Nutrition and Theriogenology

A Glimpse Into Nutrition and Nutritional Supplementation During Gestation, Lactation, Weaning and Breeding Dogs and Cats

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• Spermatogenesis • Nutraceutical

KEY POINTS

- Pregnant and growing animals need to consume a complete and balanced diet formulated for respective life stages or all-life stages based on the American Association of Feed Control Officials nutritional adequacy statement.
- Regular body weight and body condition monitoring of pregnant and growing animals at each veterinary visit is important to determine appropriate energy intake.
- Energy demands during growth are often adequately met; however, mineral balance can be a concern in large and giant breed dogs.
- There is little evidence in the canine literature that supplements for conception and gestation are worthwhile.
- Some evidence points to nutritional supplementation for spermatogenesis; however, much of the literature is in normal stud dogs without dysfunctional spermatogenesis.

NUTRITION FOR THE NORMAL INTACT MALE AND FEMALE BEFORE BREEDING

Both breeding female and male should be in an ideal body condition utilizing a common body condition scoring system (eg, 5 out of 9 on a 9-point scale) and fed a complete and balanced maintenance diet as established by the American Association of Feed Control Officials (AAFCO). Overweight or underweight females may have lower

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ovulation and conception rate and poor performance (inadequate milk production, higher neonatal mortality, hypoglycemia-prone puppies, dystocia due to larger fetus) throughout the stages of reproduction (see Sones and Balogh's article, "Body Condition and Fertility in Dogs," in this issue).[1,2] Sometime after breeding (usually during gestation growth about half way into gestation) switching to a diet designed to support the life stages of gestation and lactation or all-life stages is recommended for both female dogs and cats, and the diet should be highly digestible and palatable. Feeding a nutrient and energy-dense food (approximately 4000 kcal/kg dry matter or greater) will help queen's or bitch's nutritional demands to be easily met without volume increases during much of gestation.

The concept of "flushing," defined as increasing food intake by 5% to 15% before estrus until breeding, was once suggested to enhance the reproductive performance in that both dogs and cats accumulating body fat reserves during gestation for subsequent lactation, but this practice used mostly in pigs is not necessary in feline and canine females with optimal body condition.[1] Although it seems logical to store more energy in their body, loss of body condition followed by weeks of lactation can be recovered spontaneously later with provision of proper nutrition and management (ie, separating litters from dams earlier).

In the case of breeding males, no specific nutritional requirement is documented, but they should be in optimal physical condition without any clinical disease to ensure breeding performance. Physical examination (plus body and muscle condition scoring) can be performed to assess nutritional status of breeding animals. Intact males in heavy service may experience weight loss or hyporexia, but this can be resolved with increased ration or caloric density of the food. Selection and screening of breeding males is covered elsewhere (see Bart J.G. Broeckx's article, "Incorporating Genetic Testing into a Breeding Program," in this issue).

FEEDING THE GRAVID FEMALE

Energy requirements of cats and dogs during gestation increase in a different manner. Depending on respective fetal growth patterns and weight gain of dams; a queen's body weight increases linearly during gestation, whereas a bitch's body weight does not increase until the last half to third of gestation. The weight gain and energy requirements are correlated, and during gestation, caloric intakes should be gradually increased on an individual basis. For optimal fetal growth and development, approximately 25% to 50% increase in daily intake over maintenance requirement is desired during the last half of pregnancy to the time of whelping for dogs. In case of pregnant dogs with ideal body condition, the increment can be initiated around the fifth week of gestation (10%–15% increase each week from the fifth week). Food intake of queens is gradually increased from the second week of gestation, and 40% to 50% increase in body weight is often recognized at the point of parturition.[3] In part this increase in cats will increase adiposity which is desired considering queens will usually not increase caloric intake as robustly as dogs during lactation that can precipitate weight loss during the lactation phase as they cannot keep up with caloric demands particularly with larger litters.

