreases. By the end of the transition period puppies begin to lap liquids. A gruel or milk replacer should be presented in a bowl or saucer at this time; ground meat or thick gruels can be handfed.

**SOCIALIZATION PERIOD**

After a puppy can see and hear, it begins more active social interactions with its dam, littermates and people. Social bonds are formed and social hierarchies are begun. The critical period for socialization lasts until about 12 weeks, and exposure to people and other dogs is essential. Puppies achieve the full-grown dog form of locomotion, although they are still clumsy and have little endurance. Play fighting among puppies becomes a predominant behavior during this period. Eruption of deciduous teeth is complete by the first half of this period. Puppies no longer eliminate reflexively when the perineum is stimulated and they leave the nest box to do so. During the socialization period, puppies develop the ability to lap liquids well and are able to eat solid foods. The dam becomes less tolerant to nursing.

The Bibliography for **Box 16-1** can be found at www.markmorris.org.

# PATIENT ASSESSMENT

## History

When raising puppies, owners should be encouraged to maintain a logbook that may provide important information about the health and nutritional status of the puppies and dam. Owners should record birth weights of the puppies followed by their body weights every one to two days for the first four weeks of life, which also helps with socialization. Changes in behavior and other indicators of health such as opening of eyes, eruption of teeth, consistency of feces and food intake should also be recorded. **Box 16-1** provides a brief review of normal behavior for nursing puppies. **Table 16-1** lists normal physiologic values for neonatal puppies. Puppies should be identified in some manner (e.g., with a colored collar, nail polish, etc.) to facilitate easy recognition (**Box 16-2**).

## Physical Examination

The goal of a physical examination is to assess indicators of impaired health that may reveal serious metabolic perturbations such as hypoglycemia, hypothermia and dehydration. Special attention should be paid to assessing puppy behavior, environmental conditions and hygiene. These parameters are important markers/risk factors for potential health problems. However, because puppies depend on bitch's milk during the neonatal period, assessment must always include a thorough evaluation of the health and maternal behavior of the bitch.

The most important areas of evaluation of nursing puppies are assessment of body weight and condition (especially with respect to temporal changes), body temperature and other physical parameters.

Orphaned puppies should be thoroughly evaluated when first seen. A careful physical examination of neonates and the bitch, if available, should be performed to detect the potential cause for abandonment. Particular attention should be given to detect common problems such as hypothermia, hypoglycemia, dehydration and congenital defects. The nutritional and hydration status should also be noted.

### *Body Weight*

Low birth weight is highly correlated to neonatal mortality. Low birth weight puppies are particularly prone to hypoglycemia and sepsis, and are less likely to survive without special care. **Table 16-2** provides birth weights for selected dog breeds. Nursing puppies should be weighed daily or every other day on a gram scale. Monitoring the puppies' weight is a good way to evaluate the quality and quantity of milk the bitch is producing and the milk intake and health status of the puppies

**Table 16-1.** Normal physiologic values for neonatal puppies and data for neonatal care.

| | | |
|---|---|---|
| Birth weight | Individual | 1-6.5% of mother's weight |
| | Total litter | 12-14% of mother's weight |
| | BW at 8-10 days | 2 x birth weight |
| Daily weight gain | Week 1 | 8% (5-10%) |
| | Weeks 2-4 | 5% (3.5-6%) |
| | Weeks 5-10 | 2 g/kg adult BW |
| | >10 weeks | 2-4 g/kg adult BW |
| Body temperature | 24 hr after birth | 35.5 ± 0.8°C (96 ± 1.4°F) |
| | Weeks 1-2 | 34.5-37.2°C (94-99°F) |
| | Weeks 2-4 | 36.0-37.8°C (97-100°F) |
| | >4 weeks | 37.8-38.3°C (97-101°F) |
| Heart rate | Weeks 1-2 | 230-240 beats/min. |
| | Weeks 3-4 | 210-220 beats/min. |
| | Weeks 5-6 | 195 beats/min. |
| | Week 7 | 185 beats/min. |
| | Weeks 8-12 | 165-175 beats/min. |
| Respiratory rate | At birth | 15-35 breaths/min. |
| Shivering reflex develops | - | 6-8 days |
| Eyes | Eyes open | 10-14 days |
| | Visual following of moving objects | 3-4 weeks |
| | Recognition of owner and mother | 4-5 weeks |
| Ears | Open | 12-17 days |
| | Reaction to auditory stimuli | 3-4 weeks |
| Locomotion | Stepping movements with forelimbs | 5-6 days |
| | Stepping movements with pelvic limbs | 7-10 days |
| | Ability to stand | 10 days |
| | Steady gait | 3 weeks |
| | Walking and running | 4 weeks |
| Micturition and defecation | Voluntary control | 16-21 days |
| Activated sleep | Muscle tic disappears | 4 weeks |
| Descent of testes | - | 18-45 days |
| Urine specific gravity | - | 1.006-1.007 |
| Water requirement | - | 180 (130-220) ml/$BW_{kg}$/day |
| Eating solid food | - | 4-5 weeks |
| Deciduous teeth eruption | Incisors | 3-4 weeks |
| | Canines | 3 weeks |
| | Premolars | 4-12 weeks |
| Permanent teeth eruption | Incisors | 3-5 months |
| | Canines | 4-6 months |
| | Premolars | 4-6 months |
| | Molars | 5-7 months |
| Body water | At birth | 80% |
| Fat reserves | At birth | 1-2% |
| | At 2 weeks | 10% |
| | At 1 month | 17% |
| | Non-obese adult dogs | 22-23% |

Key: BW = body weight, C = centigrade, F = Fahrenheit.

(**Box 16-3**). Puppies should neither lose weight nor fail to gain weight for more than one day. Loss or failure to gain weight in an individual puppy or the entire litter may indicate disease in the puppies or bitch, inadequate milk production or inability to suckle. It is essential to evaluate puppies' growth rate in relation to changes in behavior such as restlessness and continuous vocalization.

## *Body Temperature*

When examining a puppy, the clinician should determine whether the puppy is warm. Neonates show a certain degree of poikilothermy during the first two weeks of life (Mosier, 1978), and have an extremely low amount of body fat (Rauchfuss, 1978). Therefore, it is vital for newborn puppies to eat and be kept in a warm environment. During the first week, the immediate environment of the puppies should be kept between 29 and 32°C (84 to 90°F). This means that the temperature in the room with the bitch and its litter should be maintained between 24 and 27°C (75 to 81°F). **Table 16-3** lists optimal environmental temperatures for orphaned puppies. Marginal hypothermia can often be detected by palpation of the lower limbs (**Box 16-4**). The behavior of the bitch may indicate whether a puppy is hypothermic or ill. A bitch may push a puppy away and neglect its cries when the puppy's skin temperature drops below a certain level (Mosier, 1978).

## Box 16-2. General Husbandry Practices for Neonates.

Puppies should be housed in warm draft-free enclosures. Incubators are ideal, particularly for newborns. Pet carriers, shoeboxes or cardboard boxes are suitable substitutes. The bedding should be soft, absorbent and warm. Thread-free cloth, fleece and wood shavings are appropriate materials and help puppies feel secure as they snuggle into them.

Neonates demonstrate a certain degree of poikilothermy and are unable to regulate body temperature well during the first four weeks of life. Puppies huddle together close to the bitch, which generates an optimal microclimate, protects them against changes in environmental temperature and decreases the rate of heat loss. Orphans cannot seek protection near the bitch and are more sensitive to suboptimal environmental conditions.

Without the bitch, puppies can quickly become hypothermic, which leads to circulatory failure and death. Artificial heat should provide age-optimal environmental temperatures (**Table 16-3**). It is best to set the heating source to establish a gradation of heat in the nest box. A gradation of environmental temperatures allows neonates to move toward or away from the heat source as needed to avoid hyperthermia, which can be as detrimental as hypothermia. Puppies can rapidly become dehydrated secondary to overheating. Maintaining humidity near 50% helps reduce water loss and maintains the moisture and health of mucous membranes.

To fulfill non-nutritive nursing needs, hand-reared puppies often nurse other littermates in the nest box. To avoid skin trauma related to excessive nursing, puppies can be housed individually or separated by dividers. Although beneficial for alleviating problems due to non-nutritive nursing, separation of the litter reduces temperature and humidity in the immediate environment and social stimulation by littermates. Brief, but regular handling, provides social stimulation. The stress associated with regular handling may increase neural development and improve weight gain in puppies. Neonates raised without social stimulation develop abnormal behavior patterns (i.e., reduced normal exploratory behavior and neonates become more suspicious and aggressive as adults). Peer contact can compensate for maternal deprivation. Therefore, benefits of separating neonates must be weighed against the potential for development of abnormal behavior and increased risk for hypothermia. Puppies should interact with littermates as much as possible until weaning.

Puppies obtain passive systemic immunity from colostrum and passive local immunity from continued ingestion of bitch's milk. If possible, neonates should receive colostrum or bitch's milk within the first 12 to 16 hours of birth. This is particularly critical for puppies fed only milk replacers because they lack systemic and local immune protection.

Normally the bitch will sever the umbilical cord. If not, it should be cut to 1.5 in. (3.5 to 4 cm) and an appropriate topical antiseptic applied. Orphaned puppies are at greater risk for infectious diseases; thus, sanitary husbandry practices are important. To reduce risk for diseases, puppies should not be exposed to older animals or grouped within multiple litters. Feeding equipment and bedding should be kept clean and sanitized frequently. Caretakers should wash their hands before handling neonates and after stimulating elimination.

Puppies cannot voluntarily urinate or defecate until about three weeks of age. Until that time, they rely on the bitch to stimulate the urogenital reflex to initiate elimination. Caretakers should stimulate puppies after feeding by gently swabbing the perineal region with a warm moistened cotton ball or cloth.

Often, puppies within a litter look similar; therefore, it may be difficult to tell them apart when hand rearing, especially in large litters. Different colored nail polish can be applied to the claws to help differentiate individuals; owners can paint a different paw for each puppy (e.g., blue front left paw, blue right rear paw, pink right front paw, etc.).

### *Other Physical Parameters*

When evaluating neonates, the clinician should hold each puppy to assess alertness, muscle tone and response to handling. Attentive, experienced breeders often are good observers and make these evaluations routinely. Gastric fullness should be evaluated and the owner asked if the puppies are nursing. Healthy puppies, if hungry, might start crying but in a short time they generally stop crying and sleep, even without nursing (**Box 16-1**). Small and weak puppies may appear to nurse and develop abdominal fullness, yet fail to thrive. Weak puppies may also have an enlarged abdomen but are often restless and vocalize, which should alert the owner. This distention may result from aerophagia (Bebiak et al, 1987); however, more often it is caused by malnutrition or illness of the bitch or puppy. Weak puppies cannot reach the bitch's nipples and stimulate milk release, which is usually achieved by kneading the mammary glands with their forelimbs.

## Key Nutritional Factors

### *Colostrum and Milk*

The liquid secretions from the mammary glands during the first few days postwhelping are known as colostrum. The composition of the milk changes rapidly to become normal or "mature" milk between 24 hours postpartum and the end of the first week of lactation. Colostrum transfers immunoglobulins, provides a concentrated source of energy and selected nutrients and produces a laxative effect.

The immune system of neonatal puppies is immature, which is offset by passive transfer of immunoglobulins from the bitch across the placenta and in the colostrum (Banks, 1981; Tizard, 1992). Investigators estimate that puppies receive only 5 to 10% of IgG from transplacental transfer; therefore, they depend primarily on immunity derived from the intake of colostrum (Tizard, 1992). Colostrum contains about twice as much protein as mature milk; globulin proteins make up the entire difference (Meyer et al, 1985a; Rüsse, 1971). Colostrum is particularly rich in IgG, as opposed to mature milk, which is richer in IgA (Banks, 1981).

Colostrum has a very different composition than mature milk. Due to its high dry matter (DM) content, colostrum is sticky and viscous (Meyer et al, 1985a), which makes nursing more difficult, especially for weaker puppies. The DM content

of colostrum decreases within 12 to 24 hours after whelping, primarily reflecting a decrease in protein.

The lactose concentration of colostrum is very low compared with that of mature milk (i.e., 1.0 vs. 3.4%) (Meyer et al, 1985a). Levels of calcium, phosphorus and magnesium are very high in colostrum and decrease after two to three days to levels that are lower than in mature milk (Meyer et al, 1985a).

Just after whelping, colostrum contains high levels of iron, copper and zinc, which decrease within 48 hours postpartum (Meyer et al, 1985a). Colostrum is high in vitamin A (Meyer et al, 1985; Ferrando et al, 1975); colostrum levels increase the liver reserve of vitamin A in puppies by 25% within a week (Meyer et al, 1985).

Milk is assumed to be a complete food for neonates. The composition of milk (i.e., water, protein, fat, lactose, minerals and vitamins) is designed to support the normal growth rate of neonates. Thus, the nutrient content of bitch's milk in **Table 16-4** summarizes the key nutritional factors for nursing puppies. For nutrients in which the concentration in mature milk is unknown, values recommended by the Association of American Feed Control Officials for growth should suffice (2007). In lieu of other information, the key nutritional factor discussion for weaning and postweaning puppy growth provides information that could be extrapolated to neonates (Chapter 17).

Milk from different mammalian species contains the same components but in different proportions. One reason for the difference in milk composition may be the relative growth rates of each species (Johnson, 1974). The faster the rate of growth, the more concentrated the milk nutrients to support growth (Table 15-4). Bitch's milk is higher in energy, protein and minerals than cow's milk (Table 15-3). As with other species, the nutrient concentration in bitch's milk changes with duration of lactation (Adkins et al, 2001).

