THE EFFECT OF NUTRITION ON FELINE REPRODUCTION

R.L. Kelley, M.S.

Introduction

There is little doubt that nutrition plays an important role in feline reproduction. Unfortunately, the majority of the current knowledge surrounding nutrition and feline reproduction is based on deficiency models. While this knowledge has aided in improving the composition of feline diets, there have been few efforts to go beyond defining sufficient nutrient requirements. This is most likely due to the difficulty of defining optimal nutrient levels. Genetics, nutrient and/or nutrient source interactions, along with numerous environmental factors present significant challenges in attempts to define how specific nutrients or the level of a specific nutrient can impact the feline reproductive process. The remainder of this paper will highlight some of the current knowledge of how nutrition can impact the feline during the reproductive process.

Nutrient Requirements

The vast majority of domestic cats are fed some form of a commercially prepared diet. However there are numerous brands, forms and flavors available, which can make the decision of selecting a diet for the breeding animal confusing. The table below highlights the nutrient level guidelines established by the Association of American Feed Control Officials (AAFCO) for growth and reproduction compared to adult maintenance. Any diet fed to a pregnant or lactating queen should at least meet these requirements, however this does not assure that this profile will fully meet the needs of the queen. These requirements have only been shown to be sufficient for reproduction and do not imply optimal levels. Collins (1987) concluded that the stress associated with reproduction would manifest even the smallest of nutrient inadequacies in diets assumed to be complete. These dietary inadequacies may not be severe enough to inhibit the queen from reproducing, however they most likely will prevent her from performing at her genetic potential. The goal of every caretaker should be to supply a diet that allows the queen to produce a litter of healthy kittens reflective of the breedings' genetics while minimizing the impact on the queens' health and nutrient status. In other words, to wean a litter of healthy kittens in much the same physical condition as she was prior to breeding.

AAFCO Cat Food Nutrient Profiles Based on Dry Matter*

Nutrient	Units DM Basis	Growth and Reproduction Minimum[t]	Adult Maintenance Minimum	Maximum
Crude Protein	%	30.0	26.0	
Arginine	%	**1.25**	1.04	
Histidine	%	0.31	0.31	
Isoleucine	%	0.52	0.52	
Leucine	%	1.25	1.25	
Lysine	%	**1.20**	0.83	
Methionine-cystine	%	1.10	1.10	
Methionine	%	0.62	0.62	1.5
Phenylalanine-tyrosine	%	0.88	0.88	
Phenylalanine	%	0.42	0.42	
Threonine	%	0.73	0.73	
Tryptophan	%	**0.25**	0.16	
Valine	%	0.62	0.62	
Taurine (extruded)	%	0.10	0.10	
Taurine (canned)	%	0.20	0.20	
Crude Fat	%	9.0	9.0	
Linoleic Acid	%	0.5	0.5	
Arachidonic Acid	%	0.2	0.2	
Minerals				
Calcium	%	**1.0**	0.6	
Phosphorus	%	**0.8**	0.5	
Copper (extruded)	mg/kg	**15**	5	
Copper (canned)	mg/kg	5	5	
Zinc	mg/kg	75	75	2000
Vitamins				
Vitamin A	IU/kg	**9000**	5000	750000
Vitamin D		**750**	500	10000
Vitamin E		30	30	

*based on values published in the 2003 Official Publication of the Association of American Feed Control Officials.

[t]Bold values denote change from adult maintenance values.

General Reproductive Characteristics

Several reports and reviews have been published on the reproductive characteristics of the domestic queen. The vast majority of these studies address general reproductive parameters such as litter size and kitten survivability. In addition, numerous studies have been published on the effects of various nutrient deficiencies and feline reproduction. This chapter will briefly highlight some of the known influences on reproductive performance in the queen, including nutrition.

ConceptionRate: Reported conception rates in the queen are highly variable. Some of the variation is probably due to differences in how the number is calculated. Some studies report conception rate based on the percentage of matings producing a pregnancy while others base the number on the percentage of queens giving birth. Considering both methodologies, an accepted range would be from 65 to 85% with an overall average in the mid-70s.

