

## Food Intake and Nutrition During Pregnancy, Lactation and Weaning in the Dam and Offspring

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### Contents

In mammalian species, the connection between reproduction and nutrition is undeniable and illustrated by numerous publications: its role concerning regulation of hormonal secretions, fertility, pregnancy outcome, lactation and neonatal development indeed retains the attention of the scientific community. The interest on the influence of nutrition in dog and cat reproductive physiology is growing. Awareness on the key aspects of feeding during critical periods like pregnancy, lactation and weaning is essential to optimize the reproductive performances in these species.

### Introduction

Many aspects of the canine and feline reproductive function remain to be fully understood. This is certainly the case when considering its connection with nutrition. Interactions between these two functions are indeed undeniable. In farm animals and humans, glucose deprivation directly affects luteinizing hormone (LH) pulsatility, while secretions of other hormones like leptin, kisspeptin, thyroid hormones and insulin growth factor 1 (IGF-1), which play a major role in the reproductive function, are influenced by nutrition (Martin et al. 2008). The interaction between these two functions becomes especially critical during pregnancy and lactation, as well as during early growth in neonates. During these essential life stages, nutrition will indeed fuel these following high-energy consuming processes: embryonic/foetal growth, milk secretion and neonatal growth. In farm animals, all these different aspects and their potential consequences are largely described, while the corresponding literature is rather scarce when referring to dogs and cats. Fortunately, more and more attention is paid to the importance of nutrition in reproductive function in companion animals. In this study, nutritional requirements of pregnant and lactating dogs and cats as well as their neonates (before and during weaning) will be reviewed in details.

### Food intake during pregnancy in dogs and cats

#### Pregnancy differences between dogs and cats

Despite the fact that pregnancy lengths in dogs and cats are almost similar ( $63 \pm 1$  days in dogs vs  $65 \pm 1$  days in cats) when counted from ovulation, the way they should be fed during this period strictly differ. Indeed, pregnancy in dogs can be divided in two distinct phases. More than 70% of the foetal growth will occur after the first 5 weeks of pregnancy, and weight gain is usually minimal before 40 days after its start (Moser 1992; Malandain 2006). During the last 3–4 weeks of gesta-

tion in bitches, the foetuses will grow rapidly, leading to a body weight increase of 15–25%. The situation is radically different in queens, where weight gain occurs in a linear way as soon as pregnancy is established (Malandain 2006; Wichert et al. 2009) and queens will typically gain up to 38% of their pre-pregnancy body weight until the end of gestation (Root Kustritz 2006). Another difference between dogs and cats is apparent right after parturition. The bitch may return to her pre-breeding weight just after delivery; whereas queens are still 19–26% above their pre-breeding body weight (Loveridge and Rivers 1989). This difference is related to an early fat deposition during the first month of gestation because the queens are usually not able to cover the high energy requirements during lactation (Malandain 2006). As a matter of fact, these differences have to be considered when it comes to defining the most appropriate feeding management (Fig. 1).

#### Key elements of feeding management

The diet fed to the pregnant animal must at least follow the minimal recommendations of the Association of American Feed Control Officials (AAFCO, i.e. for dogs: 22% proteins, 8% fat, 1% calcium and 0.8% phosphorus; for cats: 30% proteins, 9% fat, 1% calcium and 0.8% phosphorus). In bitches, the energy requirements will increase to 1.25- to 1.5-fold maintenance after the 40th day of gestation. Several meals daily are generally recommended because of the abdominal distension caused by the gravid uterus (Greco 2008). In the queen, this increase starts in the beginning of pregnancy and can be estimated around 10% a week, with a tendency to slow down during the last week of gestation. At the end of gestation, the queen should be receiving 25–50% more energy than her maintenance needs. A diet containing at least 4000 kcal ME (metabolizable energy)/kg dry matter (DM) is usually recommended for the whole gestation in cats, and after the 42nd day of gestation in dogs (Malandain 2006). Feeding commercial balanced diets is the most frequently chosen option because these diets do not require any kind of supplementation. Specific nutrients were proved to be of interest when feeding the pregnant animals. In canines, the role of folic acid has been outlined to lower the impact of cleft palates in brachycephalic breeds (Elwood and Colquhoun 1997). Daily supplementation of the bitches with 5-mg folic acid reduces the incidence of cleft palates in newborn puppies from 9.3% to 4.8% (Malandain 2006). It is essential that folic acid supplementation is initiated as soon as the bitch comes in oestrus, since the medullary tube closes during the first