## *Water*

Water is one of the most important nutrients in orphan feeding. The normal water intake of puppies is relatively high. A normal puppy needs about 60 to 100 ml of fluid/lb body weight per day (130 to 220 ml/kg body weight per day) (Lawler, 1991; Mosier, 1977). On average, orphaned puppies should receive about 180 ml of water/kg body weight to make orphan feeding successful. Water should be given until 180 ml/kg body weight is reached if the milk replacer doesn't provide this much water at the recommended dilution.

## *Energy*

Data from two studies show that bitch's milk is extremely digestible (Mundt et al, 1981; Kienzle et al, 1985). The energy intake of suckling puppies can be expressed in terms of gross energy (GE) because the energy digestibility is greater than 95%. The high digestibility of milk maximizes its usage and helps puppies survive the critical first weeks. Bitch's milk is high in energy and provides about 146 kcal GE (610 kJ)/100 g of milk.

Total milk intake per puppy is lowest during the first week of

**Table 16-2.** Average litter size and birth weight of dogs.*

| Breed | Litter size | Birth weight (g) |
|---|---|---|
| Airedale terrier | 9 | 300 |
| Appenzell mountain dog | 10 | 465 |
| Australian silky terrier | 3 | - |
| Bernese mountain dog | 5 | 445 |
| Borzoi | 9 | 450 |
| Boxer | 8 | 440 |
| Cavalier King Charles spaniel | 4 | 230 |
| Chihuahua | 2-3 | 140 |
| Chow chow | 6 | 460 |
| Dachshund | 4 | 215 |
| Dalmatian | 5-6 | - |
| Doberman pinscher | 7 | 410 |
| English bulldog | 7 | 295 |
| English cocker spaniel | 6 | 230 |
| English springer spaniel | 11 | 375 |
| Fox terrier | 3 | 260 |
| French bulldog | 5 | 215 |
| German shepherd dog | 6 | 445 |
| German shorthaired pointer | 7-8 | 415 |
| Great Pyrenees | ≥5 | 705 |
| Hovawart | 11 | 435 |
| Irish terrier | 6 | 270 |
| Labrador retriever | 5 | 450 |
| Maltese | 3 | 155 |
| Miniature dachshund | 3 | 210 |
| Miniature pinscher | 3 | - |
| Miniature poodle | 2-3 | 165 |
| Miniature schnauzer | 4 | 155 |
| Newfoundland | 7 | 595 |
| Norwich terrier | 5 | 225 |
| Papillon | 3 | 120 |
| Pekingese | 2-3 | - |
| Pomeranian | 2 | - |
| Pug | 3 | - |
| Rottweiler | 7 | - |
| Saint Bernard | 7 | 640 |
| Scottish terrier | 5 | 240 |
| Shetland sheepdog | 4-5 | 260 |
| Shih Tzu | 2-3 | - |
| Sloughi | 3 | 670 |
| Standard schnauzer | 6 | 285 |
| Yorkshire terrier | 5 | 95 |

*Because of the very large variation in adult body weight (BW) and number of puppies per litter, there is no direct relationship between the birth weight of a puppy and the BW of the mother. Puppies from largest breeds are approximately 1% of the bitch's BW, whereas a Chihuahua puppy averages 6.4% of its mother's BW. However, there is a strong relationship between the weight of the total litter and the bitch's BW. On average, the total litter weight is about 12 to 14% of the bitch's BW. This relationship and the values in this table may be helpful to determine if individual puppies are far below the average expected birth weight, and to assess the bitch's nutritional status during pregnancy.

**Table 16-3.** Optimal environmental temperatures for orphaned puppies.

| Age | °Centigrade | °Fahrenheit |
|---|---|---|
| | **Immediate environment/ incubator for orphans** | |
| Week 1 | 29-32 | 84-90 |
| Week 2 | 26-29 | 79-84 |
| Week 3 | 23-26 | 73-79 |
| Week 4 | 23 | 73 |
| | **Environment around litter** | |
| Week 1 | 24-27 | 75-81 |

## Box 16-3. Body Weight Gain in Puppies.

Birth weight of puppies is the single most important measure of their chances of survival, and reflects, among other factors, the adequacy of the bitch's nutrition during pregnancy. The evolution of a puppy's body weight gives useful information about food intake and general health. Body weight should be recorded within 24 hours after parturition, and then daily or every other day for the first four weeks of life, using an accurate gram scale.

### BIRTH WEIGHT

Due to variation in breed size, an exact optimal birth weight is difficult to estimate for individual puppies. Body weight at birth correlates primarily with the weight of the mother; birth weights range from 1% for some large and giant breeds to about 6.5% in Chihuahuas. Interestingly, investigators found a consistent ratio between the weight of the total litter and the body weight of the dam. Birth weight of the entire litter averages about 12 to 14% of adult body weight. The ratio can be slightly smaller in large breeds. Given the number of puppies and the ratio of litter to adult body weight, the birth weight of individual puppies can be evaluated in relation to the expected total number of puppies per litter.

### BODY WEIGHT GAIN

Daily weight gain averages about 5% of the puppy's current body weight during the first four weeks after parturition. The absolute daily weight gain is lowest during the first week of life; however, the relative increase is largest (average 7.7% of body weight), and can reach 10% of body weight (**Table 1**). In the first 48 hours, the increase in body weight is not related to the puppy's body weight, because healthy smaller puppies eat relatively more in an effort to replete body reserves.

The puppy's body weight often doubles by eight to 10 days after parturition and it may triple by the third week. Although the relative weight gain gradually decreases, weight gain in g/day varies little from the second to the fourth week of life.

Daily gain can vary markedly. Although puppies should be weighed every day or every other day, a more precise evaluation should be based on the average weekly weight gain.

Between one and two months of age, daily weight gain may average 3 g/kg adult body weight, and between 2 and 4 g/kg adult body weight through weaning. These numbers may be used to help assess growth rates. However, dogs do not grow linearly; the growth curve has a sigmoid shape, with a fast exponential growth component first followed by slower growth. The exact timing of these phases differs from breed to breed. As a rule, small- and medium-sized dogs (up to 25 kg) reach about 50% of their adult weight around four months of age, whereas dogs with adult weights above 25 kg reach the 50% point at about five months of age.

**Table 1**. Average daily weight gain of puppies.*

| Week | % of current body weight |
|---|---|
| 1 | 8 (5-10) |
| 2 | 6 |
| 3 | 4 |
| 4 | 3.5 |

*Adapted from Kienzle E, Meyer H, Dammers C, et al. Milchaufnahme, Gewichtentwicklung, Milchverdaulichkeit, sowie Energie- und Nährstoffretention bei Saugwelpen. Fortschritte in der Tierphysiologie und Tierernährung (Advances in Animal Physiology and Animal Nutrition) 1985; Suppl. No. 16: 27-50. Mundt H-C, Thomée A, Meyer H. Zur Energieund Eiweißversorgung von Saugwelpen über die Muttermilch. Kleintierpraxis 1981; 26: 353-360.

The Bibliography for **Box 16-3** can be found at www.markmorris.org.

life. However, expressed per kg body weight, puppies' milk intake is highest during the first week and decreases progressively (Kienzle et al, 1985). Puppies born with a lower body weight ingest an amount of milk similar to that of their larger littermates during the first 48 hours of life (Oftedal, 1984; Kienzle et al, 1985).

The energy requirement of a puppy is the sum of energy needed for maintenance and the requirement for growth. Because puppies sleep more than 80% of the time, and huddle together in a warm whelping box, they are able to decrease their energy requirements for maintenance to a level that approaches resting energy requirement (70 kcal/$BW_{kg}^{0.75}$) (Mundt et al, 1981) during the first week of life. Therefore, all additional ingested energy can be used for growth. Their energy intake averages about 240 kcal (1 MJ)/kg body weight/day during the first four weeks of life. Averages, however, may vary from as high as 287 kcal GE (1.2 MJ)/kg body weight during the first week of life to as low as 190 kcal GE (0.8 MJ)/kg body weight by Week 4 (Oftedal, 1984; Mundt et al, 1981; Kienzle et al, 1985).

This information can also be generally applied to orphaned puppies. A very common mistake is to underestimate the energy requirements of neonates. In the beginning, however, it is better not to over feed orphaned puppies to avoid diarrhea. **Table 16-5** summarizes the estimated energy requirements of orphans to transition them to milk replacers. The initial amounts in **Table 16-5** are lower than the amounts discussed above. These lower levels are intended to help orphaned puppies adapt to orphan formulas. When using commercial milk replacers, it is usually best to follow the label recommendations.

## *Protein*

Protein digestibility of bitch's milk is very high (up to 99%), and nitrogen retention is about 90% during the first week (Mundt et al, 1981). Compared with cow's milk, bitch's milk contains more than twice as much protein per 100 ml (7.5 vs. 3.3%) (Table 15-3). Bitch's milk also provides high levels of arginine, lysine and branched-chain amino acids (Meyer et al, 1985a; Swaisgood, 1995). This nutrient profile is important when assessing and formulating milk replacers, and reflects the enormous anabolic activity of puppies at this young age. Protein requirements should be met if puppies ingest adequate amounts of energy as that contained in bitch's milk.

Commercial milk and homemade replacer formulas should have adequate protein and essential amino acid content and

appropriate ratios of these constituents. The arginine and histidine levels in a formula are particularly important. Deficiency of these amino acids can cause cataract development in neonates and contribute to anorexia and poor growth. The minimum recommended levels of these two amino acids for growth in puppies after weaning are 0.79 and 0.39% (DM), respectively (NRC, 2006). These recommendations are based on a food with 22.5% DM crude protein. For four- to 14-week-old puppies, 0.01 g of arginine should be added for every 1% of crude protein in excess of 22.5% (NRC, 2006). The amount of arginine in milk is 420 mg/kg (as fed) or 1.85% (DM) (**Table 16-4**).

### *Fat*

Approximately 1.5% of a puppy's total body mass at birth is fat, which is very low compared to the 22% body fat of non-obese adult dogs (Stadtfeld, 1978; Rauchfuss, 1978). Puppies increase body fat during the first month of lactation; accretion of body fat is about 50% of total weight gain (Kienzle et al, 1985). Fat increases to about 10% of body weight by two weeks of age (Meyer and Stadtfeld, 1980) and to 17% after one month (Kienzle et al, 1985). The dam's milk, therefore, must contain enough energy (fat) to support development of these reserves. Milk fat and fatty acid composition are two of the most variable components of milk. The fat content and fat quality of milk depend on the food the bitch receives during lactation (Gross, 1993). Bitch's milk should contain 9 g or more fat/100 g of milk. Fat in bitch's milk contains a high percentage of unsaturated fatty acids and is rich in linoleic acid compared with cow's milk (Table 15-3).

Milk fat and fatty acid composition are highly variable components of milk and often reflect dietary intake of the bitch. The type of dietary fat fed in conjunction with the fatty acid profile of endogenous fat deposits may affect the fatty acid composition of milk. In one study, the fatty acid composition of bitch's milk reflected the foods fed during gestation and lactation. Furthermore, the milk of bitches fed foods enriched with α-linolenic acid (ALA) but not docosahexaenoic acid (DHA) was high in ALA. Puppies fed this milk accumulated more plasma phospholipid DHA than the control group (but not as much as puppies fed preformed DHA) during suckling (Heinemann et al, 2005). In children, during periods of early growth, DHA may be needed to support retinal and auditory

## Box 16-4. Hypoglycemia, Hypothermia and Dehydration in Neonates.

Before weaning, mortality of puppies can be as high as 10 to 30%, with 65% of the deaths occurring during the first week of life. Healthy puppies sleep and nurse; when a puppy continues to vocalize it is probably ill, malnourished, cold or dehydrated.

The syndrome of hypoglycemia, hypothermia and dehydration is by far the most common nutrition-related condition seen in neonates. Orphaned puppies are at a much higher risk than nursing puppies, especially when deprived of colostrum. Low fat stores and the degree of poikilothermy make puppies dependent on effective nursing and optimal environmental temperature during the first two weeks of life. The first three days of life, however, are the most critical. Rectal temperatures of newborn puppies may decrease up to 4 to 5°C (7 to 8°F) immediately after parturition. Furthermore, healthy puppies may lose about 0.5 g of body weight every 30 minutes that they sleep without being fed.

When food intake is inadequate or when the environmental temperature is too low, newborn puppies rapidly deplete glycogen and fat stores and soon chill and become hypoglycemic, weak and dehydrated. Etiology includes inadequate milk production by the bitch (qualitative or quantitative), and all the causes of anorexia and reasons why a puppy refuses or is unable to nurse, including early maternal rejection, prematurity and low birth weight.

Infections, parasites and other illnesses lead to anorexia and may cause hypoglycemia, dehydration and hypothermia. Diarrhea rapidly causes dehydration in young puppies.

Hypoxia is an important cause of anorexia and hypoglycemia. Hypoxia may result from dystocia, prolonged birth or trauma caused by the bitch. Neonates have significantly lower blood glucose levels during the first day of life when their dam refused food during the last days of pregnancy.

Hypoglycemia, hypothermia and dehydration are interrelated; one can cause or worsen the others, starting a vicious cycle (**Figure 1**).