Overfeeding the dams should be avoided to maintain optimal body condition (to slightly overconditioned in cats) until whelping, as excessive energy intake leads to obesity of dams that may result in heavier fetuses and dystocia (see Sones and Balogh's article, "Body Condition and Fertility in Dogs," in this issue). In cases of females with large litters or giant breed dogs, volume limitation may compromise their food intake by abdominal fill; therefore, the dogs should be fed free choice or small multiple meals

throughout the day, particularly if ultrasound shows larger numbers in the litter (greater than 8).[1]

A diet with a nutritional guarantee on the packaging to support the gestation and lactation or all-life stages is necessary and these diets are usually higher than 4000 kcal/kg dry matter for dogs and 4500 kcal/kg dry matter for cats. As fetuses get larger, protein requirements exceed maintenance especially during late gestation, and the formula should provide high-quality protein (ie, animal-based protein) to avoid protein malnutrition (often > 29% dry matter for dogs and 32% dry matter for cats).[4] With cats, optimal levels of taurine and arachidonic acid should be provided in the formula to maintain normal reproduction and prevent fetal loss. Most importantly is that commercial dog foods have an appropriate calcium to phosphorus balance (typically 2:1–1:1); therefore, adding calcium to the diet in the form of eggshell or other calcium carbonate substrates may negatively affect this ratio leading to a predisposition toward periparturient hypocalcemia that should be avoided.

FEEDING DURING LACTATION

Immediately after whelping, the dam's food intake increases dramatically and continues to increase for the first 3 weeks of lactation as it is the period where the growth rate of litters is the greatest. Maintenance energy and nutrient requirements of lactating cats and dogs are directly correlated with milk production and depend on litter size. Based on the current National Research Council guideline, maintenance energy requirements for lactating dogs and cats are approximately 145 kcal/kg $BW^{0.75}$ and 100 kcal/kg $BW^{0.67}$, respectively, and the estimations can be used as a starting point for feeding which must then be adjusted for the number of puppies or kittens in the litter.[5] Energy requirement of lactating dams can simply be estimated as 25% increase of nutrient intake above maintenance for each puppy or kitten in the litter. This is applicable to a maximum of 8 offspring (ie, 300% of maintenance energy requirement) and beyond 8 offspring it can sometimes be difficult for a lactating female to sustain themselves through food consumption without weight loss at the point of weaning. To achieve the adequate energy intake, a diet designed to support the life stages of gestation and lactation should be fed free choice or small multiple meals, and this will help lactating females meet their energy requirement and produce adequate milk, as feeding larger meals less frequently can lead to soft stools or diarrhea. To produce large quantities of milk, the dam's water requirement drastically increases as the moisture content of milk is over 75%.[6] Water requirements (mL) of lactating females are close to energy requirements in kcal, and sufficient clean water should be available (eg, a lactating 30 kg Labrador will require approximately 1800 kcals and with 6 puppies needs 4500 kcals which roughly translates to needing 4500 mL of water each day for milk production).

During lactation, body condition of lactating females should be maintained by providing adequate nutrition throughout the stage. In cats, peak milk production is reached at week 3 and energy requirement peaks around at week 7.[7] At the end of lactation, quantity and nutrient content of the queen's milk no longer can support optimal growth of offspring; therefore, weaning of the kittens should be started as early as week 2 to 4. In the case of dogs, peak lactation occurs in the fourth week, and transitioning to weaning can be started earlier based on breed difference (ie, size) and bitch's body condition.[6,8] Reducing the amount of food available to dam and/or switching back to an adult maintenance diet at around 6 to 7 weeks will decrease milk production and aid in the weaning process. After successfully weaning the litters, females can be fed the same amount of calories as pre-breeding intake.

Hand rearing of litters may be needed in some cases (eg, large litters and/or agalactia, toxic milk syndrome, illness or death of dam, eclampsia). Commercial milk replacers (Esbilac and Kitten milk replacer [KMR]) for puppies and kittens can be fed to meet their both protein and energy requirements, as the formulas approximate the nutrient compositions of bitch's and queen's milk. Milk replacers vary in their nutrient profile and bioavailability and may affect growth and health of growing neonates (eg, development of cataract due to insufficient level of essential amino acid arginine).[9] Use of cow's or goat's milk as an alternative is not recommended because of its nature of lower caloric density, and slightly higher lactose content leading to diarrhea in the neonates due to the volume needed to meet caloric demands compared to bitch's milk (**Table 1**).[10] Energy requirement during the first 4 weeks of life is around 15 to 20 kcal/100 g body weight, which may be greater than 25 kcal/100 g body weight in kittens in the first 4 weeks, and the amount of puppy and kitten formulas fed is increased accordingly as they grow, in general.