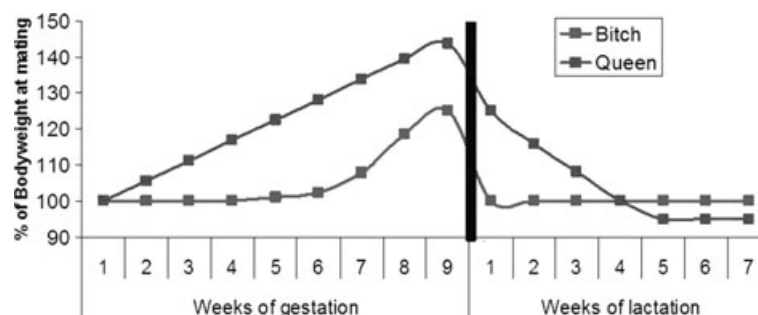


Fig 1. Changes in bodyweight during pregnancy and lactation in bitches and queens

part of gestation. In cats, the amount of taurine in the diet is of the utmost importance. A secondary deficiency in this feline essential amino acid results in early embryonic resorptions (before day 25 of gestation) that could be explained by a specific uptake of taurine by the feline placenta during gestation. Early embryonic losses are observed when taurine levels in the diet are between 0.02% and 0.05%. Higher dietary taurine levels allow for normal reproduction. In most cases with commercially manufactured cat food, the amount of taurine in the diet is sufficient to allow for normal reproduction. However, if the diet is home-made, the level of taurine should be evaluated in all cases of reproductive disorders (Malandain 2006). Supplementing the diet with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) during gestation and lactation has been proven to be beneficial in puppies and kittens (Pawlosky et al. 1997). Kittens and puppies whose dams were supplemented with EPA and DHA had improved learning ability, memory and vision (Heinemann et al. 2005; Greco 2008).

#### Pregnancy-associated diseases related to inappropriate nutrition

Only animals that are in optimal body condition should be bred. Indeed, the endocrine role played by fat tissue and its interactions with the reproductive function are now clearly outlined. In obese women, modified leptin secretion – an hormone secreted by adipose tissue and directly influencing the hypothalamic hormonal secretions – was correlated with low-quality embryos during *in vitro* fertilization procedures (Brannian et al. 2001). Such action of the canine or feline reproductive axis remains to be demonstrated, but this hypothesis is worth being considered because obese dogs do exhibit modified plasma leptin concentrations (Ishioka et al. 2007). Overfeeding pregnant animals is also something commonly observed, particularly in dogs. Many owners believe that high amounts of energy are required from the very beginning of gestation. This excess feeding tends to result in an increase in fat deposition. Unfortunately, these overweight bitches are more prone to have a dystocia (Fontaine et al. 2007). This may be a result of a decrease in the strength of their uterine contractions following myometrial fat tissue infiltration, as described in humans (Zhang et al. 2007). Weight of the bitches should therefore be monitored throughout pregnancy, and most of the authors recommend that it should not exceed 25–30% of the pre-breeding weight (Malandain

2006). Monitoring food intake during pregnancy is also important. Pregnancy toxemia that occurs in pregnant dogs is indeed associated with a relative lack of carbohydrates or alteration in carbohydrate metabolism (Fall et al. 2008; Armenise et al. 2011). A ketotic state usually develops during late gestation in bitches with inadequate nutrition or in those who cannot consume enough carbohydrates to meet energy demands. A sustained anorexia during the last 2 weeks of pregnancy requires immediate veterinary attention.

#### Food intake during lactation in dogs and cats

##### General feeding management

Lactation lasts approximately 7–8 weeks in dogs and cats, with a peak milk production.

Three to four weeks after parturition (Case et al. 2011). The amount of milk produced depends upon many factors (e.g. litter size). For example, German shepherd bitches can produce up to 1.7 kg of milk/day at peak lactation (Moser 1992). A high amount of energy is required to sustain this physiological process. On average, bitches and queens will consume 1–1.5 times their maintenance energy requirements during the first week of lactation, two times maintenance during the 2nd week, and 2.5–3 times maintenance during the 3rd and 4th week post-partum. In dogs, early studies reported that bitches with four puppies fed diets containing approximately 4200 kcal ME/kg DM had little or no weight loss during the entire period of lactation, while bitches fed a lower-energy-density diet (3100 kcal/kg) lost weight (Case et al. 2011). In queens, daily energy requirements vary from 250 to 354 kcal ME/kg body weight (BW, Wichert et al. 2009). The most convenient way to reach these nutritional requirements is to offer free-choice feeding of with a highly digestible nutrient-dense diet (e.g. diets formulated for growth or performance). In addition, as milk is comprised of 78% water, the dam's water requirement increases drastically during lactation. Water should always be offered *ad libitum*.