**HYPOTHERMIA**

After a puppy's rectal temperature drops below 34.5°C (94°F) the puppy becomes less active and nurses ineffectually, bowel movements stop and digestion no longer occurs. When a puppy's skin feels cold, the dam will push the puppy away and ignore its cries. The puppy then becomes hypoglycemic and is too weak to nurse, initiating a vicious cycle from which the puppy will not survive without help. Tissue hypoxia and metabolic acidosis may reach profound proportions. After the body temperature reaches the critical level of 32°C (90°F), hypothermia becomes severe and the puppy lies motionless, with a very slow respiratory rate and an occasional air hunger response. It has been reported that healthy newborn puppies can survive up to 12 hours of deep hypothermia and recover if warmed slowly. In practice, however, hypothermic puppies can be rescued only when the problem is detected early and treated correctly.

Hypothermia that develops in puppies kept at the correct environmental temperature may indicate insufficient milk intake by the puppy due to disease or weakness, inability to reach the bitch's nipples, insufficient milk production and/or inadequate maternal behavior and poor milk quality or quantity due to insufficient nutrition of the dam, disease of the dam and/or inherited factors.

Orphaned puppies are at greater risk because they are more sensitive to suboptimal temperatures without the dam. Additionally, the milk replacer formula or feeding schedule may be inadequate.

**HYPOGLYCEMIA**

Fetuses receive continuous infusion of glucose from the placenta, so they do not depend on their own gluconeogenesis. Because they have very low fat and glycogen reserves at birth, canine neonates may develop hypoglycemia after only 12 hours of fasting. In contrast, adult dogs can undergo weeks of starvation without developing hypoglycemia. During starvation, gluconeogenesis becomes the

*Box 16-4 continued*

sole means of glucose homeostasis. The neonate's small muscle mass, decreased use of free fatty acids as an alternate energy source and a possible lack or decreased levels of gluconeogenic enzymes limit the neonate's capacity to maintain normal glucose levels. Dietary carbohydrate and protein levels can also affect activities of gluconeogenic enzymes in puppies. Transient hypoglycemia is sometimes seen in toy-breed puppies between two and three months of age; however, transient hypoglycemia is different from this syndrome.

**DEHYDRATION**

Dehydration is characterized by wrinkled skin and dry, sticky mucous membranes, which may appear deep pink or red.

**TREATMENT**

The three treatment goals for hypoglycemia, hypothermia and dehydration are to: 1) achieve optimal core body temperature, 2) maintain glucose within physiologically normal levels and 3) achieve adequate hydration status.

Chilled puppies should receive a mixture of equal amounts of physiologic saline solution (or lactated Ringer's solution) and a 5% glucose solution by subcutaneous injection before rewarming. Glucose is necessary to meet the sudden increase in energy requirements during warming.

Hypothermic puppies should first be warmed to 34.5°C (94°F), a temperature that allows digestive enzymes to become active again. If they are not warmed before being fed, hypothermic puppies will develop diarrhea, resulting in further dehydration and hypothermia, because of nonfunctioning digestive enzymes.

Hypothermic puppies should be warmed slowly and progressively over one to three hours to prevent oxygen and energy requirements of tissues from increasing faster than the puppy can supply. Aggressive, rapid warming can compromise vascular integrity and aggravate fluid loss and dehydration, resulting in hyperthermia, hypovolemia, shock and death. Slow warming is best accomplished by using body heat. A simple method such as placing a chilled puppy in an inside pocket of a loose-fitting garment will result in slow warming and gentle massage. Warm water (36.5°C [98°F]) or a warm-water heating blanket is a good alternative. If a closed incubator is used, humidity should be around 60%. Because their normal body temperature is lower than that of adult dogs, newborn puppies should not be warmed to adult body temperature, but to about 36 to 36.7°C (97 to 98°F). Hypothermic animals are susceptible to infections, so administration of antibiotics may be lifesaving.

Dehydration should not be treated orally in markedly hypothermic puppies because of their depressed gastrointestinal motility. Parenteral fluid solutions, warmed to body temperature, can be given subcutaneously, at the dose of 1 ml/30 g body weight, and repeated as needed. After body temperature is restored, oral solutions can be administered by stomach tube. Nursing should recommence as soon as possible, although hand rearing will be necessary if the bitch is incapable of feeding the puppies.

Tube feeding with an appropriate milk replacer, parenteral fluid administration and other supportive therapy should be implemented at once each time a young puppy becomes weak and before hypothermia and dehydration are a problem.

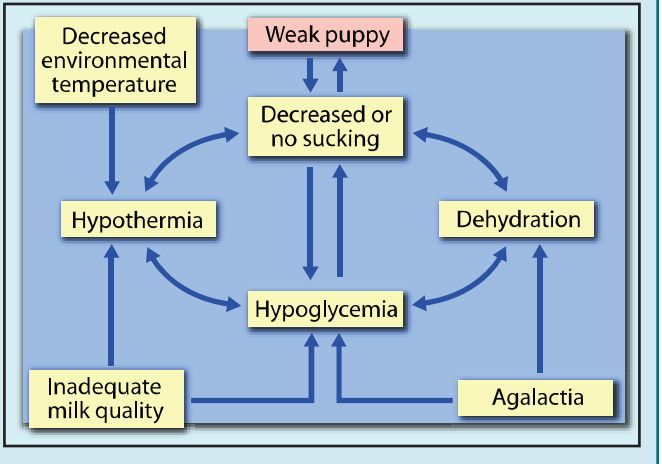


**Figure 1.** This figure shows how hypothermia, hypoglycemia and dehydration interrelate, creating a cycle that often results in neonatal death.

The Bibliography for **Box 16-4** can be found at www.markmorris.org.

development (Pawlosky et al, 1997; Birch et al, 2002; Diau et al, 2003). In addition, infants supplemented with DHA had enhanced brain development and learning ability (Birch et al, 2002; Huffman et al, 2003). As in other species, including fish oil as a source of DHA in puppy foods improved trainability (Kelley et al, 2004). Retinal function of young dogs improved when foods containing long-chain omega-3 (n-3) polyunsaturated fatty acids were fed during gestation and lactation (Bauer et al, 2006). The recommended level of DHA plus eicosapentaenoic acid (EPA) for puppies after weaning is 0.05% (DM). At this level, EPA should not exceed 60% of the total amount of DHA plus EPA (NRC, 2006). These levels probably also apply to orphan formulas. Thus, DHA needs to be at least 40% of the total DHA plus EPA, or 0.02%.

Linoleic acid is an essential fatty acid and is required for normal growth. The DM linoleic acid content of bitch's milk is 4.9% (**Table 16-4**). Bitch's milk has an energy density of 6.43 kcal/g (DM). Converting this amount of linoleic acid to a 4 kcal/g basis results in a linoleic acid equivalent of 3.0% (DM). This is greater than the minimum recommended allowance of 1.3% for foods for puppies after weaning (NRC, 2006) and probably reflects the more rapid growth rate and subsequently higher requirement of neonates.

### *Carbohydrate*

Lactose is the primary carbohydrate in milk. Lactose levels in bitch's milk vary between 3.0 and 3.5%, which are about 30% lower than those in cow's milk (Table 15-3). Although the lactose content of milk varies widely among animal species, it is very consistent and maintained within narrow limits within a species. Lactose and minerals in milk primarily contribute to osmolarity. Any increase or decrease in lactose content is offset by changes in the content of other soluble components (Johnson, 1974).

Lactose, a disaccharide, is absorbed after digestion into its constituent monosaccharides. Lactose is unique in that its glucose

and galactose molecules are linked with a β-1,4 bond instead of the α-1,4 linkage commonly found in other soluble glucose polymers (Stryer, 1988; Newberg and Neubauer, 1995). This linkage makes lactose a less suitable substrate for microbes that may infect the mammary gland or the neonate's gastrointestinal tract. Furthermore, large amounts of lactose may favor colonization of the intestine by more beneficial microflora, which compete with and exclude many potential pathogens (Newberg and Neubauer, 1995). To avoid diarrhea, lactose should be the main carbohydrate source during the first weeks of life. Pancreatic amylase activity is insignificant at four weeks of age and low at eight weeks, whereas intestinal lactase activity is enhanced until about four months of age (Kienzle, 1988; Meyer, 1992).

### *Calcium and Phosphorus*

Calcium levels are very high in colostrum; however, after two to three days, levels decrease to less than those found in mature milk (Meyer et al, 1985a). Calcium content increases over the course of lactation; however, the calcium-phosphorus ratio remains consistent around 1.3:1 (Meyer et al, 1985a). Calcium and phosphorus levels in milk are similar among canine breeds. Canine milk is rich in calcium and phosphorus; the amounts of these minerals in bitch's milk could be regarded as recommendations for daily intake by growing puppies, despite the fact that skeletal calcification does not keep pace with the increase in body size until after weaning (Gesellshaft, 1989; Baines, 1981).

### *Potassium, Sodium, Magnesium and Copper*

Potassium helps maintain acid-base and osmotic balance, transmit nerve impulses, facilitate muscle contractility and serves as a cofactor in several key enzyme systems. Sodium is also important for maintaining acid-base and osmotic balance, and transmitting nerve impulses and muscle contractions. Sodium controls passage of nutrients into cells, including absorption of sugars and amino acids from the intestinal lumen. Sodium is involved in calcium absorption and the absorption of several water-soluble vitamins. Magnesium is involved in carbohydrate and lipid metabolism and is a catalyst for a wide variety of enzymes. It is required for ATP production, catalyzes most phosphate transfers and has a potent influence on neuromuscular activity. Numerous copper-containing enzyme systems exist including those involved in hematopoiesis, control of neurotransmitters, connective tissue integrity, oxidative metabolism and protection against superoxide radicals. Thus, it is important that these minerals be present in adequate amounts and correct proportions. **Table 16-4** lists the levels of these minerals in milk.

### *Iron*

Deficiency may occur if iron stores are not accumulated during the last week of pregnancy, or if excessive blood loss occurs due to severe hookworm infection or severe flea infestation. During the first three to four weeks of life, body iron stores and hematocrit and hemoglobin values decrease below levels at birth. Decreasing hematocrit and hemoglobin values might also be due to a relative increase in total body water over this time period. The decrease is more pronounced in fast-growing, large-breed puppies (Gesellshaft, 1989a).

Milk is a poor source of iron and puppy requirements are usually higher than intake (Kienzle et al, 1985). Iron reserves increase when puppies receive food at weaning; body iron stores normalize around four months of age (Kienzle et al, 1985).

**Table 16-4.** Key nutritional factors for foods for nursing puppies (the nutritional content of bitch's milk).*

| Nutrient | Per 100 g milk, as fed | DM basis** |
|---|---|---|
| Moisture (g) | 77.3 | 0 |
| Dry matter (g) | 22.7 | 100 |
| Crude protein (g) | 7.5 | 33 |
| Arginine (mg) | 420 | 1.85 |
| Fat (g) | 9.5 | 41.8 |
| Linoleic acid (g) | 1.11 | 4.9 |
| Lactose (g) | 3.3 | 14.5 |
| Calcium (mg) | 240 | 1.06 |
| Phosphorus (mg) | 180 | 0.79 |
| Sodium (mg) | 80 | 0.35 |
| Potassium (mg) | 120 | 0.53 |
| Magnesium (mg) | 11 | 0.05 |
| Copper (mg) | 0.33 | 0.0015 |
| Iron (mg) | 0.7 | 0.003 |
| ME (kcal) | 146 (610 kJ) | 6.43 kcal/g (26.9 kJ/g) |
| Osmolarity (mOsm/kg) | 569 | Not applicable |
| DM digestibility | >95% | >95% |

Key: DM = dry matter, ME = metabolizable energy.
*Adapted from Anderson RS, Carlos GM, Robinson IP, et al. Zinc, copper, iron and calcium concentrations in bitch milk. Journal of Nutrition 1991; 121:S81-S82. Gesellschaft für Ernährungsphysiologie. Grunddaten für die Berechnung des Energie- und Nährstoffbedarfs. In: Ausschuß für Bedarfsnormen der Gesellschaft für Ernährungs-physiologie Energie-Nährstoffbedarf/Energy and Nutrient Requirements, No. 5 Hunde/Dogs. Frankfurt/Main, Germany: DLG Verlag, 1989; 9-31. Kienzle E, Meyer H, Dammers C, et al. Milchaufnahme, Gewichtentwicklung, Milchverdaulichkeit, sowie Energie- und Nährstoffretention bei Saugwelpen. Fortschritte in der Tierphysiologie und Tierernährung (Advances in Animal Physiology and Animal Nutrition) 1985; Suppl. 16: 27-50. Meyer H, Kienzle E, Dammers C. Milchmenge und Milchzusammensetzung bei der Hundin sowie Futteraufnahme und Gewichtsenwicklung ante und post partum. Fortschritte in der Tierphysiologie und Tierenahrung (Advances in Animal Physiology and Animal Nutrition) 1985; 16:27-50. Mundt H-C, Thomée A, Meyer H. Zur Energie- und Eiweißversorgung von Saugwelpen über die Muttermilch. Kleintierpraxis 1981; 26: 353-360. Oftedal OT. Lactation in the dog: Milk composition and intake by puppies. Journal of Nutrition 1984; 114: 803-812. Rüsse I. Die Laktation der Hündin. Zentralblatt für Veterinär Medizin 1961; 8: 252-281.
**Units are expressed in percentages unless otherwise indicated.