FEEDING GUIDELINES FOR WEANING PUPPIES/KITTENS

When puppies and kittens reach 4 weeks of age, the quantity and nutrient content of dam's milk are no longer suitable for optimal development.[5,6] Gestation/lactation or all-life stages formulas given to dams can be soaked in water and made into a "gruel" (particularly if using a commercial kibble ration) and offered to the puppies or kittens as early as around 3 to 4 weeks of age, depending on dam's body condition and the number of offspring in the litter. Placing the food on the paws and face of puppies and kittens will usually promote solid food intake. A canned formula that meets the energy and nutrient requirement for growth or all-life stages can be gradually introduced and weaned at 5 to 6 weeks of age for puppies and 6 to 7 weeks of age for kittens and should also be mixed into a "gruel" to optimize intake. The nutritional adequacy statement of the chosen diet should be checked to ensure that it supports growth or all-life stages, and at the point of weaning, home prepared human or raw formulas should not be fed due to their nutritional imbalance or inadequacy, particularly raw foods due to potential pathogen exposures to young offspring with poor immune system status.

FEEDING THE GROWING PUPPY/KITTEN

Although the National Research Council provides a specific lengthy equation for the energy needs of puppies based on adult body weight and current body weight throughout the growing process, it is cumbersome and difficult to use for most practitioners.[11] A simple postweaning energy requirement assumption can be made for most puppies and kittens which is 3 times resting energy requirement (RER) based on current body weight which is rapidly changing. For example, a 6 kg, 10 week old Labrador would be RER = 70 $(6)^{0.75}$ = 268 kcal. This would then be tripled to

Table 1
Average milk protein, fat, and lactose concentrations found in dog, goat, and cow milk per 100 mL as per analysis by author and USDA Nutrient Database

		Per 100 mL	
Species	Protein (g)	Fat (g)	Lactose (g)
Dog	7.9	10.5	3.8
Goat	3.5	4.1	4.3
Cow	3.3	3.2	4.8

approximately 805 kcal a day. When 50% of adult body weight is achieved, the energy intake is reduced to 2.5 times RER, and it is 1.8 to 2 times RER at 80% of adult body weight until the puppy reaches desired adult body weight (Fig. 1).[12] Though simple to calculate it should be noted that for most breeds (except some giant breed dogs) that the calories consumed between 4 to 5 months of age are likely to be the peak of calorie consumption and that to maintain an ideal body condition increasing caloric consumption is often not necessary beyond this point in development. The recommendation is a starting point for estimation of energy requirement for maintenance based, and frequent monitoring of body weight and condition and caloric adjustments should be involved for optimal growth. A complete and balanced diet designed for growth or all-life stages must be fed to prevent nutritional deficiencies in the face of high nutrient demand. Avoiding excessive energy intake during the growth period is also crucial to prevent obesity and skeletal developmental disorders especially in large and giant breeds. Feeding kittens is slightly different and less well studied; however, recommendation is to feed them at approximately 3 times their RER until they are approximately 50% of their predicted adult body weight and to then feed them at 2 x their RER until they are at adult status which is around 6 to 7 months of age and to then feed between 1.2 to 1.5 x RER into adulthood (see Fig. 1).

PROTEIN REQUIREMENTS

Protein requirements of growing dogs are highest in 4 to 14 weeks (56.3 g/1000 kcal) and decreased gradually at 14 weeks and older (43.8 g/1000 kcal).[13] Dry commercial foods formulated for puppy growth should provide high-quality protein content of at least 25% dry matter or greater. Adult maintenance diets may provide adequate levels of protein for growing dogs, but energy density (3500–4500 kcal/kg recommended for growth) of the foods and other essential nutrients such as calcium and phosphorus may not be balanced for appropriate growth. Provision of higher protein levels in growing dogs was thought to accelerate growth and contribute to development of skeletal deformities in large and giant breed puppies.[14] Faster growth rate was observed in Great Dane puppies fed higher protein (32% dry matter) compared to 15% dry matter and 23% dry matter, but the difference in protein intake across the groups did not have a deleterious effect on skeletal development.[15]

After weaning, growing kittens have a protein requirement of 56.3 g/1000 kcal throughout their growth, and this reflects their need for particular essential amino acids and nitrogen metabolism. The amount of sulfur-containing amino acids (ie, taurine, methionine) needed is greater in kittens than puppies or other growing animals, and to meet the amino acid requirement, at least 19% of a diet must originate

