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.

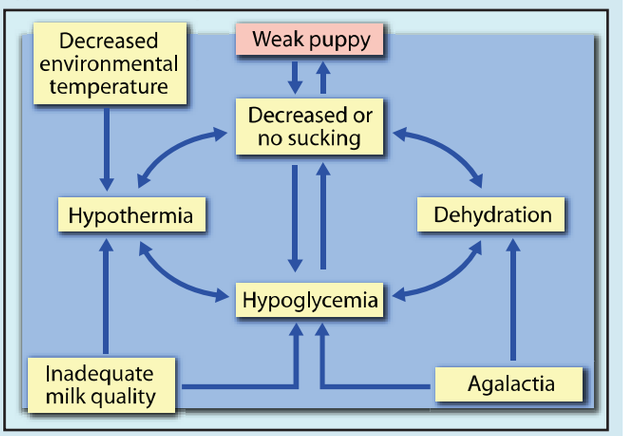

Figure 1. This figure shows how hypothermia, hypoglycemia and dehydration interrelate, creating a cycle that often results in neonatal death.

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.

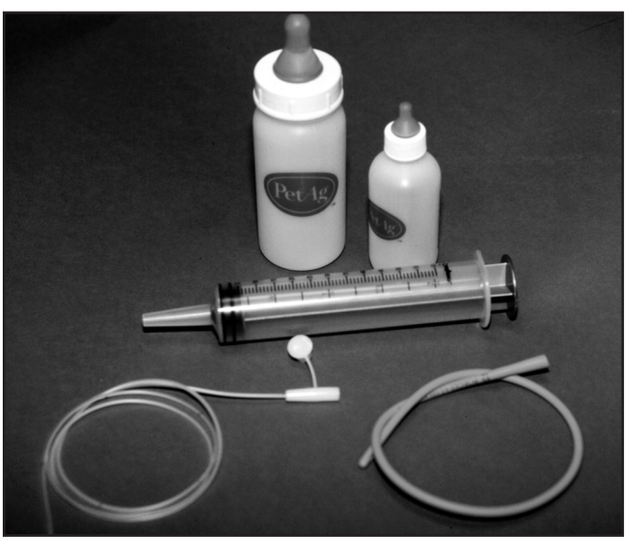

Figure 16-3. Various bottles and feeding tubes can be used for hand feeding orphaned puppies.

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.