**Table 16-5.** Recommendations for energy intake of orphaned puppies as a basis for determining orphan formula dose.*

| Feeding period | kcal ME/100 g BW | kJ ME/100 g BW |
|---|---|---|
| Days 1-3 | 15 | 60 |
| Days 4-6 | 20 | 85 |
| >6 days | 20-25 | 85-105 |

Key: ME = metabolizable energy, BW = body weight.
*Do not over feed orphan formulas initially. The feeding amount for the first six days intentionally provides less energy than would normally be provided, which is gradually increased so that the orphaned puppies' energy requirements are being met after about one week.

**Table 16-6.** Feeding plan summary for nursing puppies.

1. Ensure good husbandry practices are understood and in place (Box 17-2).
2. Ensure colostrum intake by the puppies within the first 24 hours.
3. Provide bitch's milk until three to four weeks of age; then gradually initiate the weaning process by introducing small amounts of semisolid to solid food, which augments nursing of bitch's milk (**Box 16-5**).
4. The weaning food should be a good quality growth/reproduction type commercial food (Tables 15-9 and 17-4).
5. Assess nursing puppies daily, including recording of body weight and tracking weight gain for the first month of age (**Box 16-3**); then weekly. Recommend weekly veterinary checks for the first month.
6. Puppies failing to thrive on bitch's milk should be fed via partial or total orphan feeding techniques; check bitch, including bitch's food, to ensure no health or nutrition issues are affecting lactation.
7. Wean at six to seven weeks (**Box 16-5**) and feed according to recommendations in Chapter 17 (growing puppies).

**Table 16-7.** Feeding plan summary for orphaned puppies.

1. Ensure good husbandry practices are understood and in place (**Box 16-2**); have owner(s) attempt to provide as much total care as the bitch would have.
2. Puppies should have colostrum within the first 24 hours of birth; if not, administer frozen colostrum or consider colostrum from other species, commercial colostrum sources or serum from vaccinated dogs given subcutaneously.
3. Use foster bitch if possible; partial orphan feeding is next best and bottle feeding is the best of hand-feeding techniques (**Figures 16-1** through **16-3**).
4. **Table 16-9** provides three homemade formulas and **Table 16-10** compares them to bitch's milk. Commercial milk replacers are best.
5. To determine the initial amount to feed, use **Table 16-5** to estimate the puppies' daily energy requirement (DER); divide the DER by the energy density of the milk replacer to determine the daily amount to feed. Besides energy and other nutrients, orphaned puppies should receive about 180 ml of water/kg body weight/day; if necessary, add additional water to the milk replacer if the recommended dilution doesn't provide this amount of total fluid intake.
6. Milk replacers should be heated to 38°C (100°F) and the daily amount divided and fed ≥4 times/day at equal intervals.
7. Good hygiene is critical and includes washing/boiling feeding utensils before each feeding, preparing no more than the amount of milk replacer that can be fed in 24 hours (keep refrigerated) and carefully washing puppies with a moist, soft cloth twice weekly.
8. Have owners gradually initiate the weaning process by introducing small amounts of semisolid to solid food, which augments the milk replacer (**Box 16-5**).
9. The weaning food should be a good quality growth/reproduction type commercial food (Table 17-4).
10. Assess nursing puppies daily, including recording of body weight and tracking weight gain for the first month of age (**Box 16-3**); then weekly. Recommend weekly veterinary checks for the first month.
11. For puppies not thriving on milk replacer, review milk replacer quality (**Table 16-8**), dilution calculations and feeding amounts; switch to a different milk replacer if necessary.
12. Wean at six to seven weeks (**Box 16-5**) and feed according to recommendations in Chapter 17 (growing puppies).

Therefore, puppies should receive solid food as soon as possible (around three weeks of age).

Milk replacers are often fortified with iron at concentrations higher than those found in bitch's milk. Orphaned puppies, especially low birth weight neonates born with low iron reserves, may benefit from iron intakes higher than those normally found in milk. The additional iron supports hematopoiesis and helps avoid anemia sometimes observed in three- to four-week-old neonates.

### *Digestibility*

DM digestibility of bitch's milk is very high (>95%) (Mundt et al, 1981; Kienzle et al, 1985). Digestibility of milk replacer formulas should also be high (>90%) to allow for smaller quantities to be fed and avoid diarrhea.

### *Osmolality*

The osmolality of bitch's milk is approximately 569 mOsm/kg. Milk replacers with osmolality values considerably higher than these concentrations should be avoided because they may cause hyperosmolar diarrhea and potentiate dehydration. High osmolality may delay gastric emptying and predispose to regurgitation, vomiting and aspiration during the next meal, if the stomach is not completely empty.

## FEEDING PLAN

The feeding plan includes determining the best food and feeding method. **Tables 16-6** and **16-7** provide feeding plan summaries for nursing and orphaned puppies, respectively.

### Assess and Select the Food

Puppies should receive colostrum within the first 12 to 24 hours after birth to ensure adequate intake of immunoglobulins. If bitch colostrum is unavailable, colostrum from a different species may be used. Although antibody protection may be limited, providing nonspecific defense substances such as lactoferrin, oligosaccharides, lactoperoxidases and lysozymes may be beneficial. Alternatively, sterile serum from vaccinated dogs administered subcutaneously has been recommended (England, 2005).

Direct assessment of milk quality is difficult; therefore, indirect parameters should be evaluated, including failure to grow, weakness, an enlarged abdomen and abnormal behavior such as restlessness and continuous vocalization. After illness is ruled out, these signs may indicate insufficient milk production by the bitch and/or deficient milk quality.

Milk intake can be estimated by weighing puppies before and after they nurse. The ratio of weight gain to milk intake may indicate milk quality. However, weight gains range from about one g/two g of milk intake to one g/to almost five g of milk intake during the first weeks of life (Oftedal, 1984; Mundt et al, 1981; Jean-Blain, 1973). This wide range results primarily from differences in ability to estimate milk intake. Also, an underweight bitch (body condition score 1/5 or 2/5) may be at risk for producing inadequate or poor quality milk. Therefore,

## Box 16-5. Weaning.

Weaning is a gradual process with two phases. The first phase begins when puppies start eating solid food between three and four weeks of age. This phase should be encouraged, especially if the bitch has a large litter. Additionally, nursing is an important stimulus for milk production. Therefore, milk production will progressively decline as the puppies' intake of solid food increases, making complete weaning (second phase) less stressful. However, some bitches may continue to produce large quantities of milk and are at risk for development of mammary congestion when the puppies are completely separated. The feeding schedule in **Table 1** may be helpful, particularly in cases of early weaning (around the fifth week of age).

Limiting food intake for a day or two while weaning reduces nutrients available for milk production, thereby reducing mammary gland engorgement. Leaving one or two puppies to nurse will not alleviate mammary gland engorgement in bitches that are still producing a large amount of milk at weaning. This practice continues to stimulate milk production, and therefore prolongs the problem. When it is decided to completely separate the puppies from the mother, all puppies should be taken away at once.

Puppies should be encouraged to start eating solid food as soon as possible. This practice will reduce reliance on the bitch, reduce the nutritional burden on the bitch and make complete weaning less stressful. Most puppies will start eating solid food between three and four weeks of age, the time when deciduous teeth begin to erupt. Oftentimes, during play, puppies will come in contact with the bitch's food and progressively start eating small amounts.

Puppies can be offered gruel to stimulate food intake at three weeks of age. Gruels are made by blending a moist growth/reproduction-type food with an equal volume of warm water. Alternatively, one part of dry food can be ground and mixed with three parts of warm water (volume basis). Puppies should be encouraged to lap the gruel; owners can dip their fingertips in the gruel and then into the puppies' mouth. Ideally, the food used to make the gruel should be highly digestible, contain at least 25 to 30% protein and have an energy content of at least 4.0 kcal (16.7 kJ) metabolizable energy/g (dry matter). A good quality growth/reproduction-type food such as the bitch is eating should be appropriate (Chapters 15 and 17). Puppies are very prone to vomiting and diarrhea during this period. If gastrointestinal disturbances occur, gruel can be made from a highly digestible moist food intended for dietary management of diarrhea with a minimum of about 25% dry matter protein.

As the puppies' interest in solid food increases, the water content of the gruel can be reduced progressively. Puppies should be eating sufficient quantities of solid food at five weeks of age because the bitch's milk production will probably start declining.

From three weeks of age on, puppies can be separated from their mother for short periods of time. The time away from the dam can be progressively increased to about four hours a day by around six weeks of age. Weaning should be effectively completed between six and seven weeks of age and puppies can be removed from the dam. After weaning, the puppies should be fed the same food to minimize stress and the risk of diarrhea.

**Table 1.** Recommended feeding schedule for reducing mammary congestion in bitches during weaning of puppies.*

| Day of weaning | No food |
|---|---|
| First day after weaning | One-fourth of DER for adult maintenance (0.5 x RER) |
| Second day after weaning | One-half of DER for adult maintenance (RER) |
| Third day after weaning | Three-fourths of DER for adult maintenance (1.4 x RER) |

Key: DER = daily energy requirement, RER = resting energy requirement.
*Adapted from Meyer H. Praktische Fütterung. In: Ernährung des Hundes, 2nd ed. Stuttgart, Germany: E Ulmer Verlag, 1990; 162-223.

The Bibliography for **Box 16-5** can be found at www.markmorris.org.

the bitch's food and feeding method should also be assessed. Most lactating bitches should be fed free choice (Chapter 15).

Foods used to feed orphans may consist of bitch's milk, commercial milk replacer or homemade replacer formulas. Milk from a healthy bitch is the food of choice and is assumed to provide nutrients in the proper levels for nursing puppies. Bitch's milk is rarely available in sufficient quantities to hand raise orphans. Of the alternatives, commercial milk replacers are preferred although several homemade formulas have proved sufficient. **Table 16-8** lists commercial milk replacers and compares their nutrient profiles (key nutritional factors) with bitch's milk. **Table 16-9** provides three homemade milk replacer recipes and **Table 16-10** compares these recipes' nutrient profiles with that of bitch's milk. Commercial and homemade milk replacers should closely mimic the profile of bitch's milk. Unsupplemented ruminant milk may be used as a base for homemade formulas but doesn't meet the nutritional needs of puppies. For puppies, goat's milk provides no nutritional benefit over cow's milk.

Foods should be liquid until nursing puppies and orphans are three to four weeks old, then semisolid to solid foods should be introduced. This transition marks the beginning of weaning (**Box 16-5**).

## Assess and Determine the Feeding Method

Puppies should be encouraged to nurse often during the first week of life (eight to 12 times per day); after Week 1, they should be encouraged to nurse at least three to four times daily. Inexperienced bitches should be carefully observed to ensure that all puppies receive sufficient amounts of colostrum within 24 hours of birth, when puppies are able to absorb intact proteins such as immunoglobulins. This involvement may include positioning the puppies on the bitch's nipples at feeding time or encouraging a nervous bitch to lie quietly as the puppies nurse. Handling the dam and puppies facilitates monitoring the progress of the litter.