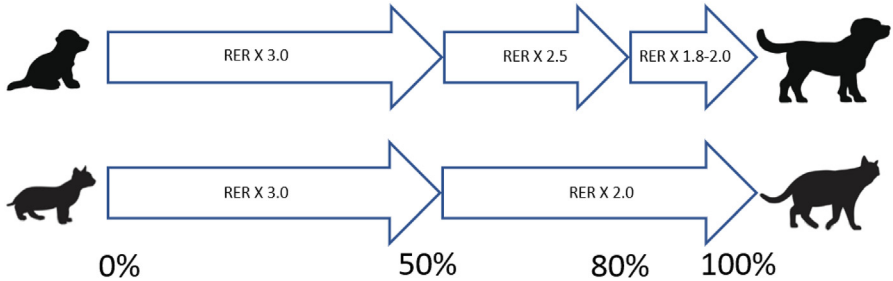

Fig. 1. Initial estimation of daily energy requirements of growing dogs and cats for maintenance and growth.

from animal protein sources for growing kittens; hence, animal-based protein sources are generally used.[16] Arginine is another essential amino acid that is needed in greater quantity in growing kittens, especially when a diet is high in protein content (56% dry matter), to support growth and normal functioning of urea cycle.[17] Optimal protein levels in kitten growth diets are 30% to 36% metabolizable energy calories or 35% to 50% dry matter, in general.[18]

FISH OIL AND DOCOSAHEXAENOIC ACID

Long-chain omega-3 polyunsaturated fatty acids, especially docosahexaenoic acid (DHA, 22:6 n-3), are essential in neural and retinal tissue development in puppies and kittens. This is based on the presence of DHA in the tissues, and dogs and cats have limited ability to convert alpha-linolenic acid (18:3 n-3) to DHA as they mature.[19,20] As prenatal and postnatal DHA supplementation is considered crucial for enhancing neural development and performance, many pet foods formulated for growth and reproduction contain about 0.5% omega-3 fatty acids with omega-6 and omega-3 ratio of 5:1 to 10:1.[21,22] Omega-3 content in the diets can be increased by incorporating omega-3 sources such as marine oils (fish, crustacean, and algal oils high in n-3 fatty acids).[23] Supplementing reproducing female's nutrition with omega-3 during gestation and lactation would have the similar effects for developing fetuses and neonates, as dam's milk becomes enriched with omega-3 fatty acids.[24] When a complete and balanced diet designed for growth or gestation/lactation contains forementioned amount of omega-3 fatty acids and proper omega-6 and omega-3 ratios, additional supplementation of omega-3 is not necessary, yet it should be recognized that this enrichment of DHA should also be in the lactating dam's diet as well as the offspring for optimal development.

OBESITY AND BODY CONDITION SCORE

Diets formulated for growth are higher in fat as energy density of a food is largely determined by fat content. Despite increased nutrient needs during growth, excessive energy intake can result in obesity at an early age. In large or giant breed puppies, the excess food intake involves overconsumption of nutrients such as calcium and can lead to developmental orthopedic problems, since intake of all required nutrients in commercial formulas is increased as energy intake increases.[14] On the other hand, excessive growth rate in kittens does not involve such skeletal or developmental disorders, but obesity can become an issue leading to increased risk for critical feline diseases such as diabetes mellitus and idiopathic hepatic lipidosis.[25] Therefore, regular body condition monitoring of growing puppy and kitten at each veterinary visit is important for determining appropriate energy intake to optimize proper growth of individuals.[26,27] Depending on body condition score, reduction of food intake or portion-controlled feeding is recommended. Switching to a food with a lower energy density (<3500 kcal/kg) seems logical preventing further excessive weight gain in growing animals as long as nutrient intake is still sufficient for growth, particularly in the obesity prone animal.

CALCIUM AND PHOSPHORUS: LARGE BREED CONSIDERATIONS

Growing large and giant breed puppies have special needs with respect to calcium and phosphorus. Contrary to the belief that additional calcium would be helpful for the puppies' skeletal health, use of supplemental amounts of the minerals is of no value and can be deleterious. During their growth from weaning to 6 months of age,

