

Nutrition for optimum reproductive performance

Kara A. Kolster

Springfield Veterinary Center, Glen Allen, VA

Reproductive success has been defined as “the generation and weaning of an adequate sized litter of healthy viable puppies reflecting the genetic potential of both the dam and sire”. Many factors work together to determine reproductive success: age and health status of sire and dam, inherent fertility of the breed and of individuals, type and timing of mating, and nutritional status of the dam during breeding, pregnancy and lactation. This is the most nutritionally challenging period in a bitch’s life and providing optimum nutrition will allow her to maintain condition while producing the healthiest possible puppies.

The American Association of Feed Control Officials (AAFCO) publishes minimum standards for nutrient levels in animal foods. All commercial diets must meet these standards through feed analysis or feeding trials and specify compliance on the label. These standards are specific to life stage of the animal: adult maintenance, growth and pregnancy/lactation, or all life stages (defined as weaning through adulthood). Adherence to AAFCO standards guarantees that an animal fed that diet is receiving an adequate balanced ration for its life stage. However, an important but undefined distinction exists between *adequate* and *optimum* nutrition. This difference can become evident during the physiologic stress of pregnancy and lactation. An adequate but suboptimal diet is unlikely to inhibit reproduction but can limit peak performance. Concerns specific to the pregnant bitch include: adolescent bitches that are still growing themselves and thereby competing with fetuses for nutrition; bitches re-bred before recovering from a previous litter and are in a state of nutritional deficit at the onset of next pregnancy; and bitches with placental insufficiency on a diet that is adequate for the dam’s needs but resulting in decreased nutrient transfer to developing fetuses. When evaluating a diet for reproduction, it is important to remember that excess nutrients can cause as much harm as deficiencies.

Early work in canine nutrition showed that maintenance diets were inadequate for reproduction and that selective supplementation enhanced reproductive performance. Bitches fed a maintenance diet showed no outward signs of disease or nutritional deficiency but experienced a higher incidence of perinatal mortality as compared to bitches fed a supplemented diet. This was most evident early in neonatal life, which suggests a prenatal cause. There was also a significant increase in puppy weight gain in supplemented bitches. Nutrient deficiencies in the maternal diet have the greatest impact on fetal development during the pre-implantation period and the period of rapid placental development, both of which occur in the first third of pregnancy.

Deficiencies in maternal nutrition have also been associated with disease in adult progeny. The phenomenon known as “fetal programming” occurs when alterations in the fetal environment result in permanent changes to an individual’s structure, physiology and metabolism that can predispose them to disease in adult life. Numerous epidemiologic studies have linked deficient maternal nutrition and intrauterine growth retardation (IUGR) to cardiovascular disease in adult offspring. IUGR in dogs is known to cause effects such as reduced weight gain in puppies post-weaning.

Glucose

Glucose is the primary fuel for almost all cells in the body. An animal’s blood glucose level is a reflection of glucose absorbed from food and glucose produced within the body. These systems work together to create homeostasis, a state of balance within the body. Pregnant bitches have altered glucose homeostasis which, if nutritional stress and environmental factors combine, can affect reproductive performance. Pregnancy affects blood glucose levels by 1) causing insulin resistance, which leads to a

decreased ability to absorb glucose from food, and 2) limiting the body's ability to produce its own glucose in response to hypoglycemia (low blood sugar). For these reasons, hypoglycemia is common in late-term pregnancy. Complicating factors such as decreased appetite, change in type of diet, or other external stress can turn this "normal" condition into a significant problem. Seemingly minor changes in the quantity or quality of a bitch's diet may affect litter size, fetal development, and birth weight.

Protein

Suboptimal levels of dietary protein cause reduced maternal weight gain during pregnancy, smaller litter size, IUGR, and reduced birth weight of puppies. It is believed that it also causes permanent changes in the puppies' physiology, as reduced weight gain continues post-weaning. However, excess dietary protein can decrease function of the placenta due to oxidative damage. The AAFCO minimum standard for protein in a gestation/lactation diet is 22%. More recent studies show that 29-32% protein is ideal. Dogs may not be able to effectively utilize greater than 32% protein in their diet.

The type and quality of protein is equally as important as the amount. The quality of a protein is related to the amount and balance of amino acids it contains. Animal-based protein sources provide the most appropriate balance of amino acids. The exception is an animal protein source that contains primarily connective tissue, which is high in non-essential amino acids. Biologic value (BV) is a measure of protein quality based on a food's balance of essential amino acids. Generally, the higher the BV of a protein, the lower the amount that needs to be fed in order to meet an animal's amino acid requirements. The BV of an egg is set at 100 and all other protein sources are evaluated relative to this standard. Mixing protein sources is a way of providing a complete and balanced complement of amino acids without feeding excessive amounts of protein.