**Table 16-8.** Nutrient content of milk replacers compared with that of bitch's milk/100 grams of milk, as fed*

| Nutrients** | Bitch's milk | Esbilac Liquid | Esbilac Reconstituted Powder | Nurturall C Puppy Liquid† | Nurturall-C Reconstituted Powder† | Just Born Puppy Liquid† | Just Born Reconstituted Powder† | Goat's Milk Esbilac Liquid | Goat's Milk Esbilac Reconstituted Powder |
|---|---|---|---|---|---|---|---|---|---|
| **Manufacturer** | - | PetAg | PetAg | VPL | VPL | Farnam | Farnam | PetAg | PetAg |
| Dilution*** | na | na | 1+2 | na | 1+2 | na | 1+2 | na | 1+2 |
| Moisture (g) | 77.3 | 84.9 | na | 80.1 | 85.7 | 80.1 | 85.7 | 84.2 | - |
| Dry matter (g) | 22.7 | 15.1 | na | 19.9 | 14.3 | 19.9 | 14.3 | 15.9 | - |
| **Crude protein (g)** | 7.5 | 5.1 | 6.2 | 7.6 | 4.5 | 7.6 | 4.5 | 4.7 | 6.12 |
| Arginine (mg) | 420 | 290 | 390 | 200 | 102 | 200 | 102 | 210 | 390 |
| Lysine (mg) | 380 | 370 | 470 | na | na | na | na | 360 | 470 |
| **Fat (g)** | 9.5 | 6.4 | 7.5 | 4.3 | 4.4 | 4.3 | 4.4 | 6.2 | 7.5 |
| Linoleic acid (g) | 1.1 | na | 0.4 | na | na | na | na | - | 0.86 |
| **Carbohydrate** | | | | | | | | | |
| NFE (g) | 3.8 | 2.9 | 2.7 | 6.4 | 4.3 | 6.4 | 4.3 | 2.9 | 2.7 |
| Lactose (g) | 3.3 | na | - | na | na | na | na | - | - |
| Crude fiber (g) | na | 0 | 0 | <0.1 | <0.1 | <0.1 | <0.1 | 0 | 0 |
| **Minerals** | | | | | | | | | |
| Total ash (g) | 1.2 | 0.8 | 1.3 | 1.5 | 1.1 | 1.5 | 1.1 | 1.2 | 1.3 |
| Calcium (mg) | 240 | 145 | 220 | 254 | 215 | 254 | 215 | 150 | 207 |
| Phosphorus (mg) | 180 | 110 | 178 | 221 | 186 | 221 | 186 | - | 149 |
| Sodium (mg) | 80 | 65 | 53 | na | na | na | na | 110 | 94 |
| Potassium (mg) | 120 | 130 | 194 | 113 | 186 | 113 | 186 | 250 | 142 |
| Magnesium (mg) | 11 | 12 | 12.6 | 6.5 | 7.0 | 6.5 | 7.0 | 18 | 14.2 |
| Copper (mg) | 0.33 | 0.18 | 0.23 | 0.2 | 0.16 | 0.2 | 0.16 | 0.22 | 0.46 |
| Iron (mg) | 0.70 | 0.60 | 0.82 | 2.70 | 2.17 | 2.7 | 2.17 | 1.90 | 0.83 |
| **Energy** | | | | | | | | | |
| ME (kcal) | 146 | 82 | 95 | 86 | 68 | 86 | 68 | 82 | 94.7 |
| ME (kJ) | 610 | 343 | 396 | 358 | 285 | 358 | 285 | 343 | 396 |
| Osmolarity (mOsm/kg, $H_20$±SD) | 568.7±41.2 | na | - | na | na | na | na | na | - |
| **Nutrient content of milk replacers compared with that of bitch's milk/100 kcal metabolizable energy††** | | | | | | | | | |
| **Protein (g)** | 5.20 | 6.21 | 6.56 | 8.89 | 6.63 | 8.89 | 6.63 | 5.70 | 6.46 |
| Arginine (mg) | 288 | 354 | 411 | 234 | 149 | 234 | 149 | 256 | 412 |
| Lysine (mg) | 260 | 451 | 495 | na | na | na | na | 439 | 496 |
| **Fat (g)** | 6.40 | 7.78 | 7.92 | 5.03 | 6.41 | 5.03 | 6.41 | 7.55 | 7.94 |
| Linoleic acid (g) | 0.76 | na | 0.43 | na | na | na | na | na | 0.91 |
| **Carbohydrate** | | | | | | | | | |
| NFE (g) | 2.60 | 3.51 | 2.80 | 7.49 | 6.29 | 7.49 | 6.29 | 3.51 | 2.81 |
| Lactose (g) | 2.3 | na | na | na | na | na | na | na | na |
| Crude fiber (g) | na | 0 | 0 | <0.1 | <0.1 | <0.1 | <0.1 | 0 | 0 |
| **Minerals** | | | | | | | | | |
| Total ash (g) | 0.82 | 0.98 | 1.32 | 1.75 | 1.62 | 1.75 | 1.62 | 1.46 | 1.38 |
| Calcium (mg) | 164 | 177 | 232 | 297 | 314 | 297 | 314 | 183 | 219 |
| Phosphorus (mg) | 123 | 134 | 187 | 258 | 272 | 258 | 272 | 0 | 157 |
| Sodium (mg) | 55 | 79 | 56 | na | na | na | na | 134 | 99 |
| Potassium (mg) | 82 | 159 | 204 | 132 | 272 | 132 | 272 | 305 | 150 |
| Magnesium (mg) | 7.5 | 14.6 | 13.3 | 7.6 | 10.2 | 7.6 | 10.2 | 22.0 | 15.0 |
| Copper (mg) | 0.23 | 0.22 | 0.24 | 0.23 | 0.24 | 0.23 | 0.24 | 0.27 | 0.49 |
| Iron (mg) | 0.48 | 0.73 | 0.86 | 3.16 | 3.18 | 3.16 | 3.18 | 2.32 | 0.88 |

Key: na = not applicable/available, NFE = nitrogen-free extract, ME = metabolizable energy, mOsm = milliosmoles.
*Manufacturers' data; nutrient content for reconstituted powdered products are manufacturers' calculations based on the recommended dilution. Nutrient data per 100 ml would be reduced slightly (between 1 to 2%) because the specific gravity of milk is greater than that of water.
**g/100 g = %.
***The first number is the milk powder, the second the water (e.g., 1+2 = one part of powder plus two parts of water).
†Nutrients in liquid and powder forms are averages from the yearly laboratory analyses of composite samples from 2004 to date.
††The nutrient levels per 100 kcal ME were calculated from the nutrient and energy levels in the top portion of the table.

Competition in large litters may prevent smaller, weaker puppies from nursing and predispose them to dehydration and hypoglycemia. Partial orphan rearing of the entire litter should be done in these cases (see below). Partial orphan rearing allows the puppies to stay with the dam in their normal environment and permits proper socialization.

Puppies that fail to thrive when receiving bitch's milk should be fed immediately via partial or total orphan feeding techniques (see below) to avoid the risk of hypoglycemia, hypothermia and dehydration.

It may be necessary to alter the feeding method when managing orphaned puppies, especially if they are hand reared. Evaluation of the current feeding method with knowledge of growth demands will facilitate this part of feeding plan development. Orphaned puppies and those too weak to nurse are candidates for fostering, partial orphan rearing or hand feeding. The caregiver for orphans should provide the level of care provided by the bitch; good husbandry is essential.

### *Fostering*

The optimal means of feeding orphaned or rejected puppies is to foster them to another lactating bitch. In general, fostering is the least labor intensive, provides optimal nutrition, reduces mortality, improves immune status, usually provides an optimal physical environment and promotes normal social development of puppies. Unlike large animals, bitches readily accept additional puppies during lactation. If several foster mothers are available, it is best to place orphans in litters with fewer than 14 days age difference. Larger puppies often crowd out smaller individuals if the age discrepancy is too large. This situation can be managed by supervised feeding until the orphans can fend for themselves. Unfortunately, foster mothers are not normally available and alternative techniques must be used. Foster mothers should be well fed.

Puppies fostered onto another bitch should be supervised initially to detect any behavioral problems between the foster parent, its young and the orphans. Puppies should be accepted immediately and allowed to nurse. Encourage owners to watch for signs of rejection or impending cannibalism by the mother.

**Table 16-9.** Homemade milk replacers for puppies.

| Recipe 1 | | Recipe 2 | | Recipe 1 (modified) | |
|---|---|---|---|---|---|
| Skim milk | 43.8 g | Cow's milk** | 800 ml | Skim milk | 64 g |
| Low-fat curd* | 40 g | Half cream*** | 200 ml | Low-fat curd* | 15 g |
| Egg yolk (2/3) | 10 g | Bone meal | 6 g | One egg yolk | 15 g |
| Vegetable oil | 6 g | Citric acid | 4 g | Vegetable oil | 3 g |
| Vitamin-mineral mix | 0.2 g | One egg yolk | 15 g | Vitamin-mineral mix | 2.5 g |
| - | - | Vitamin A | 2,000 IU | $CaCO_3$ | 0.5 |

*Do not use cottage cheese because it may increase the risk of clotting in the neonate's stomach.
**3% fat.
***12% fat (i.e., half cream in the UK).

### *Partial Orphan Rearing*

Puppies that cannot be successfully raised by the bitch for reasons such as poor health, poor lactation performance or too large of a litter may be left with the mother but given supplemental feeding to support nutritional needs. Supplemental food may be given by hand feedings or timed feedings using a surrogate bitch. Puppies may also be reared in a communal situation. Partial orphan rearing can be accomplished by dividing the litter into two groups of equal number and size. One group remains with the mother while the other is removed and fed milk replacer. The groups are exchanged three to four times daily. It is important to feed the separated group before it is returned to the mother. As a result, the group just placed with the dam will be less inclined to nurse immediately (Björck, 1984). It is better to supplement all the puppies in the litter rather than just a few. The advantages of partial orphan rearing are similar to those of fostering. In addition, continued access to the mother can help stimulate milk production and mothering behaviors. When using foster or surrogate mothers, clients should monitor for signs of rejection and cannibalism. Partial orphan rearing may be necessary to assist the efforts of foster mothers. Unfortunately, foster and surrogate mothers are rarely available.

### *Hand Feeding*

The most common method of raising orphaned puppies is hand feeding. Eyedroppers, syringes, bottles and stomach tubes are typically used to feed orphans.

**Table 16-10.** Comparisons between bitch's milk and homemade milk replacers for puppies (See **Table 16-9**).

| Nutrients* | Bitch's milk | Homemade milk replacers | | |
|---|---|---|---|---|
| | - | Recipe 1** | Recipe 2** | Recipe 1 (modified)*** |
| Moisture (g) | 77.3 | 76.6 | 85.3 | 79.9 |
| Dry matter (g) | 22.7 | 23.4 | 14.7 | 20.1 |
| Crude protein (g) | 7.5 | 9.9 | 3.5 | 7.5 |
| Fat (g) | 9.5 | 9.5 | 5.5 | 8.1 |
| NFE (g) | 3.8 | 3.3 | 4.6 | 3.5 |
| Ash (g) | 1.2 | 0.8 | 0.7 | 1.3 |
| Calcium (mg) | 240 | 92.6 | 290 | 287 |
| Phosphorus (mg) | 180 | 177 | 200 | 186 |
| Sodium (mg) | 80 | 32 | 50 | 34 |
| Potassium (mg) | 127 | 96 | 150 | 110 |
| Copper (mg) | 0.33 | 0.03 | na | 0.05 |
| Iron (mg) | 0.7 | 0.68 | na | 0.95 |
| Zinc (mg) | 0.95 | 0.79 | na | 1.01 |
| **Energy** | | | | |
| ME (kcal)† | 146 | 130 | 80 | 110 |
| ME (kJ)† | 610 | 544 | 335 | 460 |

Key: NFE = nitrogen-free extract, ME = metabolizable energy.
*g/100 ml or g/100 g = %.
**Calculated before addition of the vitamin-mineral mix.
***Calculated based on the addition of 2.5 g Pecutrin (Bayer).
†Calculated except for bitch's milk, for which the actual energy density was known from the literature.

## BOTTLE FEEDING

Bottle feeding is the preferred method for vigorous puppies with good nursing reflexes (**Figures 16-1** and **16-2**). Bottle feeding has the advantage that neonates will nurse until they are satiated and reject the milk or formula when full. However, bottle feeding can be time consuming, especially with large litters.

Most puppies will readily suckle small pet nursers, which are available in pet stores (**Figure 16-3**). Feeding bottles for dolls or bottles with nipples for premature human infants are alternatives. The nipple opening should only allow one drop at a time to fall from the nipple when the bottle is inverted. A horizontal slit made with a razor blade instead of a round hole may make it easier for neonates to obtain milk or formula. Milk should be sucked-never squeezed-from the bottle. A rapid flow rate may lead to aspiration of milk and pneumonia and/or death.

Puppies should normally be held horizontally with the head in a natural position (**Figure 16-1**). This position reduces the risk of aspiration. Although some puppies may prefer a different position during feeding (**Figure 16-2**), careful observation is necessary because the risk of aspiration is increased.

**Figure 16-1.** This is the preferred position for bottle feeding puppies. This position mimics the normal nursing position and decreases the likelihood of aspiration.

**Figure 16-2**. Some neonates prefer different positions for bottle feeding. This puppy prefers nursing in dorsal recumbency. Close observation is required because this position may predispose to aspiration.

**Figure 16-3.** Various bottles and feeding tubes can be used for hand feeding orphaned puppies.

## TUBE FEEDING

Puppies that are weak or suckle poorly may need to be tube fed. Tube feeding is quicker than bottle feeding and is often used when the same person must care for several orphans. Bottle feeding allows puppies to control the amount of food intake, whereas tube feeding bypasses this control mechanism. Infant feeding tubes (5 to 8 Fr.) or soft urethral or intravenous catheters may be used (**Figure 16-3**).

The tube should be lubricated and placed in the lower esophagus, which is approximately 75% of the distance from the nose to the last rib. Measure and mark the tube with an indelible marker or a piece of tape before insertion. Recheck measurements every few days to account for growth. The orphan should normally be placed horizontally in the palm of the hand with its head in a natural position.

The mouth can be opened using the same hand that steadies the head. Gently advance the tube to the premeasured mark. If resistance is encountered or the puppy suddenly struggles, the tube may be in the trachea. It should be removed and repositioned into the esophagus. Do not feed until proper placement is ensured. After the tube is placed, attach the feeding syringe and slowly administer the warmed formula (over about one to two minutes). The stomach may be palpated to determine the degree of distention. Administration should be stopped if the stomach becomes taut or resists formula flow. Continuation of feeding may result in overdistention and regurgitation. If regurgitation occurs, withdraw the tube and discontinue feeding until the next meal.

## Feeding Schedule: Amount, Rate and Formula Temperature

An important part of successful hand feeding is adhering to a strict feeding schedule. Orphans should be fed at least four times daily. Very young neonates and weak puppies should preferably be fed every two to four hours. Older puppies should be fed every four to six hours. Normally, one- to two-week-old puppies will obtain more than 90% of their normal daily intake in four to five meals.

To determine the initial daily amount to feed, first use **Table 16-5** to estimate a puppy's daily energy requirement (DER). Then divide the DER by the energy density of the milk replacer to determine the daily amount to feed. When properly diluted, most milk replacers will provide approximately one kcal/ml. Besides energy and other nutrients, on average, orphaned puppies should receive about 180 ml of diluted milk replacer/kg body weight/day; if necessary, add additional water to the milk replacer if the recommended dilution doesn't provide for this amount of total fluid intake. This amount might underfeed energy but is less likely to cause diarrhea. During the first week of life, the capacity of milk intake by smaller breeds may be limited to about 10 to 15 ml per feeding.

Milk replacers should be warmed to 38°C (100°F) and delivered slowly. Cold foods, rapid feeding rates and over feeding may result in regurgitation, aspiration, bloating and diarrhea. Review and correct the feeding methods if untoward signs develop. If diarrhea is observed, food volume should be reduced or the food

should be diluted with water, then gradually returned to levels to meet caloric requirements over successive feedings. It is better to underfeed than over feed neonatal puppies.