passive absorption of calcium in the small intestine is upregulated, and the calcium absorption is directly proportional to calcium concentrations in their diets. Excessive dietary calcium (>4.5 g/1000 kcal) leading to hypercalcitoninism, which reduces osteoclast activity and interferes with normal bone remodeling, is likely to negatively affect skeletal development (eg, articular cartilage development) and cause the beginnings of clinical signs (shifting lameness, pain on musculoskeletal examination) of osteochondrosis.[28] Several pet food manufacturers have responded to this by formulating large breed puppy formulas with lower amounts of Ca and P per 1000 kcal of diet, and the diets are formulated to contain calcium levels no more than 1.1% (dry matter) and calcium and phosphorus ratio between 1:1 and 1.5:1, with a dietary range of calcium per 1000 kcals of 2.0 to 4.5 g[15,29,30] For large and giant breeds puppies it is very important to examine the nutritional guarantee regarding life-stage feeding to ensure that the product is appropriate for growth of large and giant breed dogs which will be on all appropriate commercial dog foods per AAFCO regulations. Phosphorus intake in skeletal development is not considered as critically important as the calcium intake, but low phosphorus intake in growing dogs led to impaired growth and development of musculoskeletal abnormalities (muscle weakness).[31] Therefore, supply and balance of both essential bone forming minerals are crucial for skeletal health of growing puppies. In mature dogs, passive calcium absorption is downregulated and begins to rely on vitamin D metabolism to regulate calcium absorption and retention which does not seen to occur in puppies; therefore, adult dogs are able to tightly regulate the calcium homeostasis mechanisms even with higher calcium intake.[32] Small and medium canine breeds also possess the same passive calcium absorption pattern during their growth, but probably because of genetic differences in calcium metabolism and slower growth rates, the breeds' skeletal development is unlikely to be impacted by excessive dietary calcium.[33,34]

NUTRITION AND NUTRACEUTICALS: OVULATION AND CONCEPTION

As previously stated, the fact that commercial dog foods approved by AAFCO are replete in vitamins and minerals and are typically approved for all-life stages or gestation and lactation the addition of nutrients is not essential for ovulation or conception. The complete and balanced nature of dog and cat foods are a significant disconnect between human ovulation, conception, and gestation studies where there are sometimes modest benefits supplementing vitamins and minerals due to the incomplete nature of the common western diet.[35,36] There is a paucity of research in companion animals to suggest that vitamin or mineral supplementation can improve fertility of female dogs or cats. In human medicine a majority of nutraceutical (eg, nonessential nutrients and herbals) research involves libido rather than improving conception with considerable research around endocrine disruptors from estrogenic compounds found in soy product.[37,38] In the current dog food market there are less expensive products that still use soy as an ingredient; however, because of client perception it is not utilized in premium products very often and even at levels utilized in less expensive foods, it is unlikely that the ability for dogs to conceive and carry conceptuses to whelping is concerning due to endocrine disruptors in foods. Water contamination particularly when using well water has the potential to be issues that are not within the scope of this review. A recent publication examining dog food formulation suggests that a diet containing additional flaxseed meal (which is known to contain phytoestrogens), fermentable fibers, calcium, and phosphorus may have some utility in improving litter size; however, there were different breeds represented and often larger dogs have increased litter numbers making the data somewhat suspect.[39] Ironically,

as an author (JW), it is commonly reported by breeders that flaxseed may have some anti-conceptus properties that are not founded in the scientific literature, and considering the test diet from the study above had additional flaxseed meal or other ingredients with phytoestrogens as a major addition to the diet negates this theory to some extent, particularly with new evidence in rodent models suggesting that flaxseed phytoestrogens may be beneficial in polycystic ovaries.[39,40] These dietary concerns related to cumulative phytoestrogen exposure in humans are still heavily questioned in the emerging vegetarian trends with no firm conclusions and our pet foods are typically meat rich rather than vegetable and legume heavy and the fact that dam reproductive lifespan is much shorter than human makes this less of a concern.[41]

There is some literature in the human arena suggesting that there are nutraceuticals with equivocal improvements in oocyte quality for women undergoing in vitro fertilization; however, this was not associated with live births. In humans undergoing in vitro fertilization oocyte quality was enhanced modestly by using a supplement that included folic acid, selenium, vitamin E, catechins, glycyrrhizin, diosgenin, damiana, and omega-3-fatty acids; however, in humans the dietary history often reveals modest nutrient deficiency which is not commonly observed in dogs.[35,36,40] In human medicine folic acid is supplemented in many foods and prenatal vitamins to diminish midline defects in fetuses; however, complete and balanced pet foods make this issue irrelevant to canine and feline theriogenology. In addition, the use of herbal nutraceuticals like the ones utilized above are generally considered safe, yet there is little information on the safety of such herbal nutraceuticals in dogs and cats, which should be a first step in understanding toxicity and pharmacology of the active ingredients which can be vastly different between species. Rodent studies, which are a better example of a multiparous species and more relevant to the dog and cat, often use intraperitoneal injection of high concentrations of herbal extracts that bypasses the gastrointestinal system and may not be relevant to oral application of these herbal remedies further distancing some rodent studies from the reality of oral supplementation in dogs and cats. Furthermore, the herbal remedies in meta-analyses often show equivocal improvements in ovulation or litter size and the studies are not rigorously performed suggesting bias in interpretation.[40] In dogs and cats, the study of ovulation and live births is difficult since they are multiparous and there are many confounding factors such as oocyte maturation and release, typical breed differences in live births, and poorly validated research tools to follow ovulation and conception.

