

# Feeding Reproducing Dogs

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*“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 interestrus 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.

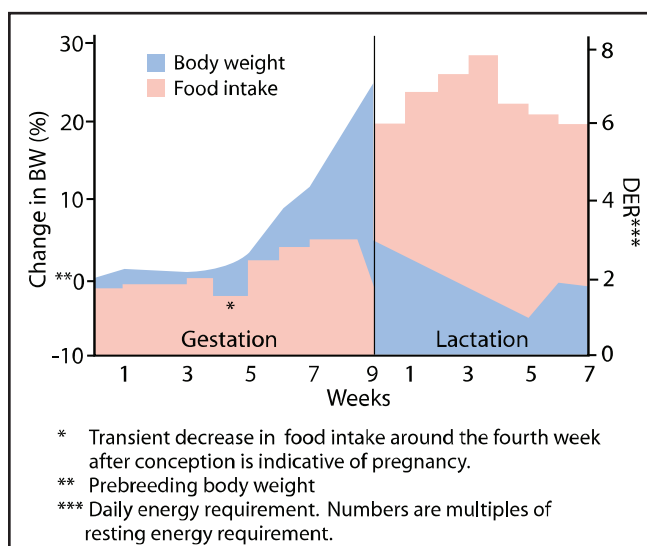
### Pregnancy

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
<b>Underfeeding</b>	Small litter size Low birth weight Increased neonatal morbidity and mortality Decreased milk yield Decreased immunity and decreased response to vaccination Decreased fertility later
<b>Obesity</b>	Hair loss and weight loss in bitches Decreased ovulation Decreased fertility Silent heat Prolonged interestrus interval Anestrus Smaller litters
<b>Malnutrition*</b>	
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.



**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; Gesellschaft, 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; Gesellschaft, 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 (Ofstedal, 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; Ofstedal, 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; Ofstedal, 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 (Gesellschaft, 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
<b>Total protein</b>	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
<b>Total fat</b>	9.5	3.5
Linoleic acid (C18:2)	11.7	2.5
<b>Lactose</b>	3.4	5.0
<b>Gross energy (kcal/100 g)</b>	146	74

\*Adapted from Meyer H, Kienzle E, Dammers C. *Milchmenge und Milchzusammensetzung bei und Hündin sowie Futteraufnahme und Gewichtsentwicklung 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

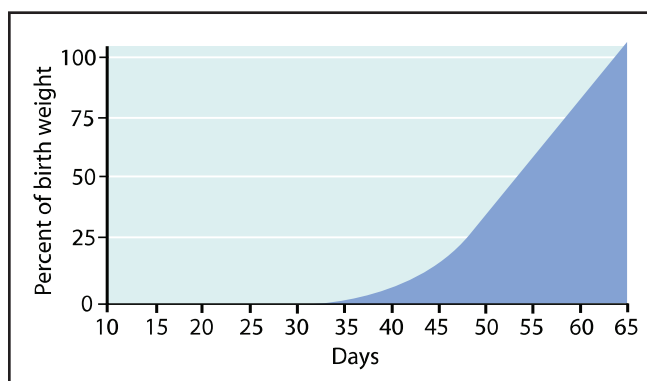
Key: na = not available.

\*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 digestibility	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 Energie und 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 (Gesellschaft, 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 (Gesellschaft, 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	kcal ME/day**	Total DER	kJ ME/day**
-	DER***		DER***
1-4	DER + 18 kcal ME/kg BW		DER + 75 kJ ME/kg BW
5	DER + 36 kcal ME/kg BW		DER + 150 kJ ME/kg BW
6-8	DER + 18 kcal ME/kg BW		DER + 75 kJ ME/kg BW
9			

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. Ausschluß 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  $1.9 \times RER$  ( $DER = 132 \text{ kcal ME}/BW_{kg}^{0.75}$  or  $550 \text{ kJ ME}/BW_{kg}^{0.75}$ ).

**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:  $ME \text{ (kcal)} = DER + (BW_{kg} \times [24n + 12m] \times L)$ , where DER equals the DER for maintenance.

The calculation requires the DER for lactating bitches, without allotment for milk production, which is  $145 \text{ kcal} \times BW_{kg}^{0.75}$  (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:

$ME \text{ (kcal)} = DER + (BW_{kg} \times [24n + 12m] \times L)$  where DER is the daily maintenance energy requirement without lactation and  $BW_{kg} \times [24n + 12m] \times L$  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) =  $145 \text{ kcal} \times 20^{0.75} = 145 \text{ kcal} \times 9.5 = 1,378 \text{ kcal}$

Number of puppies = 6:  $n = 4$ ,  $m = 2$

Week of lactation =  $L = 0.95$  (correction factor for Week 2)

Requirement for lactation =  $20 \times (24 \times 4 + 12 \times 2) \times 0.95 \text{ kcal} = 2,280 \text{ kcal}$

Total requirement for maintenance and lactation =  $1,378 + 2,280 = 3,658 \text{ kcal}$

#### 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  $ME_{\text{peak lactation}} \text{ (kcal)} = 2.1 \times RER_{\text{bitch}}$  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 =  $2.1 \times 70(20^{0.75}) = 1,390 \text{ kcal}$

Requirement for lactation = 25%/puppy or  $348 \text{ kcal} \times 6 = 2,088 \text{ kcal}$ .

\*Adapted from NRC, 2006.

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

**TP (liters) =  $(BW_{kg} \times k) + [(n-4) \times (0.1 \times BW_{kg})]$**   
**Peak milk production (Weeks 3 to 4) = TP x 0.04.**  
 Example = 30-kg bitch with 8 puppies  
 $TP = (30 \times 2) + [(8-4) \times (0.1 \times 30)] = 60 + (4 \times 3) = 72$  liters milk  
 Peak milk production (Weeks 3 to 4) =  $72 \times 0.04 = 2.9$  liters/day  
 Key: TP = total milk production through Day 45 of lactation, n = number of puppies, k = 1.6 for bitches  $\leq 8$  kg BW, 1.8 for bitches  $>8$  to  $<25$  kg BW and 2.0 for bitches  $\geq 25$  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 (Gesellschaft, 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) (Gesellschaft, 1989b; Meyer et al, 1985a). The food should contain about 4 g digestible protein/100 kcal ME (about 10 g of digestible protein/MJ) (Gesellschaft, 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  $\alpha$ -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; Diao 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.\*

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

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  $\beta$ -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](http://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<sub>kg</sub><sup>0.75</sup> (Gesellschaft, 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 (Gesellschaft, 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:

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

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](http://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 (Gesellschaft, 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 (Gesellschaft, 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 phenylala-

nine, 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 (Gesellschaft, 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 (Haupt 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 ( $\text{DER} \div \text{food energy density}$ ).
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](http://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/ $\mu$ l) 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<sup>a</sup>) 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.

### Bibliography

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