### Hygiene

Success of hand feeding orphans also depends on how well the caregiver fulfills the daily routine of hygienic measures. Hygienic measures must be more stringent for orphaned puppies because they may have received less colostrum and be more susceptible to infections than other neonates.

- Feeding materials (e.g., bottles and nipples) should be cleaned thoroughly and boiled in water between uses.
- Ingredients for homemade milk replacers should be fresh and refrigerated until used.
- Never prepare more milk replacer than can be used in 24 hours and refrigerate.
- Formulas should be discarded after one hour at room temperature.
- At least twice a week, orphans should be washed gently with a soft moistened cloth to simulate cleaning by the dam's tongue.

## REASSESSMENT

Nursing puppies should be reassessed daily. Puppy body weights should be obtained at birth, daily or every other day for the first four weeks and then weekly. Adequacy of the bitch's milk production can be assessed by the growth rate of the puppies, puppy contentment and mammary gland distention. To determine whether an individual mammary gland is producing milk, gently express milk from the nipple while the bitch is relaxed. Most breeders are experienced enough to do this without help. Less experienced owners may need to be taught how to do this; weekly veterinary checkups during the first month may be helpful.

Orphaned puppies should be evaluated daily for the first two weeks of life. They should remain normally hydrated, sleep quietly between feedings and gain weight at a rate similar to bitch raised neonates. Alertness, eagerness to suckle, general behavior, body temperature (i.e., temperature of skin and lower limbs), body weight and stool character should be recorded daily or more often if neonates appear weak or listless.

Orphan rearing requires precise measurement of food intake. Nursing puppies should gain from one g body weight/two to five g of milk intake during the first weeks of life. It is realistic to expect orphaned puppies to gain somewhat less because they are fed at a lower energy intake and milk replacers are not the same as bitch's milk. However, if orphaned puppies do not thrive when fed a commercial milk replacer or homemade replacer, the nutrient content should be compared with mother's milk (**Tables 16-8** through **16-10**). The dilution recommended by the manufacturer should also be checked. In some cases, it may be necessary to switch to another formula.

Puppies with rectal temperatures less than 35°C (95°F) should not be fed milk formula. At this temperature, the sucking reflex is usually absent and normal gut motility has ceased. Neonates should first be warmed slowly after receiving a warm solution of 2.5% glucose by subcutaneous injection (1 ml/30 g body weight).

Weaning is an important event and is integral to successful feeding of nursing and orphaned puppies (**Box 16-5**).

## REFERENCES

The references for **Chapter 16** can be found at www.markmorris.org.

Chapter 17

# Feeding Growing Puppies: Postweaning to Adulthood

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*"Whoever said you can't buy happiness forgot little puppies."*
*Gene Hill*

## INTRODUCTION

This chapter covers puppy growth from immediately postweaning to adulthood, which generally occurs between 10 to 12 months of age, depending on breed. The goal of a feeding plan for puppies is to create a healthy adult. The specific objectives of a good puppy feeding plan are to achieve healthy growth, optimize trainability and immune function and minimize obesity and developmental orthopedic disease. Growth is a complex process involving interactions between genetics, nutrition and other environmental influences. Nutrition plays a role in the health and development of growing dogs and directly affects the immune system (Sheffy, 1985), body composition (Meyer and Zentek, 1992; Toll et al, 1993), growth rate (Meyer and Zentek, 1992) and skeletal development (Hazewinkel, 1985; Hedhammar et al, 1974; Kealy et al, 1992). Chapter 33 provides in-depth recommendations for feeding large- and giant-breed puppies (>25 kg adult weight) to avoid developmental orthopedic disease.

## PATIENT ASSESSMENT

Puppies should be assessed for risk factors before weaning to allow implementation of recommendations for appropriate nutrition. A thorough history and physical evaluation are necessary. Special attention should be paid to large- and giant-breed puppies (Chapter 33) and breeds and sexes (intact and neutered) at risk for obesity (Chapter 27). In addition, growth rates and body condition scores (BCS) provide valuable information about nutritional risks.

Besides being breed dependent, growth rates of young dogs are affected by the nutrient density of the food and the amount of food fed (Meyer and Zentek, 1992). Puppies should be fed to grow at an optimal rate for bone development and body condition rather than at a maximal rate. Growing animals reach a similar adult weight and size whether growth rate is rapid or slow. Feeding for maximum growth increases the risk for skeletal deformities (Hedhammar et al, 1974; Kealy et al, 1992) and decreases longevity in other species (Chipalkatti et al, 1983). In Labrador retrievers, even moderate overfeeding resulted in overweight adults and decreased longevity (Kealy et al, 2002).

The most practical indicator of whether or not a puppy's growth rate is healthy is its BCS. All puppies should have their body condition evaluated and reassessed at least every two weeks to allow for adjustments in amounts fed and, thus, growth rates (Chapter 1). Owners can be trained to assess body condition and are likely to become more aware of the appearance of a healthy growing puppy. A markedly less effective option is to compare the puppy's weight to breed standards for

**Table 17-1.** Key nutritional factors for foods for growing puppies.*

| Factors | Recommended levels in food (DM) Puppies with an adult BW <25 kg | Puppies with an adult BW >25 kg |
|---|---|---|
| Energy density (kcal ME/g) | 3.5-4.5 | 3.5-4.5 |
| Energy density (kJ ME/g) | 14.6-18.8 | 14.6-18.8 |
| Crude protein (%) | 22-32 | 22-32 |
| Crude fat (%) | 10-25 | 10-25 |
| DHA (%) | ≥0.02 | ≥0.02 |
| Calcium (%) | 0.7-1.7 | 0.7-1.2 |
| Phosphorus (%) | 0.6-1.3 | 0.6-1.1 |
| Ca:P ratio | 1:1-1.8:1 | 1:1-1.5:1 |
| Digestibility | See energy density recommendations, above; foods with higher energy density values tend to be more digestible | See energy density recommendations, above; foods with higher energy density values tend to be more digestible |

Key: DM = dry matter, BW = body weight, kcal = kilocalories, kJ = kilojoules, ME = metabolizable energy, DHA = docosahexaenoic acid.
*For large- and giant-breed dogs (adult BW >25 kg), also see Table 33-5.

**Table 17-2.** Recommendations for initial estimate of energy intake of growing dogs.

| Time frame | x RER | kcal/$BW_{kg}^{0.75}$ | kJ/$BW_{kg}^{0.75}$ |
|---|---|---|---|
| Weaning to 50% of adult BW* | 3 | 210 | 880 |
| 50 to 80% of adult BW | 2.5 | 175 | 735 |
| ≥80% of adult BW | 1.8-2.0 | 125-140 | 525-585 |

Key: RER = resting energy requirement, kcal = kilocalories, kJ = kilojoules, BW = body weight. RER can be obtained from Table 5-2 or calculated. If calculating RER, use one of these two formulas: for puppies of all body weights, $RER_{kcal} = 70(BW_{kg}^{0.75})$; or for puppies weighing more than 2 kg, $RER_{kcal} = 30(BW_{kg}) + 70$. To convert kcal to kJ, multiply by 4.184.
*Great Dane puppies may need 25% more energy during the first two months after weaning = 250 kcal or 1,050 kJ/$BW_{kg}^{0.75}$. See text.

various months of age based on its estimated mature weight. Furthermore, regularly assessing body condition provides more immediate feedback about optimal nutritional status than using body weights based on estimated adult size.

## Key Nutritional Factors

The requirements for all nutrients are increased during growth compared with requirements for adult dogs. Most nutrients supplied in excess of that needed for growth cause little to no harm. However, excess energy and calcium are of special concern; these concerns include energy for puppies of small and medium breeds (for obesity prevention) and energy and calcium for puppies of large and giant breeds (for skeletal health). Also, essential fatty acids can affect neural development and trainability of puppies.

**Table 17-1** summarizes the key nutritional factors for growing puppies. The following sections describe these key nutritional factors in more detail. The concept of key nutritional factors is based on the assumption that commercial foods are fed.

### *Energy*

Energy requirements for growing puppies consist of energy needed for maintenance and growth. During the first weeks after weaning when body weight is relatively small and the growth rate is high, puppies use about 50% of their total energy intake for maintenance and 50% for growth (Gesellshaft, 1989; Sheffy, 1978). Gradually, the growth curves reach a plateau, as puppies become young adults (**Figure 17-1**). The proportion of energy needed for maintenance increases progressively, whereas the part for growth decreases. Energy needed for growth decreases to about 8 to 10% of the total energy requirement when puppies reach 80% or more of adult body weight. Because of the shift in energy usage, total food intake of a typical German shepherd puppy (adult body weight ~35 kg), based on energy needs, may no longer increase after about four months of age.

A puppy's daily energy requirement (DER) should be about 3 x its resting energy requirement (RER) until it reaches about 50% of its adult body weight (**Table 17-2**). Thereafter, energy intake should be about 2.5 x RER and can be reduced progressively to 2 x RER. When approximately 80% of adult size is reached, 1.8 to 2 x RER is usually sufficient. Great Dane puppies may have energy requirements 25% higher than those of other breeds. Young Great Dane puppies may not grow when daily energy intake is less than 175 kcal (735 kJ) metabolizable energy (ME)/$BW_{kg}^{0.75}$ (2.5 x RER) (Meyer and Zentek, 1992; Meyer and Zentek, 1991). However, this finding should not be extrapolated to other giant-breed puppies (Rainbird and Kienzle, 1990). These factors are general recommendations or starting points to estimate energy needs. Body condition scoring should be used to adjust these energy estimates to individual puppies.

Prevention of obesity is essential and should start at weaning. As in people, after puppies become overweight, it is very difficult to return to, and maintain, normal weight. Excessive food intake during growth may contribute to skeletal disorders in large- and giant-breed puppies (Chapter 33) (Kealy et al, 1992). If overweight and obesity are carried into adulthood, the risk for several important diseases is increased (Chapter 27). These include hypertension, heart disease, diabetes mellitus, dyslipidemias, osteoarthritis, heat and exercise intolerance and decreased immune function. Obesity also increases cellular oxidative stress. Long-term oxidative stress has its own serious health implications (Chapter 7). Studies show that moderate energy and food restriction during the postweaning growth period reduces the prevalence of hip dysplasia in large-breed (Labrador retriever) puppies and increases longevity in rats without retarding adult size (Kealy et al, 1992; Chipalkatti et al, 1983; Nolen, 1972; Ross and Bras, 1973; Ross, 1972). However, feeding a food with a very low energy density and low digestibility may not supply enough energy and nutrients to support optimal growth. This

approach can lead to intake of large quantities of the food, which can overload the gastrointestinal (GI) tract resulting in vomiting and diarrhea. Together, these factors make for a prudent argument to initiate monitoring of energy and food intake and body condition at an early age. Recommended energy density requirements for growing dogs are listed under the key nutritional factor "Fat" below.

## Protein

Protein requirements of growing dogs differ quantitatively and qualitatively from those of adults. Quantitatively, at this stage of growth, protein requirements are highest at weaning and decrease progressively (Meyer, 1990; Burns et al, 1982; Case and Czarnecki-Maulden, 1990). For example, the level of crude protein in bitch's milk is 33% dry matter (DM). Bitch's milk is a highly digestible food with an energy density of 6.4 kcal/g DM. This level is equivalent to 21% highly digestible protein in a commercial food with 4 kcal/g DM. In one study, beagle puppies needed a food with a minimum of 15% DM protein of high biologic value and 90% digestibility to achieve optimal growth immediately after weaning. Only 11.7% (DM) of the same high-quality protein was needed at three months of age (Burns et al, 1982).

For puppies 14 weeks and older, the minimum recommended allowance for crude protein is 17.5% DM (NRC, 2006). The recommended protein range in foods intended for growth in all puppies (small, medium and large breed) is 22 to 32% DM (**Table 17-1**). Most dry commercial foods marketed for puppy growth provide protein levels within this range.

Protein levels above the upper end of this range have not been shown to be detrimental but are well above the level in bitch's milk. Earlier work suggested that excessive protein intake might play a role in the development of skeletal deformities in giant-breed dogs (Hedhammar et al, 1974). Since then, it has been shown that foods containing 23 to 31% crude protein (6.4 to 8.8 g/100 kcal ME) do not have a deleterious effect on skeletal development. Furthermore, these levels support optimal growth, provided calcium and energy levels are appropriate (Nap et al, 1991; Nap, 1993). Most commercial foods for puppy growth contain more protein than is needed.

Protein requirements of growing dogs differ quantitatively and qualitatively from those of adults. An important difference is that arginine is an essential amino acid for puppies, whereas it is only conditionally essential for adult dogs (Young et al, 1978) (Arginine is present in ample amounts in essentially all pet foods and thus is not considered a key nutritional factor for commercial foods).

Foods formulated for adult dogs should not be fed to puppies. Although protein levels may be adequate, energy levels and other nutrients may not be balanced for growth.