##### Nutrients influencing lactation

The diet fed during lactation will definitely impact the quality of the dam's milk. For instance, the level of fat and the quantity of essential fatty acids influence the quality and quantity of fat in the milk during the lactation phase (Malandain 2006). When a balanced diet is fed, milk quality is generally not a concern. However,

it is not an unusual practice for dog and cat breeders to supplement the diets of their females during gestation and lactation, especially with calcium (e.g. mineral supplements, dairy products). Adding this mineral is believed to ensure healthy foetal development and adequate milk production. However, calcium homeostasis is tightly regulated by hormones like parathyroid hormone (PTH) and calcitonin. When serum calcium concentration decreases, PTH promotes calcium liberation from the bones and increases the efficiency of calcium absorption in the small intestine. However, when the animal is supplemented, serum calcium concentration remains high, resulting in down-regulation of PTH activity. The female can no longer respond to the high demands for calcium mobilization occurring with the onset of lactation, increasing the risk of developing eclampsia. Eclampsia is a common post-partum condition small and toy breeds. Clinical signs of eclampsia include ataxia, muscular tetany and convulsive seizures. Even animals that respond to treatment with intravenous calcium should have their offspring removed to prevent relapse (Greco 2008).

## Food intake during lactation in puppies and kittens

### Importance of colostrum

Colostrum is the first milk produced by the mother. In dogs and cats, an important role of colostrum is to transfer immune protection to the newborn animals. During their first weeks of life, the immune system on newborn animals mainly relies on the antibodies passively transferred through the dam's colostrum. Colostrum is only produced during the first 24 h after parturition, with a peak in antibody concentration 8 h after parturition. The intestinal absorption of these antibodies in puppies and kittens is only possible during their first 24 h of life as well. Without this passive immune transmission, puppies and kittens may not be able to fight off an infection. If a newborn is unable to receive any colostrum (i.e. death of the mother, agalactia), then a colostrum substitute should be given. Unlike in horses and cattle, there are no artificial colostrum products available for dogs and cats that possess the same immune properties. If a foster mother is available, this is the best option, but this option is generally difficult to use except in large breeding facilities. Breeders should be encouraged to collect and store colostrum post-partum so they can administer it if needed. Colostrum can be stored at  $-20^{\circ}\text{C}$  for up to 6 months. The use of adult serum is also an acceptable alternative (Poffenbarger et al. 1991). Whichever colostrum substitute is chosen, it is recommended to administer 3 ml/100 g orally to newborns (Munnich A, personal communication). In cats, it is of the utmost importance to consider the blood group of the mother/adult used before feeding the neonates because of the risk of neonatal isoerythrolysis. This condition results from a blood group incompatibility between individuals from the [B] and [A] blood types. Blood type [B] individuals produce antibodies against type [A] red blood cells.

### Feeding regimen for neonates

In addition to the immunological benefits of the colostrum, the volume of fluid ingested immediately after birth contributes significantly to post-natal circulating volume, and a lack of adequate fluid intake shortly after birth can result in circulatory failure in newborns. For this reason, the continuous ingestion of adequate fluids by the neonates and the production of sufficient milk volume by the mother are as important as the milk's content. During the first few weeks, the food intake is mainly limited by the stomach volume. Most newborn puppies can handle only 10–20 ml of milk per feeding. Kittens are able to handle approximately  $\frac{1}{2}$  to  $\frac{1}{3}$  of this amount. Puppies and kittens are usually suckling at will (Case et al. 2011). A decrease in milk production and quality will also directly affect the neonates as it is their only source of energy and nutrients during their first weeks of life. To monitor adequate milk intake during this period, the best method remains to weight the newborns on a daily basis. A 10% weight loss might sometimes be encountered after birth, but then neonates should grow on a regular basis. When any stagnation or loss of weight is detected, and after ruling out that there is no underlying problem, bottle feeding or tube feeding is required.