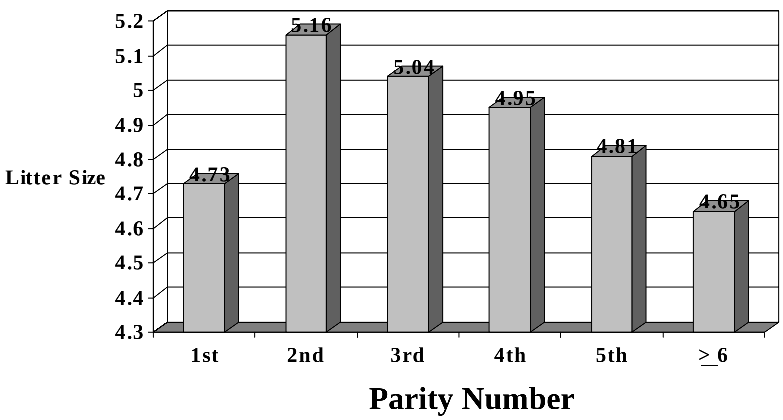
Several studies have identified nutritional influences on conception rate. Efforts by several groups, including Sturman as well as Morris and Rogers have established that dietary taurine is essential for the queen. A common observation in taurine deficient queens is reduced conception rate along with other reproductive problems (Sturman, 1986; Dieter, 1993). With regard to other nutrients, Fascetti (1998) reported that conception in the queen is influenced by dietary copper source. In this study, queens receiving their copper in the form of copper oxide had significantly lower pregnancy rates when compared to queens receiving a copper sulfate form. Collaborative efforts by The Iams Company have observed mild reductions in conception rates in queens fed diets containing less than 14% dietary fat (DM basis), even though the diets meet all of the AAFCO requirements for growth and reproduction.

Gestation Length: Gestation length for the domestic queen is reported to range from 63 to 67 days post breeding. There are conflicting reports that gestation length is affected by the litter size. Laliberte (1986) reported that gestation length was reduced with larger litters while Root (1995) failed to detect a correlation between gestation length and litter size. Data from personal efforts would support published literature with an average gestation length of 65.6 days (180+ litters). Similar to Laliberte (1986), we to have observed a numerical reduction in average gestation length in queens carrying larger litters, particularly for litters of 6 or more kittens.

Litter Size: The typical litter size for the domestic queen ranges from 3 to 5 kittens. Internal data (not published) would support the upper end of this range with an average litter size of 4.94 kittens (500 litters). In this retrospective study, litter size ranged from 1 to 9 kittens with half the litters containing 4 or 5 kittens. Additional findings from this study suggest that parity number influences litter size. Queens were found to produce their largest litters during their 2nd parity and then numerically decline thereafter with significant reductions beyond the 4th parity (Figure 1). In other efforts, while not as dramatic, support this observation (see litter size number relative to parity in Figure 4).

Maternal nutrition has also been found to influence litter size. Olovson (1986) reported that colony litter size was increased from 4.5 to 5.5 kittens during a period where dietary fat was increased from 15 to 27% on a dry matter basis. Jayawickrama (1998) observed similar results when comparing queens fed diets containing either 23% or 10% fat. In addition, past efforts by The Iams Company comparing 2 commercially available kitten formulas (both diets recommended for gestation & lactation) observed

Figure 1.Effect of Queen Parity Number on Litter Size



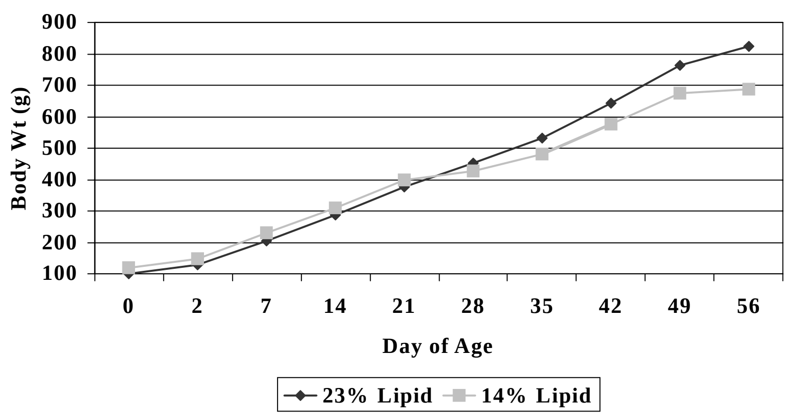
significantly larger litters (5.4 vs 3) in queens fed more caloric dense diet. While this study did not address any specific nutrient or nutrient class, dietary fat was one of the most dramatic differences between the 2 formulas (23 vs 14%). It is also plausible, based on work by Sturman (1991 & 1992), that the difference was partially due to higher dietary taurine level (0.35 vs 0.16%) in the higher density formula. Unfortunately, in studies where multiple differences exist in dietary treatments, it is impossible to identify a specific nutrient influence.

Birth Weight: Generally speaking, the vast majority of kittens that survive to weaning have birth weights ranging from 95 to 125 grams. While this range would be considered typical, a more accurate range would be much wider with a lower end in the 60s and the upper end in the 150-gram range. As with most population characteristics, the extremes are observed only in a few individuals. When compiled, collaborative efforts by The Iams Company result in an average birth weight of 116 grams per kitten. As with many litter bearing species, one of the largest influences on birth weight is litter size. In most cases, birth weight tends to be reduced in larger litters and increased in smaller litters. Nutritionally, dietary taurine and arachidonic acid (AA) have clearly been identified as influencing birth weight, along with other reproductive parameters with deficiencies in either nutrient resulting in reduced birth weights.