## Fat

Dietary fat serves three primary functions: 1) a source of essential fatty acids, 2) a carrier for fat-soluble vitamins and 3) a concentrated source of energy. Growing dogs have an estimated

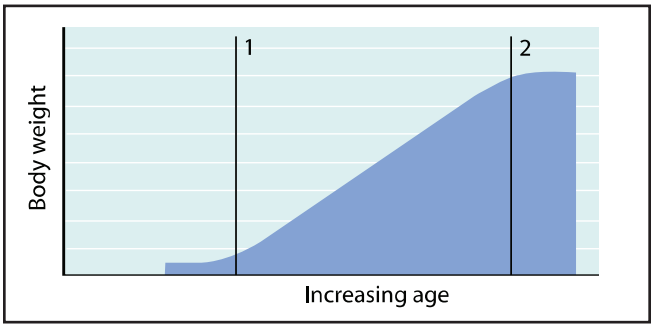


**Figure 17-1.** Typical sigmoidal growth curve of puppies. Growing puppies' energy needs may be subdivided into two components: the energy needed for maintenance and the energy required for accretion of body tissue. During the first weeks after weaning, when body weight is relatively small and growth rate exponential, puppies use about 50% of the energy for maintenance and 50% for growth. Gradually, the growth curve reaches a plateau. As body weight increases, the share of energy needed for maintenance increases progressively, whereas the part for growth becomes proportionately less important. The starting (line 1) and endpoint (line 2) of exponential growth can shift depending on the breed and individual variation. (See text and references.)

daily requirement for essential fatty acids (linoleic acid) of about 250 mg/kg body weight (Meyer, 1990b), which can be provided by a food containing between 5 to 10% DM fat (Meyer, 1990). The fat source must be carefully chosen when low-fat foods (<10% DM fat) are fed to ensure that sufficient amounts of linoleic acid are provided.

Studies indicate that docosahexaenoic acid (DHA) is essential for normal neural, retinal and auditory development in puppies (Pawlosky et al, 1997). Similar results have been found in other species (Pawlosky et al, 1997; Birch et al, 2002; Diau et al, 2003; Hoffman et al, 2003). Inclusion of fish oil as a source of DHA in puppy foods improves trainability (Kelley et al, 2004). Conversion of short-chain polyunsaturated fatty acids to DHA is an inefficient process in puppies (Bauer et al, 2006). Thus, adding a source of DHA should be considered essential for growth. The minimum recommended allowance for DHA plus eicosapentaenoic acid (EPA) is 0.05% DM; EPA should not exceed 60% of the total (NRC, 2006). Thus, DHA needs to be at least 40% of the total DHA plus EPA, or 0.02% DM.

Fat contributes greatly to the energy density of a food; however, excessive energy intake can cause overweight/obesity and developmental orthopedic disease, as discussed above. The minimum recommended allowance of dietary fat for growth (8.5% DM) is much less than that needed for nursing, but more than is needed for adult maintenance (5.5% DM) (NRC, 2006). To provide a DM energy density between 3.5 to 4.5 kcal/g, between 10 and 25% DM fat is required; this range of dietary fat is recommended from postweaning to adulthood.

## Calcium and Phosphorus

Although growing dogs need more calcium and phosphorus than adult dogs, the minimum requirements are relatively low. Puppies have been successfully raised when fed foods contain-

**Table 17-3.** Feeding plan summary for growing puppies.

1. Estimate adult body weight for determination of the recommended calcium range (>25 kg adult weight, use large-/giant-breed recommendation).
2. Using **Table 17-4** (or manufacturer's information), select a food with the recommended levels of key nutritional factors; ensure the selected food has been approved for puppy growth by a credible regulatory agency (e.g., AAFCO).
3. Avoid free-choice feeding; use food-restricted meal feeding, dividing the amount fed into two to four daily feedings.
4. Estimate the initial amount to feed from recommendations on product package or by calculation (**Table 17-5**). Remember, such recommendations and calculations should be used as guidelines or starting points and not as absolute requirements.
5. Teach owners to perform body condition scoring and have them monitor body condition at least every two weeks and adjust the amount fed by 10% increments to maintain a BCS of 2.5/5 to 3/5.
6. Veterinarians should assess body condition and weight of puppies in conjunction with routine vaccinations and more frequently if any indication of under- or overnutrition is detected. The feeding plan, including food dosage, should be modified as necessary.
7. Underfeeding through the growth phase is healthier than overfeeding and results in the same mature size.

Key: AAFCO = Association of American Feed Control Officials, BCS = body condition score.

## Box 17-1. Digestible Carbohydrates in Foods for Growing Puppies.

No specific recommendations for digestible (soluble) carbohydrate levels are available for growing dogs. It has been suggested that foods contain about 20% digestible carbohydrate until puppies are four months of age to ensure optimal health. In one study, feeding young puppies a food high in protein and fat without carbohydrate resulted in lethargy, poor appetite, diarrhea and mortality, which were attributed to fatty liver syndrome. However, another study failed to confirm these results. Body fat is higher when puppies are fed a very high-fat, low-carbohydrate food during growth.

The Bibliography for **Box 17-1** can be found at www.markmorris.org.

ing 0.37 to 0.6% DM calcium and 0.33% DM phosphorus (Jenkins and Phillips, 1960; Jenkins and Phillips, 1960a). Intestinal absorption of calcium can vary from almost 0 to 90% (Hazewinkel, 1985; Nap, 1993), and phosphorus absorption can increase to almost 80% to adapt to intake (Gesellshaft, 1989a; Jenkins and Phillips, 1960). Generally, calcium absorption depends on requirements and calcium intake (Meyer, 1990a). Calcium homeostatic mechanisms may be less precise in young puppies. In puppies between two and six months of age, intestinal absorption of calcium never decreases below approximately 40%, even if they receive high levels of calcium in foods (Hazewinkel, 1985; Hedhammar et al, 1974; Nap, 1993; Jenkins and Phillips, 1960). Retention of calcium, therefore, increases when young dogs receive high levels of calcium, either in the food or as a supplement (Hazewinkel, 1985; Nap, 1993). Absorption of calcium gradually is more regulated after puppies are about 10 months old (Hedhammar et al, 1974).

Foods for large- and giant-breed puppies should contain 0.7 to 1.2% DM calcium (0.6 to 1.1% phosphorus) (Chapter 33). Foods with a calcium content of 1.1% DM provide more calcium to puppies just after weaning than if bitch's milk is fed exclusively (Resnick, 1978). Because small- to medium-sized breeds are less sensitive to slightly overfeeding or underfeeding calcium (Nap, 1993), the level of calcium in foods for these puppies can range from 0.7 to 1.7% DM, (0.6 to 1.3% phosphorus) without risk. The phosphorus intake is less critical than the calcium intake, provided the minimum requirements of 0.35% DM are met and the calcium-phosphorus ratio is between 1:1 and 1.8:1 (Jenkins and Phillips, 1960; Jenkins and Phillips, 1960a). For large- and giant-breed dogs, the calcium-phosphorus ratio should be between 1:1 and 1.5:1.

### *Digestibility*

The ability of 11-week-old puppies to digest foods was less than at 60 weeks of age (Weber et al, 2003). Also, puppies fed foods low in energy density and digestibility need to eat larger quantities of food to achieve growth, increasing the risk of flatulence, vomiting, diarrhea and the development of a "pot-bellied" appearance. Therefore, foods recommended for puppies should be more digestible than typical adult foods. Most pet food companies, however, do not provide digestibility data. An indirect indicator of digestibility is energy density. Foods with a higher energy density are likely to be more digestible.

## Other Nutritional Factors

### *Copper*

Most commercial pet foods should contain adequate levels of copper unless the availability is low (e.g., when sources such as copper oxide are used) (Aoyagi and Baker, 1993). Puppies with copper deficiency may have loss of hair pigmentation, with graying of black and dark brown hair (Zentek, 1991; Zentek et al, 1991). Hyperextension of the distal phalanges and splayed toes on the front feet and normochromic, normocytic anemia may develop in more extreme cases (Zentek, 1991; Zentek et al, 1991). The recommended minimum allowance for copper in growing puppies is 1.1% DM (NRC, 2006).

### *Phenylalanine and Tyrosine*

Tyrosine is not an essential amino acid but is made from phenylalanine. Also, tyrosine spares about half of the need for phenylalanine. Therefore, it is appropriate to consider the amount of phenylalanine required as the sum of phenylalanine plus tyrosine. Although phenylalanine and tyrosine have not been shown to be the most limiting amino acids for growth in commercial food, at least twice as much phenylalanine, or phenylalanine plus tyrosine, is required for maximal black hair color as for growth (Biourge and Sergheraert, 2002). Other metabolic needs for phenylalanine and tyrosine include protein, thyroid hormone and catecholamine synthe-

sis (NRC, 2006). The recommended minimum allowance for phenylalanine plus tyrosine in foods for puppy growth is 1.0% DM.

### *Carbohydrates*

Although no specific level of digestible (soluble) carbohydrates exists for growing puppies, inclusion of about 20% (DM) may optimize health (**Box 17-1**).

## FEEDING PLAN

The feeding plan consists of choosing the best food and the best feeding method. Reassessment at appropriate intervals is another key to a successful feeding plan. **Table 17-3** summarizes the feeding plan.

### Assess and Select the Food

The food assessment phase will help determine the best food to feed or whether it is necessary to change foods if a food has already been selected. If a change is indicated, select a food that has been approved by a credible regulatory agency such as the Association of American Feed Control Officials (AAFCO). However, AAFCO feeding trials only last 10 weeks. During this time, potential problems related to excess calcium and energy consumption, especially in large- and giant-breed puppies may not have had time to manifest. Therefore, foods selected for growth should have key nutrients in the ranges provided in **Table 17-1.**

If the appropriate food was selected for reproduction, puppies of small- to medium-sized breeds (<25 kg anticipated adult weight) may continue to receive the same food as the bitch received during lactation. These puppies were probably transitioned to this food during weaning. Large- and giant-breed puppies should be fed a food that contains less calcium and energy to decrease the risk of developmental orthopedic disease. If possible, such foods should be fed during early weaning. Chapter 33 contains more detailed information about feeding large- and giant-breed puppies. The greatest nutritional influence on the incidence of phenotypic hip dysplasia occurs when energy is restricted very early in life (Lust et al, 1973).

Besides selecting an AAFCO (or a food approved by another credible organization) approved food, the food assessment/selection process includes comparing the nutrient profile of the current food, or the food under consideration, with the key nutritional factors in the amounts discussed above. **Table 17-4** lists levels of key nutritional factors in selected commercial foods marketed for healthy puppy growth and compares them to the recommended levels. If the food in question is not listed in **Table 17-4**, contact pet food manufacturers for this or other missing information. The guaranteed or typical analysis on pet food labels is of limited use and will not contain information about digestibility. Information about digestibility and energy density should be obtained from the manufacturer; digestibility must be sufficiently high to avoid GI problems. Also, foods with similar label declarations can have markedly different nutrient availabilities and growth performance (Huber et al, 1986; Huber et al, 1991).

Growing dogs should not receive vitamin-mineral supplements when fed complete, balanced commercial foods. Supplements may be justified to balance homemade foods. Because it is very difficult for breeders to exactly balance a homemade food, large- and giant-breed puppies should only receive a commercially prepared food specifically designed for such breeds. If an owner insists on using homemade foods, it is best to consult with a qualified veterinary nutritionist to ensure a homemade recipe is balanced (Chapter 10).

The calcium and energy content of treats should be similar to that recommended for the food (**Table 17-4**). If not, the number of treats fed should be limited to no more than 10% of the total amount of food fed. Treats given in large amounts may almost double a puppy's calcium intake (Box 33-5). Most treats are not complete and balanced for puppy growth. Check the product label for this information.

### Assess and Determine the Feeding Method

Feeding method assessment is critical to successful management of growing puppies, especially those of large and giant breeds. The feeding method includes how much food is fed and how it is offered. Food can be offered three ways: free choice, time-restricted meal feeding and food-restricted meal feeding. Free-choice and time-restricted feeding should be avoided during rapid growth.

Free-choice feeding may increase body fat, predispose the dog to obesity and, in large breeds, induce skeletal deformities at a young age. Breeders who want to maximize growth of large- and giant-breed puppies should be informed that overfeeding predisposes to developmental orthopedic disease. Even under these circumstances, rate of weight gain and body condition should be monitored closely (at least every two weeks).

Previously, time-restricted meal feeding was recommended (feeding a puppy all it can eat in 20 minutes, twice daily) (Lewis et al, 1987). However, more recent research showed that puppies fed using this method had increased body weight, more body fat and increased bone mineral accretion than puppies receiving the same food free choice (Toll et al, 1993).

During periods of rapid growth, puppies should be fed a measured amount of food (food-restricted meal feeding) every day based on body condition and age. The allotted amount of food can be offered in one or two meals per day. This recommendation includes thin puppies owned by clients who are tempted to feed more food so their puppies can "catch up."

Feeding puppies an allotted amount of food is best for most puppies because it allows for better control of body condition and rate of growth. Using this feeding method for growing puppies is complicated because the amount fed per unit body weight needs to be adjusted regularly. Initially the amount fed needs to be greater per unit body weight and then is reduced as the growth rate and energy requirements per unit body weight decline (**Figure 17-1** and **Table 17-2**). Also, the initial amount fed needs to be determined.