Regardless, of these trepidations one herbal remedy worth mentioning is the use of *Foeniculum vulgare seeds (aka* Fennel Seed) that has some evidence in improving lactation and has been used for centuries.[42] It is thought that fennel seed supplementation provides possible estrogenic effects and inhibition of dopamine that is a negative regulator of prolactin release from the specific polyphenolics dianethole and photoanethole, inducing galactogenic effects.[42] The proestrogen effects may also have utility as fennel seed at 2% and 4% of the diet has improved litter size in rats, further proving that this may be a globally beneficial nutraceutical for conception and lactation within limits[43]; however, there are no dog or cat studies to prove that this would be an effective supplement for breeding females.

NUTRITION AND NUTRACEUTICALS FOR SPERMATOGENESIS

Spermatogenesis and dysfunctional sperm production are often related to heritable issues in dogs. When feeding a complete and balanced diet in the normal stud dog, there is no real need to provide supplemental nutrition or nutraceuticals; however, if a veterinary theriogenologist finds issues with sperm production or motility issues

there may be some interesting nutritional supplements and nutraceutical supplements that can be offered. Of course, unlike ovulation the study of spermatogenesis is much easier considering the ease of enumerating sperm, motility, and functional versus dysfunctional sperm. In the human literature specific supplements have been shown to increase sperm count or even improve motility issues including selenium, omega-3 fatty acids eicosapentaenoic acid (EPA) and DHA, coenzyme Q, and carnitine. These data are relatively low in quality with selenium being the universally studied nutrient that has some benefits in humans, but again most human diets are relatively low in selenium due to the poor diet.[44–47] There are a number of herbal and nutritional supplements that may have some utility in human studies, and a few canine studies mentioned below appear to be safe, and are not phytochemicals typically found in commercial dog foods.

A relatively well-designed study in dogs where both control and treatment groups were assessed for semen volume, sperm number, motility, and dysfunctional sperm was performed using a nutritional supplement over 90 days.[48] The dietary supplement was designed to provide vitamin E (1.5 times dietary intake), zinc (1 times dietary intake), folic acid (30 times dietary intake), and selenium (2.5 times dietary intake) at higher intake concentrations than the standardized diet between control and treatment groups. Results showed a decrease in semen volume and an increase in total sperm counts by approximately 2-fold, respectively. Though deemed positive, in these fertile dogs it would be difficult to extrapolate the effects on overall fertility in subfertile dogs, and the lower semen volume may be detrimental to fertilization since the accessory sex gland contributions to semen quality cannot truly be assessed. Though the use of such nutrients cannot be definitively recommended, supplements of the nature at these modest increases are likely safe and may be worthwhile (**Table 2**).

Maca root

Lepidium meyenii is a plant native to the Peruvian Andes region, also known as Latin Ginseng (which may be the reason that Asian Ginseng is thought to be a fertility enhancer), that has been studied extensively for improvements on male fertility.[49] The root and its extract have a range of phytochemicals that are thought to have the medicinal properties beyond just fertility enhancement, and the macerate cooked root can be ingested as a powder or the filtrate can be consumed as a beverage. There is limited data in rodents to suggest the exact dose or phytochemicals involved in increased spermatogenesis, with dosing ranging from 10 mg/kg to 1 g/kg per day with positive results.[50] A study in young bulls using a dose of 233 mg/kg improved semen quality in one study showing interspecies benefits.[49] It should be noted that

Table 2
Potential nutrients and nutraceutical agents to potentially aid in spermatogenesis in dogs

Supplement	Dosing (mg or IU/kg)
L-Carnitine	20–30
Vitamin E (alpha tocopherol – 1 IU = 1 mg)	10
Selenium	0.02–0.05
Folic acid	0.1–0.2
Peruvian Maca root	10–100
Fish oil (25% EPA/DHA formulation)	60–100
Pinus taeda	50
Ashwaghanda root	100

there is no data in dogs and cats and those considering this extract should likely start at lower dosing regimens such as 10 mg/kg and working up from there. A note of caution is that in studies there were discrepancies in results depending on the preparations whether powders or tinctures and modest differences between subspecies plant differences (red, yellow, or black root extracts) and it appears that Peruvian grown extracts may be superior to those grown in Asia.[49]

