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Improving Puppy Trainability Through Nutrition

Russ Kelley, MS
Allan J. Lepine, PhD
Research & Development Division
The Iams Company, Lewisburg, Ohio, USA

INTRODUCTION

Every breeder has the desire to produce a litter of healthy puppies that grow and develop to exemplify the characteristics of their breed — the perfect litter. Unfortunately, this task is far easier to describe than to accomplish. There are several factors that influence the outcome of a breeding (reproductive factors) and numerous factors that ultimately influence the pups produced (non-reproductive factors). Reproductive factors include genetics (breed and selection of the dog and bitch), the age, health and maternal ability of the bitch, the size of the litter, and the bitch’s nutritional status. Non-reproductive factors include the environment in which the litter is born, the level and type of socialization that the puppies receive, the home environment, the ability of the owner to teach (train) expected behaviors, and nutritional support. Although nutrition remains important throughout the puppy’s life, it is especially critical during the early developmental windows of puppy growth (pre-, neo-, and post-natal). This manuscript will focus on the impact of maternal and post-weaning nutrition on the puppy’s learning ability with particular emphasis on essential fatty acids.

MATERNAL NUTRITION

Numerous factors have been shown to impact the reproductive process in the canine. Maternal breed, health, age, reproductive history, and nutrition can all impact the outcome of a breeding and influence the health and well-being of the offspring. Historically, the main emphasis for canine nutrition has focused on growth (puppy diets) and adult maintenance with little attention given to more specialized lifestyles and life stages. The more recent approach to canine nutrition is to determine the nutritional needs of specific events and to provide or design diets that meet those needs. A good example of the traditional approach was to transition the bitch onto puppy diet late in pregnancy and maintain on this diet throughout lactation. While this practice is more appropriate than maintaining the bitch on an adult maintenance product, it should be recognized that the bitch is not a puppy. Newer information would suggest that the nutritional requirements for pregnancy and lactation are more similar to the metabolic requirements of a working dog with regards to energy.
Many advances have been made during the past decade with regards to nutritional evaluation. Historically, nutritional minimum requirements for reproduction were based on physical observations such as changes in body weight, litter size, and puppy growth rate. Newer guidelines consider not only these parameters, but also biological observations including maternal blood parameters and serum chemistry profiles. However, it is becoming increasingly evident that additional criteria will need to be evaluated to accurately predict a nutritional value of a diet in supporting reproduction.

Essential Fatty Acids

Nutrients are classified as essential when the body lacks the ability to produce a sufficient quantity to supply the biological need. Nutrients of this classification include amino acids, vitamins, minerals and fatty acids. Essential fatty acids (EFA) are composed of 2 families, the omega-6 (n-6) and omega-3 (n-3) fatty acids. The parental forms of these fatty acid classes are linoleic acid and linolenic acid. Linoleic acid is 18 carbons in length and contains 2 double bonds, with the first double bond occurring at the n-6 position. The common terms for linoleic acid are LA or 18:2n-6. Linolenic acid is also 18 carbons in length, but contains 3 double bonds with the first occurring at the n-3 position. Common terms for linolenic acid are ALA or 18:3n-3.

Both LA and ALA can be converted through desaturation and elongation to other long-chain polyunsaturated fatty acids (LCPUFA). The n-6 pathway results in the production of arachidonic acid (AA; 20:4n-6) while eicosapentaenoic acid (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3) are products from the n-3 pathway. While the n-6 and n-3 metabolic pathways use common desaturation and elongation enzymes, interconversion between these pathways is not possible. Therefore, dietary requirements for the n-6 and n-3 fatty acids must be addressed individually.

Omega-6 fatty acids, specifically LA, have long been recognized as being essential for the canine. Recent findings have suggested that under specific biological conditions, and perhaps under all conditions, n-3 fatty acids are also essential nutrients. Previous findings by The Iams Company have clearly demonstrated positive benefits (inflammation regulation, immune function) of supplying a dietary balance of n-6 and n-3 fatty acids. While these findings do not support classifying n-3 as essential nutrients, a recent series of studies by The Iams Company clearly demonstrate the need to include n-3 fatty acids in diets formulated for selective canine life stages, such as pregnancy and lactation for the adult and early post-weaning growth in the puppy.

EFFECT OF REPRODUCTION ON MATERNAL ESSENTIAL FATTY ACID STATUS

A report by Kelley suggested that bitches maintained on a diet that contained the appropriate level of both n-6 and n-3 fatty acids resulted in increased litter size and decreased stillbirths. A total of 106 female Beagles comprised of 10 nulliparous (0 parity), 80 parity 1–4 bitches, (20 per parity), and 16 parity 5 bitches were used in a subsequent study to further elucidate the relationship between reproductive activity and maternal EFA status. All females were maintained throughout their adult lives on a common diet and were managed under similar conditions.

Findings from the study demonstrated that reproductive activity reduced maternal EFA stores in a linear fashion (Figures 1 and 2). Reductions in both maternal EFA status (Figure 1) and maternal DHA status (Figure 2) were found to be impacted by parity (litter number) and litter size. These findings suggest the possibility that reductions in maternal reproductive performance as parity number increased could be due to reductions in maternal nutrient stores.

To access whether dietary intervention could attenuate reductions in maternal EFA status and reproductive per-

![Figure 1. Effect of parity on maternal essential fatty acid index in the bitch.](image1)

![Figure 2. Effect of parity on maternal red blood cell membrane DHA content.](image2)
formance, a study was undertaken whereby 119 first parity Beagle bitches were evaluated for reproductive performance (litter size) and EFA status. The 60 most similar bitches based on these criteria were assigned to 2 dietary treatments: (1) low n-3 or (2) elevated n-3. Findings from this study demonstrated that maternal EFA status was impacted not only by diet, but also by stage of the reproductive process. This study produced 3 critical findings: (1) while maternal EFA status was influenced by the stage of reproduction, any reduction in maternal EFA status could be minimized (Figure 3) by supplying the appropriate levels of both n-6 and n-3 fatty acids; (2) maternal EFA status, including DHA, could be maintained (Figure 4) across multiple parities; and (3) puppy DHA status (Figure 5) was dependent upon the maternal pre-breeding DHA status and maternal dietary DHA supply.