The initial daily food dose can be estimated by dividing the puppy's DER by the energy density of the food. From a practi-

**Table 17-4.** Comparison of recommended levels of key nutritional factors for small- to medium-breed puppies (adult BW <25 kg) to the key nutritional factor content of selected commercial foods marketed for healthy puppy growth.* For large- to giant-breed puppies (>25 kg), see foods and recommended levels in Table 33-6.

| Dry foods | Energy density (kcal/cup)** | Energy density (kcal ME/g)*** | Protein (%) | Fat (%) | DHA (%) | Ca (%) | P (%) | Ca:P |
|---|---|---|---|---|---|---|---|---|
| **Recommended levels** | **-** | **3.5-4.5** | **22-32** | **10-25** | **≥0.02** | **0.7-1.7** | **0.6-1.3** | **1:1-1.8:1** |
| Hill's Science Diet Puppy Healthy Development Original | 384 | 4.2 | 31.8 | 22.9 | 0.22 | 1.59 | 1.21 | 1.3:1 |
| Hill's Science Diet Puppy Lamb Meal & Rice Recipe | 377 | 4.2 | 31.7 | 21.7 | 0.22 | 1.58 | 1.10 | 1.4:1 |
| Hill's Science Diet Nature's Best Chicken & Brown Rice Dinner Puppy | 445 | 4.3 | 30.2 | 22.1 | 0.20 | 1.43 | 1.05 | 1.4:1 |
| Hill's Science Diet Nature's Best Lamb & Brown Rice Dinner Puppy | 442 | 4.2 | 30.1 | 22.1 | 0.17 | 1.50 | 1.10 | 1.4:1 |
| Iams Eukanuba Medium Breed Puppy | 463 | 4.1 | 31.7 | 19.2 | na | 1.50 | 1.07 | 1.4:1 |
| Iams ProActive Health Smart Puppy | 432 | 4.2 | 30.8 | 18.9 | na | 1.30 | 1.10 | 1.2:1 |
| Medi-Cal Veterinary Diet Development Formula | 425 | na | 28.4 | 17.5 | na | 1.20 | 1.10 | 1.1:1 |
| Nutro Natural Choice Puppy Lamb Meal and Rice | 333 | 3.8 | 29.7 | 14.3 | na | 1.98 | 1.54 | 1.3:1 |
| Purina ONE Healthy Puppy Formula | 465 | 4.6 | 31.7 | 20.6 | na | 1.61 | 1.11 | 1.5:1 |
| Purina Puppy Chow | 416 | 4.2 | 29.8 | 15.6 | na | 1.31 | 1.01 | 1.3:1 |
| Purina Pro Plan Chicken & Rice Formula Puppy | 473 | 4.6 | 31.6 | 20.7 | na | 1.23 | 1.04 | 1.2:1 |
| Royal Canin Medium Puppy 32 | 402 | 4.6 | 35.6 | 20.0 | na | 1.12 | 0.88 | 1.3:1 |
| **Moist foods** | **Energy density (kcal/can)**** | **Energy density (kcal ME/g)***** | **Protein (%)** | **Fat (%)** | **DHA (%)** | **Ca (%)** | **P (%)** | **Ca:P** |
| **Recommended levels** | **-** | **3.5-4.5** | **22-32** | **10-25** | **≥0.02** | **0.7-1.7** | **0.6-1.3** | **1:1-1.8:1** |
| Hill's Science Diet Puppy Healthy Development Savory Chicken Entrée | 205/5.8 oz. 459/13 oz. | 4.1 | 28.2 | 23.6 | na | 1.33 | 0.96 | 1.4 : 1 |
| Purina Pro Plan Puppy Chicken & Rice Entrée Classic | 459/13 oz. | 4.9 | 42.4 | 38.4 | na | 1.92 | 1.48 | 1.3:1 |

Key: BW = body weight, ME = metabolizable energy, DHA = docosahexaenoic acid, Ca = calcium, P = phosphorus, na = not available from manufacturer.
*From manufacturers' published information or calculated from manufacturers' published as-fed values; all values are on a dry matter basis unless otherwise stated.
**Energy density values are listed on an as fed basis and are useful for determining the amount to feed; cup = 8-oz. measuring cup.
***Energy density also reflects digestibility; foods with higher energy density are likely to have better digestibility than foods with lower energy density; for kJ/g, multiply kcal/g by 4.184.

cal standpoint, the energy requirement can be estimated but not determined precisely. Estimates of a puppy's DER can be obtained from **Table 17-2** (i.e., this phase of growth can be divided into three periods). The DER can also be calculated. DER calculations are simple and are based on the puppy's RER; **Table 17-2** lists RER factors. RER can be calculated (**Table 17-5**) or obtained directly from Table 5-2 or the food manufacturer.

The initial daily food dose estimate is merely a starting point. Body condition scoring (Figure 1-2) should be used to adjust the food dose estimate to individual puppies and will need to be readjusted regularly (10% increments) to allow for changes in growth rate. This amount can be fed in two to four meals per day. Note that Great Dane puppies may have energy requirements 25% higher than those of other breeds. As mentioned above, young Great Dane puppies may not grow when daily energy intake is less than 175 kcal (735 kJ) $ME/BW_{kg}^{0.75}$ (2.5 x RER) (Meyer and Zentek, 1992; Meyer and Zentek, 1991).

However, this finding should not be extrapolated to other giant-breed puppies (Rainbird and Kienzle, 1990).

## REASSESSMENT

Owners should weigh growing puppies weekly and record body weights and food intake (including snacks and treats). Veterinarians, or members of their health care team, can instruct owners about how to BCS their own puppies. A BCS should be obtained at least every two weeks. During office calls for routine vaccinations, veterinarians can compare the owners' scores with their own. This level of attention to BCS can be important to the development of a healthy puppy. The owner is then prepared to continue to make these observations throughout the life of the dog. Such dogs, as adults, should be less likely to experience skeletal diseases (large and giant breeds) and overweight or obesity and the myriad of related problems (most breeds).

Veterinarians should reassess puppies at the time of routine vaccinations and more frequently if any indication of under- or overnutrition is detected. Reassessment should include body weight and body condition assessment, food assessment and determination of correct food dosage (**Table 17-5**).

**Table 17-5.** Example of a food dosage calculation for a growing puppy.

Problem: what is the estimated amount of a growth food (375 kcal/cup) that should be fed to a five-month-old male Labrador retriever puppy weighing 18 kg?

1) Determine RER by using the linear formula: $RER_{kcal} = 30(BW_{kg}) + 70$; $RER_{kcal} = 30(18) + 70 = 610$ kcal/day or from Table 5-2.
2) Determine DER by using the RER factors in **Table 17-2**, based on age: 2.5 x RER = 2.5 x 610 kcal = 1,525 kcal/day.
3) Divide the DER by the energy density of the food (**Table 17-4**), to obtain the estimated daily amount to feed: 1,525 kcal ÷ 375 kcal/cup = 4 cups/day.
4) Divide the daily amount to feed into two to four individual meals.
5) This amount is only an estimate and is intended to be used as a starting point. The puppy's body condition should be monitored regularly (at least every two weeks) and the amount fed should be increased or decreased by 10%, depending on body condition score.

Key: cup = 8 volume oz. measuring cup (240 cc), RER = resting energy requirement, DER = daily energy requirement.

## REFERENCES

The references for **Chapter 17** can be found at www.markmorris.org.

## CASE 17-1

### Initial Health Care for a Welsh Corgi Puppy

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### Patient Assessment

A 10-week-old, female Welsh corgi puppy was examined as part of a routine health maintenance program. The owners had recently purchased the puppy from a local breeder and had never owned a dog before. They were interested in vaccinations and any other information about caring for puppies. They had had the puppy for two days and indicated that everything appeared normal.

Physical examination revealed an alert and active puppy with no obvious problems. The puppy weighed 6.5 kg and had a normal body condition (body condition score [BCS] 3/5). The estimated adult weight was about 17 kg. Results of a fecal flotation test were negative for intestinal parasites. Routine vaccinations were given.

### Assess the Food and Feeding Method

The breeder provided a small amount of an unknown dry food in a plastic bag. The owners had offered small amounts of this food three times per day, and the puppy ate the food very well. They were also given a bottle of chewable vitamin-mineral tablets by the breeder and instructed to give the puppy one tablet per day.

### Questions

1. What are the key nutritional factors to consider in developing a feeding plan for this puppy?
2. Outline a specific feeding plan for this patient including an appropriate food and feeding method.
3. Should the owners continue to provide the chewable vitamin-mineral supplement?

4. Besides nutrition, what other health care topics for puppies should be discussed with these owners?

## Answers and Discussion

1. Key nutritional factors for growing dogs include energy, protein, fat, calcium, phosphorus and digestibility. Energy is required to support rapid accretion of new tissue; however, excessive energy intake increases the risk of obesity and, in some breeds, developmental orthopedic disease. Foods for puppies should contain 3.5 to 4.5 kcal (14.6 to 18.8 kJ) metabolizable energy (ME)/g dry matter (DM). Fat makes the greatest contribution to the energy density of food and should be 10 to 25% DM in growth-type foods. Puppies also have higher protein requirements than adult dogs to support tissue growth. Protein levels of 22 to 32% DM are recommended for puppies. Adequate calcium is important in foods for growing dogs to support skeletal development. Known calcium deficiency is rarely a concern in growing dogs fed commercial foods, but it may be a problem for dogs fed homemade foods. Excess calcium intake is a risk factor for developmental orthopedic disease and may occur in growing dogs eating some commercial foods and/or receiving mineral supplements. Calcium levels of 0.7 to 1.7% DM are generally recommended for growing dogs. Phosphorus is less critical than calcium provided minimum requirements of 0.35% DM are met and the calcium-phosphorus ratio is between 1:1 and 1.8:1. No specific recommendations for dietary carbohydrate are available for growing dogs; however, puppies appear to do better if growth-type foods contain more than 20% complex carbohydrate DM. Gastrointestinal (GI) distention ("pot-bellied" appearance) and GI disturbances (i.e., flatulence, vomiting, diarrhea) are less common in puppies fed highly digestible foods.
2. A food specifically formulated for growing dogs that addresses the key nutritional factors described above should be recommended. A number of commercial products meet these objectives. Homemade foods can also be fed to growing dogs; however, recipes should be used that contain adequate protein, fat, calcium, vitamins and trace minerals to support growth.Feeding methods for growing dogs include free-choice (ad libitum) feeding, time-limited feeding and food-limited feeding. Free-choice feeding is relatively effortless and may reduce abnormal behavior such as barking at feeding time. In addition, frequent trips to the food bowl may help reduce boredom and coprophagy, and timid or unthrifty dogs experience less competition when eating. Disadvantages of free-choice feeding include food wastage, only dry or semi-moist forms of pet food can be fed and competition or boredom may stimulate overeating. The most serious disadvantage in young growing dogs is increased risk for obesity and developmental orthopedic disease due to over consumption of even a properly balanced food.

   Time-limited feeding is a method in which dogs are allowed free access to food for a defined period, usually 10 to 15 minutes, once or twice daily. This feeding method may result in less overall food consumption when compared with puppies fed free choice. Time-limited feeding may also help in disciplining and housetraining young puppies. The owner interacts with the puppy during this time and is able to observe its general condition and behavior, which may lead to earlier detection of problems. A routine of feeding a puppy and then taking it outdoors can reinforce housetraining by taking advantage of the gastrocolic reflex. Advocates of this feeding method suggest that when some dogs fed in this manner reach adulthood they may voluntarily limit their feeding to once or twice a day and thus avoid overeating. However, research has shown that some dogs may eat as much in 15 minutes as when fed free choice. In this study, dogs fed by a time-limited method had higher weight gain, more body fat and increased bone mineral accretion than dogs receiving the same food free choice. This method is also less convenient for the owner than free-choice feeding.

   Food-limited feeding (feeding a measured amount of food every day) requires knowing how much to feed. This is best obtained by estimating the amount to feed based on the puppy's calculated daily energy requirement or as recommended by the manufacturer, and then adjusting the amount as necessary to maintain a BCS between 2.5/5 to 3.5/5. This amount is divided into two to four meals per day. This is the method of choice for feeding all puppies to reduce the risk of obesity and developmental orthopedic disease because it limits food intake to maintain optimal growth rate and body condition. This method is also less convenient and more time consuming than free-choice feeding because food amounts must be increased as growth occurs.
3. Routine vitamin-mineral supplementation is not necessary for healthy puppies eating balanced commercial growth foods. Supplementation is important if homemade foods are used.
4. In addition to vaccination, intestinal parasite control and nutritional counseling, the following health maintenance procedures should be discussed with puppy owners: 1) external parasites and appropriate control programs, 2) heartworm preventive programs, in endemic areas, 3) the pet's behavior and socialization, 4) specific breed characteristics, 5) routine grooming procedures, 6) basic obedience training and reputable obedience schools, 7) recommendations for neutering, 8) housetraining and 9) manipulation of the mouth to accustom the puppy to toothbrushing later on. All of these topics should be discussed with these clients, especially because they are novice dog owners.

## Progress Notes

All of the health maintenance procedures mentioned above were discussed with the owners by the veterinarian or veterinary technician. A commercial specialty brand dry food formulated for canine growth (Science Diet Puppy Healthy Development Original[a]) was recommended. The quantity of food to be fed was based on the feeding instructions on the pet food bag. This amount was divided into three equal daily meals. The owners were instructed to discontinue the vitamin-mineral supplement and were given an

instruction sheet that outlined how to assess the body condition of puppies. The food amount was to be adjusted as the puppy grew according to the feeding guidelines on the bag. The owners were asked to weigh and assign a BCS for the puppy every other week and adjust the food amount as needed to maintain optimal body condition. The veterinary technician would also assess the body weight and condition during subsequent office visits when the puppy was 14 to 16 and 20 to 22 weeks of age.

## Endnote

a. Hill's Pet Nutrition, Inc., Topeka, KS, USA.

## Bibliography

Toll PW, Richardson DC, Jewell DE, et al. The effect of feeding method on growth and body composition in young puppies (abstract). In: Abstract Book. Waltham Symposium on the Nutrition of Companion Animals. Adelaide, Australia, September 23-25, 1993: 33.