Fat and docosahexaenoic acid

Essential fatty acids (EFA) are important components of the nervous system, especially the brain, eyes, and blood vessels. They accumulate in the brain and retina during fetal and perinatal development. Essential fatty acids are transferred from dam to offspring through the placenta and milk. Docosahexaenoic acid (DHA) is an omega-3 fatty acid. It can be formed in the adult liver but production in young animals is not sufficient to support optimal brain and eye development, so availability of DHA in the dam's diet is crucial. Maternal EFA levels are naturally decreased during pregnancy and lactation, which substantiates the benefit of dietary supplementation during these times. Animals that were deficient in DHA early in life can experience developmental abnormalities with life-long effects. Offspring of dams fed DHA-enhanced diets showed improvements in neurologic development, learning and memory ability, and response to stress. Both the amount and type of fat in the diet are important. Litter size was larger in bitches fed diets with a higher percentage of fat and an optimal omega-6 to omega-3 fatty acid ratio. Cold water fish, eggs, and organ meats are all sources of DHA. For optimal reproductive success, an 18% fat diet with a 5:1 to 10:1 ratio is recommended.

Carbohydrates

Dogs do not generally require carbohydrates in their diet as long as the protein level is high enough to allow production of glucose within the body. However, glucose producing ability is compromised in pregnancy while nutritional demand is increased, setting the stage for significant deficiency if diet is not appropriate. An early study showed many negative effects of feeding a carbohydrate-free diet to pregnant bitches, including: hypoglycemia in dams, increased stillbirth and

perinatal mortality, decreased mothering behavior, decreased milk quality, and decreased length of lactation. Based on available information, the current recommendation is that 20-30% of a diet's calories should be derived from carbohydrates. It is important to remember that this information is not stated on the pet food label but can be calculated. Higher levels of carbohydrates are not necessarily harmful, but may indicate that a diet is compromised on protein and other essential nutrients.

Vitamins and minerals

The majority of information available regarding recommended vitamin and mineral levels for gestation/lactation diets is based on AAFCO standards, which specify minimum adequate but not necessarily optimum levels. Most commercial foods contain approximately 250% of the AAFCO minimum standard, which is expected to be sufficient for all life stages including reproduction. Increased intake of a balanced diet late in gestation accounts for increased nutrient needs; it is not necessary to change the diet profile for a pregnant bitch.

The only valid reason to utilize dietary supplements is when the diet fails to supply the needed amount of a given nutrient. Vitamins and minerals must be consumed in proper balance to maintain health and nothing is supplemented in pure form. For example, a 1.2:1 ratio of calcium to phosphorus is recommended, but a sufficient level of vitamin D is necessary to aid absorption. Commonly supplemented meats provide extra protein but also contain much higher levels of phosphorus than calcium. Cottage cheese also contains more phosphorus than calcium. It follows that adding unbalanced supplements to a balanced diet will result in unhealthy excesses or deficiencies of nutrients.

It is generally accepted that vitamins and minerals derived from whole food sources are preferred over inorganic supplements. Ideally, animal-based protein and other whole foods (vegetables, grains, etc) should be high on the ingredient list of a pet food.

Nutriceuticals and supplements

Docosahexaenoic acid is the best studied dietary supplement in dogs. As discussed previously, it is beneficial at many points during reproduction, and is now commonly added to commercial growth diets.

Folic acid, also known as vitamin B9, plays a role in DNA synthesis, neurotransmitter activity in the brain, and midline closure of the palate during intrauterine development. Cleft palate results if fusion between left and right halves of the palate does not occur around day 33 of gestation. This is usually due to either a genetic cause or environmental exposure during pregnancy, such as excess alcohol, nicotine, vitamin A, or corticosteroids. Cleft palates have been caused experimentally in puppies by administering a drug that blocks folic acid to the dam during days 25-28 of gestation. Administering folic acid to women during the first trimester of pregnancy significantly decreases the risk that their babies will be born with a cleft lip or palate. Similar results are seen in dogs where studies show that folic acid supplementation from 15 days prior to breeding through whelping decreased the incidence of cleft palates in Boston terriers and French bulldogs.

Other supplements that may be beneficial to a dam's health include probiotics and glucosamine. They may or may not provide any advantage to fetuses but are not expected to cause any harm. Many commercial foods now include these supplements.

There are many quality diets available to meet the nutritional needs of a bitch during gestation and lactation, and no single feeding recommendation is appropriate for all dogs. When selecting a food, consider the overall nutrient levels, the source and quality of ingredients, as well as supplements already

included in the diet. A complete and balanced diet does not generally require additional supplements, and adding them may result in an unbalanced diet. Reproductive success requires a combination of health, fertility, pedigree, and proper nutrition. Each of these factors should be optimized in order to reach peak reproductive performance.

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