**BIOLOGICAL ROLES OF DHA**

Docosahexaenoic acid is transferred across the placenta, is present in canine milk, and is accumulated in the brain and retina during fetal and perinatal development. It is also an important structural component of the highly specialized membranes lipids of the human central nervous system. DHA is the major polyunsaturated fatty acid in the outer segments of the retina rods and cones where it can constitute as much as 80% of all the polyunsaturated fatty acids. These membranes are specialized for the rapid transmission of light and contain 90 to 95% of the lipid as phospholipid. The phospholipids contain unusual species in which both acyl groups are DHA. Approximately 10% of the weight of the brain, and 50% of the dry weight, is lipid. About half of this lipid is phospholipid, with approximately 20% cholesterol, 15 to 20% cerebrosides, and smaller amounts of sulphatides and gangliosides.

The phospholipids of brain gray matter contain high proportions of DHA. These usual characteristics of brain and retina phospholipids suggest that specific mechanisms are available to allow the brain and retina to accumulate large amounts of DHA and that DHA has functional roles specific to visual and neural processes. Studies over the last three decades have provided evidence that a deficiency of DHA in the developing retina and brain leads to abnormalities in electroretinogram and visual evoked potential (VEP) responses and learning behaviors.
In recent years, several studies have shown that omega-3 fatty acid deficiency alters the metabolism of dopamine and serotonin in the brain of rodents and young piglets. Particular interest has been given to the dopaminergic system because of the role of dopamine in the cognitive advances of early childhood in humans, as a modulator of attention and motivation, and in the visual pathways.

The effects of DHA on memory formation was evaluated in rats fed a fish oil-deficient diet through three generations. When young (5-week-old) male rats of the third generation were given oral DHA over 10 weeks, the number of errors in reference memory (information that should be retained until the next trial) in performance of a maze test was significantly reduced, without affecting the number of errors in working memory (information that disappears in a short time). These results indicate that DHA supplementation is conducive to the improvement of reference memory-related learning ability. This improvement in reference memory-related learning ability could lead to improved trainability. In rhesus monkeys one of the characteristics of DHA deficiency is reduced learning ability. In another study by the same authors, rhesus monkeys with a severe deficiency of DHA were placed on a diet enriched in fish oil. The DHA content of neural lipids increased from 3.9 to 28.4% over a 12-week period as did performance on learning associated tests.

**EFFECT OF MATERNAL AND POST-WEANING DIETARY DHA IN THE CANINE**

Numerous studies in several species have demonstrated the cognitive benefits of dietary DHA. However, until a recent study by The Iams Company, little attention had been given to DHA and trainability in the canine. These recent efforts examined the effect of supplying various DHA levels in both the maternal (throughout pregnancy and lactation) and puppy (post-weaning) diets. Thus the impact of the treatment was considered to span the entire development of a puppy through 16 weeks of age.

To assess the effect of dietary DHA on puppy trainability, 19 litters were produced across 5 replications to undergo testing in a standard T-maze when the puppies were between 10 and 15 weeks of age. All bitches were sourced from a single Beagle colony and had similar nutritional profiles and reproductive histories. Selected bitches (19) were assigned across 2 dietary treatment groups at breeding and maintained throughout gestation and lactation on their assigned diet. Bitches were fed ad libitum and diet was the exclusive source of nutrition. Thirty-nine puppies from these litters (20 Low DHA and 19 High DHA) were selected from these litters at weaning for trainability assessment through 16 weeks of age.

All puppies were weaned onto and fed their respective maternal diet throughout the duration of the study. All puppies were fed based on energy needs to achieve a normal growth curve. Assessment of red blood cell (RBC) membranes demonstrated that treatments were effective in influencing the DHA status of both the bitch and puppies (nursing and post-weaning; Figure 6). Puppies received one week of training in the T-maze at 9 weeks of age and were then tested twice daily (5 days/week) for 5 weeks. A Success Criterion in the maze was defined as a puppy achieving 8/10 trials correct for 2 consecutive sessions.

A significant (P<0.05) effect of dietary DHA level was
observed with the greatest percentage of puppies (68%) achieving at least one success criterion when fed the High DHA diet compared to the Low DHA group, which produced the fewest successes (30%) (Figure 7). These data demonstrate the importance of dietary lipid sources (fatty acids) on neurological function (trainability) and nutrient status in the canine during critical developmental periods.

CONCLUSION

Genetics and environment are key contributors to the development of the puppy and ultimately determine the characteristics that will be predominant as an adult. Environment can be continually modified (for better or worse) throughout growth and development, however, genetic potential is fixed at the time of breeding. Traditionally, nutrition has been considered as important relative to the supplying of necessary building blocks for organ and system growth. Clearly this remains vitally important; however, it is becoming increasingly evident that nutrition can also significantly impact the achievement of genetic potential in the puppy in ways not previously appreciated. Such is the case with increased puppy trainability with appropriate dietary concentrations of DHA. Improving trainability can strengthen the owner-companion animal bond and increase the likelihood of a successful integration of the pet into the human household. This clearly points to the importance of continuing to expand nutritional horizons beyond the current dogma and identify opportunities to fulfill the puppy’s genetic potential through optimal nutritional support. Through these efforts the puppy will have the greatest opportunity to become the “perfect puppy.”

REFERENCES