Ashwagandha

The root of *Withania somnifera*, otherwise known as Ashwagandha root, has been purported to have many different medicinal properties, similar to Maca root.[51] This is a native plant to India and has been termed "Indian Ginseng" by some. Unlike Maca root whose exact actions on spermatogenesis and the exact polyphenols involved remain elusive, Ashwagandha root has 3 major polyphenols that are thought to exert a majority of the pharmacological properties of this plant. A number of rodent studies suggest that doses of 100 to 300 mg/kg of Ashwagandha root extract show 50% plus increases in sperm motility and enhanced sperm counts over 30 to 90 days.[51] Further human clinical assessments in subfertile men suggest that 3 to 5 g a day of Ashwagandha root extract improves sperm counts and motility with 14% improvement in conception rates.[51] There is currently no data on the safety and efficacy of such supplements or the quality of supplements available; hence, utilizing the lowest doses effective in rodent studies above may be the most prudent way forward realizing that this would require approximately 3 g a day for the average Labrador Retriever and more concentrated products are likely to be more cost-effective.

Pinus Taeda

A recent study in dogs was performed over 90 days of supplementation with 50 mg/kg of a hydrolyzed lignin extracted as byproduct waste from the "loblolly pine," which is abundant in the southeastern and southwestern United States.[52] The hydrolysis of these lignans liberates a plethora of polyphenols that may have medicinal properties. This study examined the antioxidant properties in serum samples that was prominent and may have protective properties for spermatogenesis. The mean sperm counts and semen volume were doubled within 90 days of supplementation; however, a significance over 90 days was not found because of the large variation in these parameters across dogs, and motility and viability appear to be no different between the control and treated dogs.[52] Again, these were samples from normally fertile dogs and not from dogs with low or abnormal sperm motility populations giving pause to whether they would be effective, yet this supplement appears to be safe for longer term use allowing for confidence that supplementation is not harmful.

Carnitine

Carnitine is a quaternary amino acid derivative that is important in mitochondrial energy utilization that is essential to normal sperm function. Carnitine is not an essential amino acid and is commonly synthesized in the liver due to its importance in fatty acid metabolism in all organ systems and deficiency is not commonly observed without distinct heritable defects.[53] There is evidence in the human arena that supplementation with carnitine or acylcarnitine has some utility in improving sperm function that cannot be ignored. This provides some nidus for potential supplementation in dogs and possibly cats with dietary carnitine. In human theriogenology tentative recommendation of 2 to 3 g per day are often recommended for spermatogenesis; however, there have been no studies in dogs or cats. A size-based algorithm of approximately 20 to 30 mg/kg body weight can be made as carnitine supplementation does not appear harmful unless

super supplementing with very high amounts which leads to some carnitine reaching the colon that can be metabolized to tri-methylamine dioxide which has been associated with increased risk of chronic disease; hence, moderation is advised.[54]

Eicosapentaenoic Acid and Docosahexaenoic Acid

The long-chain omega-3 fatty acids EPA and DHA are highly important in puppy development and proper nutritional supplementation in the form of marine oils is often found in well-formulated gestational and puppy growth products. There appears to be a relationship between sperm counts and quality of sperm and the presence of EPA and DHA intake in humans, and the human diet is often quite devoid of these marine fatty acids.[47] There is trepidation in making global recommendations regarding fish oil additions to provide a better profile as all dog and cat feeds are different regarding their EPA and DHA levels. Based on the author's opinion, there is little detriment in supplementing marine oils (fish, krill, algae) to dogs, as there are health benefits to these oils regardless of the current diet that is being consumed. Typical recommendations are to supply approximately 25 to 65 mg/kg of EPA/DHA and based on dietary energy requirements if a dog or cat food is formulated with approximately 1% fish oil this recommendation is typically reached.[55] A typical Labrador consuming 300 g of a typical 400 kcal per cup of dog food will get approximately 1 g of EPA/DHA (assuming the fish oil used in the product is around 25%–30% EPA/DHA) per day which translates to around 30 mg/kg on average. If 1 teaspoon per 20 kg body weight of a high-quality marine oil is supplemented, the intake of EPA and DHA would increase by approximately 1200 mg. In a typical well-conditioned 30 kg Labrador (1.5 teaspoons in a 30 kg Lab), the total EPA/DHA intake would be approximately 1800 mg that translates to 60 mg/kg of additional EPA/DHA in the diet. This is a common recommendation for a variety of ailments and may also be beneficial in the male dog with fertility issues.