Weaning Weight: Kitten weaning weight is highly variable and is influenced by numerous factors, including genetics (gender and growth potential), litter size, weaning age and maternal nutrition. Overall, kitten weight at weaning will range from 400 to 900 grams with an average of around 650 grams with males being slightly heavier than females. Husbandry practices vary from breeder to breeder with regard to weaning age. Generally, kittens are weaned from 6 to 8 weeks of age. As one would expect, kittens weaned at 8 weeks of age will be heavier than at 6 weeks, provided that all other factors (litter size, maternal nutrition) are somewhat equal.

Nutritionally, several nutrients can influence weaning weight. As with other parameters, a deficiency in taurine or AA can result in reduced weaning weight. While taurine and AA are probably the most documented nutrients effecting reproductive performance, including weaning weight, in the queen, there are other nutrient influences. Recent efforts (Jayawickrama, 2003) have demonstrated that maternal dietary fat level influences kitten weight with queens fed a diet with $\geq$ 16% lipids having greater milk production when compared to queens fed a diet with 9% lipid. Previous efforts by The Iams Company (data on file) would support the finding by Jayawickrama. In the previously mentioned study comparing 2 commercial formulas, kittens reared by queens fed the more caloric dense diet (23% lipid) were significantly ($P < 0.05$) heavier than kittens from queens fed the other formula (14% lipid). In this study, kitten growth was similar through the first 3 weeks of age with increasing differences between groups observed through weaning at 8 weeks (Figure 2).

Figure 2. Effect of Maternal Diet on Body Weight of Nursing Kittens



Maternal Nutrient Status:

Discussions on feline reproduction are often limited to issues addressing reproductive performance (litter size, number of litter per year, weaning weight). However, there are other parameters that need to be considered, such as the health and nutrient status of the queen. The reproductive process is one the most metabolic demanding periods that the queen will experience as an adult. Much as an umbrella protects us during a rainstorm, proper nutrition will help protect the queen and her progeny from the various metabolic and environmental stresses that will occur during the pregnancy and lactation periods. During the reproductive process, a queen’s diet must support three areas: 1) body maintenance, 2) growth of her reproductive tissues, and 3) growth and development of her offspring. However, the requirement and nutrient priority is not equal between the areas. Once the queen has undergone maternal recognition of pregnancy, the developing offspring will have the highest nutrient priority followed by her reproductive tissues, with her body's maintenance having the lowest priority. A key component to remember is that unlike the queen, the developing offspring have 2 sources of nutrients, the queen’s diet and the queen’s body. Should the queen’s diet fail to meet the required nutrient levels, the queen will respond by sacrificing her body's maintenance and mobilize nutrients from her body's fat, muscle and skeletal tissue for the developing offspring and reproductive tissues (Nutrient Depletion). In extreme cases, her only solution may be to reduce the demand by decreasing the number of offspring or abort the pregnancy all together. To what extent the queen is able to offset the nutrient shortfall remains unclear. However, since deficiencies in maternal nutrition are known to impact the offspring, it is critical that all attempts be made to supply optimal nutrition to the queen.

One of the most common examples of nutrient depletion is the reduction of body fat by the queen during lactation. In this case, the impact of the reduction may be minimal, as the queen has hopefully deposited additional body fat during pregnancy. Generally, most queens will wean their litter possessing around 90% of the pre-breeding fat mass. However, some queens when supplied insufficient nutrition may lose as much as 40% of the pre-breeding status. In a study by The Iams Company comparing 2 commercial kitten formulas (36% protein – 23% fat vs 36% protein – 14% fat), body composition was estimated via DEXA prior to breeding and weeks 1, 4 and 8 of lactation. Relative to their pre-breeding status, queens fed the 36-23% matrix completed the reproductive process with 102 $\pm$ 5.2% of the pre-breeding fat mass. In contrast, the queens fed the 36-14% matrix retained only 73% of their pre-breeding fat mass (Figure 3). This is even more profound considering that the 36-14% queens had significantly smaller litters (5.2 vs 3.0).