### Using milk replacers in canine and feline neonates

Before feeding a neonate, it is important to ensure that the neonate has an optimal body temperature (approximately  $36^{\circ}\text{C}$ ). At a body temperature below  $34^{\circ}\text{C}$  internal temperature, intestinal peristalsis will be disrupted. At a body temperature below  $32^{\circ}\text{C}$ , the suckling reflex will also disappear. In these cases, warming will therefore be the first mandatory prerequisite. The quality of the milk replacer fed is also of great importance. A milk replacer will nourish the puppies and kittens for the first weeks of life until their digestive and metabolic functions develop to the point at which semi-solid food can be introduced. Feeding a formula that differs in composition from the species' natural milk can result in diarrhoea and digestive upsets and has the potential to compromise growth and development. Several commercially produced canine and feline milk replacers are commercially available. Most of these products are composed of cow's milk that has been modified to approach the composition of the bitch's and queen's milk. These milk replacers therefore strictly differ from ruminant milks (like cow's and goat's milk), which were proposed in the past as valuable solutions to use in puppies and kittens. Dedicated canine and feline milk replacers have higher energy content and a lower proportion of lactose than the milk of ruminant species. Concerning puppies, the milk replacer should have a caloric value of 1400–1800 kcal ME/L, a concentration similar to the bitch's milk. Queen's milk has a caloric density of approximately 850–1600 kcal ME/L. A general accepted guideline suggests that during the first 3 weeks of life, puppies and kittens need to receive between 130–150 kcal ME/kg BW per day. After 4 weeks, caloric needs increase to 200–220 kcal ME/kg BW. When bottle feeding, 8–12 meals per day (every 2–

3 h) are usually required during the 1st week of life, then the number of meals can be decreased to 5–6 (every 4 h) during the 2nd week and 4–5 during the 3rd week (every 6 h, Case et al. 2011). When bottle feeding, neonates usually drink *ad libitum*, but when tube feeding them, it is recommended to administer 1–5 ml of milk/100 g per meal.

## Food intake during weaning in puppies and kittens

### Feeding regimen during weaning in puppies and kittens

After 4 weeks, milk alone no longer provides enough energy and nutrients to sustain the growth of the neonates, and therefore, the transition to solid food has to start. Weaning is usually conducted around 4–5 weeks, but in orphaned puppies/kittens, it can be as early as 3 weeks of age. Dry food can be mixed with water and/or milk replacer in a ratio of 1 : 3 to form gruel. If canned food is preferred, a 2 : 1 ratio can be made. At first, little of the semi-solid gruel will be consumed, and the litter's major food source will continue to be the dam's milk. However, by 5 weeks of age, puppies and kittens are readily consuming semi-solid food. As the deciduous teeth erupt between 21 and 35 days after birth, puppies and kittens are able to chew and consume dry food by 5–6 weeks of age. Nutritional weaning is usually completed by 6 weeks of age, although some bitches and queens might allow their young to nurse for 8 weeks of age or longer. As stated before, during this period, caloric needs are about 200–220 kcal ME/kg BW for kittens and puppies.

### Risks associated with weaning and how nutrition can help

The food transition at weaning usually generates stress, with diarrhoea as the main clinical symptom. Because weaning also corresponds to a period of an immunological gap, the impact of digestive pathogens (e.g. parvovirus, coronavirus, *Trichomonas* sp.) might be enhanced. The feeding plan should be accurately managed in order to decrease as much as possible this potential predisposing factor. Recent research showed that more meals/day increases the faecal quality in puppies (Grellet et al. 2012). Therefore, 4 meals/day should be given to minimize the impact of weaning on digestive stress (Grellet et al. 2012). The addition of specific nutrients was also used to enhance the immune function through the addition of antioxidants or probiotics (Benyacoub et al. 2003). Puppies receiving these supplements were proved to have an increased immune response when being vaccinated against distemper and parvo viruses (Greco 2008).

### Conclusion

Adequate food intake is mandatory through pregnancy, lactation and during the early growth stages. Any mistake (inappropriate energy levels or supplementation) can lead to detrimental consequences in the considered individuals. In order to optimize the reproductive performances in canines and felines, these aspects have therefore to be considered carefully.

### Conflicts of interest

The author confirms he has no conflicts of interest in relation to this work.

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**Submitted: 6 Jun 2012; Accepted: 4 Jul 2012**

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