Nontraditional dietary approaches

The rise in feeding nontraditional diets (raw and cooked home prepared) is growing and may be as high as 20% in the dog owning population.[56] Exactly how these numbers transpire among breeding populations is unknown. There are 2 major concerns around these practices that include the incomplete nature of the diet and the potential for zoonotic pathogen exposure. Survey literature suggests that when providing home prepared diets whether cooked or raw to dogs, approximately 60% or greater will have one or more nutrient deficiencies which have the potential to be catastrophic for the parturient female and potentially for reproductive efficiency.[57] The benefits of home prepared diets are that they are often highly digestible and lead to better fecal quality particularly in the whelping and lactating female where energy demands are high.[58,59] One issue surrounding lactation is that many of the home prepared diets are relatively high in protein and fat and lower in carbohydrate which is antithetical to appropriate milk production and diet need to be relatively high in protein so the mammary tissue can synthesize lactose which is a primary nutrient for the growing puppy and addition of minimally 25% of calories as a carbohydrate source is recommended for appropriate milk production.[60] Similarly, at least 26% protein as dry matter in a typical 4000 kcal/kg diet is necessary in the lactating dam, with cats likely requiring more.[13] To this end for breeders who are using home prepared diet plans it is ideal to get both a veterinary theriogenologist and a veterinary nutritionist involved to ensure the dietary plan can support reproduction and lactation.

The more tenuous debate around home prepared diets is the utilization of raw meats in the diet plan. We always recommend cooking meats to reduce the likelihood of pathogen exposure to the reproducing dog or cat, and carbohydrates require cooking

for optimal digestibility. A recent case report of abortion related to microbial exposure (ie, salmonella) set the tone for discouraging raw feeding to gravid breeding females.[61] The exposure to pathogenic microbial or protozoal contaminants (eg, salmonella, enteropathogenic *Escherichia coli*, toxoplasmosis, *Listeria*, and *Neospora*) has been associated with illness and/or death in some case reports where dogs, particularly puppies or gravid females, have been exposed to raw feeding practices or pre-weaning periods for puppies.[62–67] It is recommended to not employ these practices in gravid dogs and cats and puppies/kittens in particular. If owners are adamant about these feeding practices, they provide these sorts of diets only when dogs and cats are mature (over 6 months of age) and not actively reproducing.

SUMMARY

The complexity of life-stage nutrition surrounding feeding the gravid and lactating female centers around optimizing intake for proper development and ensuring proper caloric intake during the time of high demand. From there, proper weanling growth and bone formation and developmental issues center around ensuring proper muscling with adequate protein and caloric intake, as well as calcium and phosphorus nutrition whose window in very small between excess and deficiency, particularly in the larger and giant breed dogs. It is essential to choose commercial diets whose nutritional guarantee states that these feeds are adequate for large and giant breed dogs ensuring a proper diet for growth minimally for the first 6 months and potentially even longer in giant breed dogs. Feeding breeding males and females is a more simple requisition unless there are issues with spermatogenesis, ovulation, or conception where using safe supplements in an incremental fashion can be tried in an effort to improve conception if necessary; however, there are few studies in subfertile and fertile dogs to support these efforts. As feeding practices have become more diverse over the years, the first and foremost effort should be doing things in a safe and reliable manner to foster success, ensuring that puppies and kittens and their parents remain healthy for years to come.

CLINICS CARE POINTS

- Lactation: Energy demands during lactation will increase approximately 200% to 300% from energy requirements to maintain an average female dog and weight loss may still occur with large litters.
- Lactation and weaning: Often feeding a puppy or kitten food with higher energy density is recommended for the lactating female and for the weaning puppies or kittens.
- Pregnancy: Energy demands for cats begin to increase from the day of conception, whereas dogs do not require energy intake increases (30%–50%) until about 30 days into pregnancy.
- Breeding females: Optimal body condition is ideal for breeding and nutritional supplementation is not necessary if well-balanced nutritionally complete foods are being used.
- Puppy weaning: It is ideal to use puppy foods that are well balanced energy dense and have a calcium to phosphorus ratio of 1:1 to 2:1 and have a calcium content in the window of 2.0 to 4.5 g/1000 kcal.
- Infertility: Nutritional or herbal supplements to improve fertility in males and females is an inexact science and often starting with lower dosing working toward higher dosing is recommended with veterinary-guided health screens to ensure proper organ function when using herbals is warranted.

DISCLOSURE

The authors have nothing to disclose.

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