Another common, although not well documented, example of nutrient depletion is the essential fatty acids (EFA). The first evidence of EFA maternal depletion can be obtained from efforts by Rivers, Sinclair and Crawford when addressing the inability of the cat to utilize linoleic acid (18:2n-6) to form arachidonic acid (20:4n-6), which is now recognized as an essential nutrient for the cat (MacDonald, Rogers and Morris, 1984). During a series of experiments, queens fed diets containing only linoleic acid, the parental EFA of the omega 6 family, were only able to successfully reproduce for 2 litters. It is likely that the arachidonic acid (AA) status of these queens was being slowly reduced as they mobilized body stores for the kittens and had reached levels after 2 litters incapable of supporting reproduction.. Efforts by The Iams Company support the likelihood of this suggestion. One hundred and twelve queens of various parity number (1-6), managed under identical conditions for their entire adult lives, were evaluated to determine the effect of reproduction on maternal EFA status ($\sum$n6+n3 FA/$\sum$n7+n9 FA). In addition, 20 virgin adult females (0 parity) were utilized as a control group. When compared to the control group, all reproductively active queens were found to have reduced EFA status as well as reduced AA levels in RBC membranes. Reductions for EFA status and AA were affected by both parity number (Figure 4) and litter size. It should be noted that in this study, all animals were fed a diet that contained at least 0.05% AA.

Figure 3. Effect of Diet on Maternal Fat Stores During Lactation Relative to Pre-Breeding

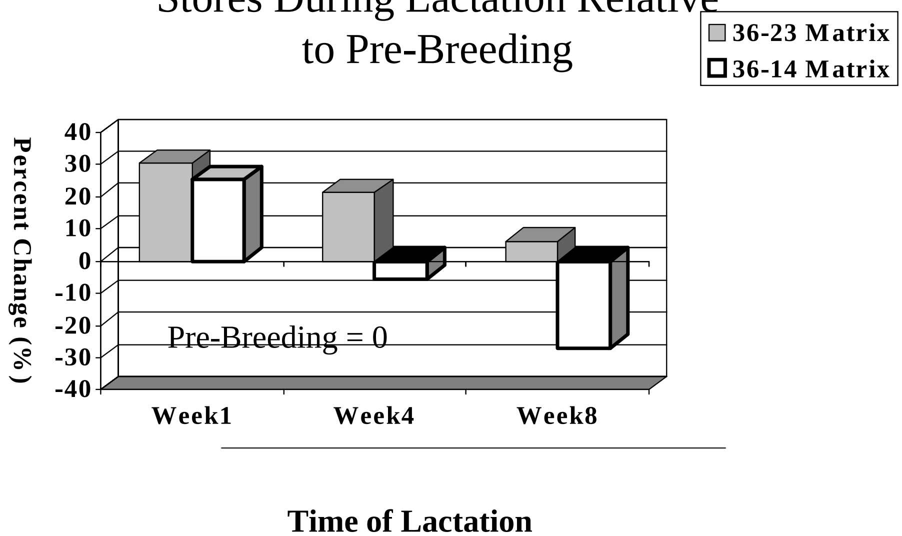
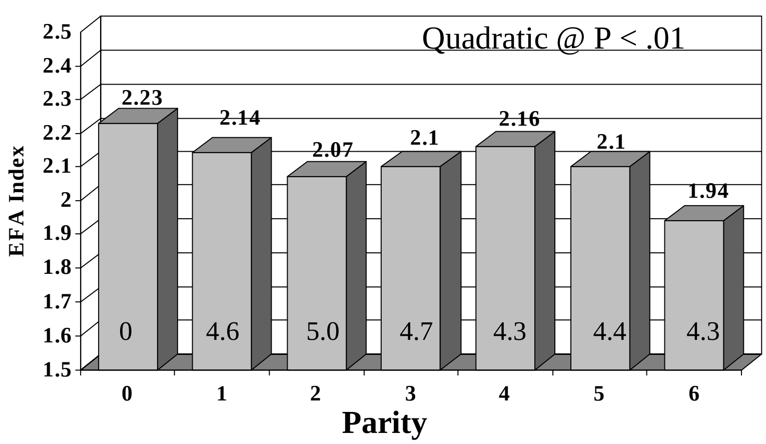


Figure 4. Effect of Parity on Feline Maternal EFA Status



Numbers at lower portion of bars denote average litter size at sample collection

Conclusions

Few would argue the importance of maternal nutrition during reproduction. Unfortunately, it remains impossible to define "optimal nutrition" for the queen during pregnancy and lactation given the current knowledge base. Presently there are numerous commercial formulas available that are nutritionally sufficient to support the queen and her kittens. While promising this does not guarantee that the queen will perform at her genetic potential or ensure that the health and nutrient status of the queen and her kittens will not be compromised. Thus, what recommendations should be given to the breeder? First and foremost, encourage the breeder to obtain a complete and balanced formula that has been proven through animal feedings to support reproduction from a reputable company. In general, the diet should contain at least 32% high quality protein and 18% fat. While nutrition is only one component of queen management, it is one of the most (if not the most) important. Thus by providing the proper nutrition, the breeder has taken a great step forward in achieving a successful breeding program.

References:

Available upon request at kelley.rl@pg.com