Maximizing litter size in the bitch

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Introduction

When we plan to breed a bitch, one of our main goals is to maximize litter size. Having large litters provides several functions: 1) ensures that there will be enough stimulus from the fetuses to initiate labor; 2) increases the genetic diversity of the litter; 3) helps controls fetal size; 4) maximizes the choice of puppies for clients and breeders; 5) increases socialization activity among the puppies. In order to increase reproductive efficiency we must understand the factors we can influence and those that are predetermined. By making proper choices, veterinarians and breeders can improve their litter statistics.

Keywords: Dog, litter size, breeding, ovulation, pregnancy

Breed

Small breed dogs tend to have smaller litters than large breed dogs, while the giant and large breed dogs tend to have the largest litters. The American Kennel Club (AKC) evaluated litter size from their 15 most popular breed registrations over a three year period and the results are reported in Table 1.

Genetics

Some bloodlines are more prolific than others. In any given breed, there are lines that tend to produce at the high end of the litter size range while others produce at the low end of the range. This likely has to do with ovulation rate more than uterine capacity, since most bitches of similar breed have similar sized uteri. There is a genetic component to pathology of the bitch's uterus as well, with some lines and breeds developing inflammation, scarring and related changes at much earlier ages then others.

There may be a genetic component to the male's fertility as well, although the impact on litter size is not clear. One common example of genetics and infertility in the male is immune mediated orchitis and epididymitis which has been shown to be familial in some cases. In these cases, the male typically proves to be fertile at a young age, only to lose their capacity to successfully mate in early – middle age. So the impact on litter size in these cases is likely minimal.

The genetic combination of the male and female may have more impact genetically if there is some type of chromosomal incompatibility between the selected sire and dam lines either resulting in fertilization failure or embryo/fetal development. In humans it has been shown that 15% of miscarriages are due to genetic incompatibility. The gene pool for each breed of dog is certainly far smaller than the human gene pool, so there must be some impact on pregnancy rate and litter size associated with genetic incompatibility. The extent of this impact is not known. Inbreeding can impact litter size. The inbreeding coefficient measures how inbred an individual is and ranges from 0 (completely unrelated individuals) to 1.0 (completely inbred; i.e., brother/sister mating). As the inbreeding coefficient increases, the litter size decreases and the number of stillborn puppies increases.

Breeders tend to choose the animal(s) they want to breed on factors other than reproductive performance, such as conformation, athletic ability, temperament, etc. In other litter bearing species, like the rabbit and pig, it has been shown that selectively breeding for litter size quickly increases the average litter size of the line. So if litter size is of the utmost importance, breeders should selectively chose the bitches with the highest ovulation rates and they will likely see coincident increases in their litter size.

Age

Very young and very old bitches are less fertile than bitches between 1.5 and 5 years of age. Very young bitches tend to ovulate fewer follicles, while older bitches have more chance for pathology in the uterus in the form of acute or chronic inflammation and cystic change which results in an inhospitable environment for the fetuses, a greater incidence of resorption, abortion, and stillbirths. If a bitch is bred from 1.5 to 2 years of age onward, on every cycle, the first litter born will have a lower litter size than the

second litter because the uterine wall has never been stretched before and so space is somewhat constrained coupled with decreased ovulation rate. The subsequent three litters tend to increase in size and then from the fourth litter onward litter size will begin to decline again (Figure 1). If a bitch is middle aged for her first litter, one cannot expect her maximal litter size to compare to a bitch bred at two years for her first litter, since some aging change has already likely occurred in her uterus, negatively impacting litter size.

Reproductive performance will decrease at an earlier age in large and giant breed bitches compared to small and medium breeds. The largest litter a bitch will produce will therefore vary with her breed and size. For large and giant breed bitches we consider the height of their reproductive potential to be around five years of age, while for toy and small breeds, they might not reach their reproductive peak until eight to ten years of age (see Table 2 – extrapolated from the three year AKC study). When deciding when to breed your bitch for the first time, this should be taken into consideration, and breeding instituted well before their peak performance is anticipated in order to maximize litter size during her reproductive lifetime.

Ovulation timing

One of the most important determinants of litter size is breeding the bitch during her fertile period. We know that when bitches have atypical cycles they will stand to be bred at either prior to or after their fertile period. Even experienced males will be interested in the female outside their fertile window. Thus, the use of receptive behavior +/- the instincts of the stud dog alone will result in non-pregnancy in a portion of bitches that stand outside the fertile window. Breeding outside the fertile window may still result in pregnancy because of the length of time sperm can survive in the female's reproductive tract, but litter size will not be optimized. Accurate ovulation timing is necessary in order to be sure that viable sperm are delivered to the oviductal reservoir so that they are present as the eggs are maturing. Poor breeding management is the number one cause of non-pregnancy or small litter size. Determination of the appropriate time to breed a bitch requires accurate ovulation timing including vaginal cytology, speculum examination of the vaginal mucosa, serum progesterone concentrations and sometimes luteinizing hormone (LH) measurement. The more of these techniques that are combined to determine the fertile window the more accurate the assessment will be. In some cases, vaginal cytology will be performed until the bitch appears to be mid-late proestrus and then the addition of progesterone (and LH) measurement may be initiated.

The bitch ovulates immature eggs (ova or oocytes) and they require two to three days to mature before fertilization can begin. After the eggs mature, they will remain healthy and fertilizable for about two to three days and then will slowly start to degenerate. We now know that ova may be fertilized for up to 200 hours (eight days) post-ovulation if they can be accessed by spermatozoa. Often the limiting factor regarding fertilization is the ability of the sperm to gain access to the uterus. Once progesterone begins to rise rapidly the cervix begins to close. The cervix closes within 7 +/- 1 days after the LH surge. For bitches whose cervices close by day 6 after the LH surge, they will often still be in standing heat, but their closed cervix will block the entry of sperm to the uterus and thereby prevent fertilization from occurring even though the eggs may still be viable. In cases, where bitches are being bred for the first time late in the fertile window, use of an insemination technique that bypasses the cervix (transcervical or surgical insemination) may be a more appropriate choice.

Type of breeding

Depending on the type of semen being used, the quality of the semen, the age of the dog and/or bitch, and number of inseminations, a decision must be made on what type of breeding should be performed. The types of breeding that are available include natural breeding, vaginal artificial insemination (VAI), transcervical artificial insemination (endoscopic or Norwegian catheter technique; TCI), or surgical artificial insemination (SAI). Natural breeding is typically best for younger dogs and bitches with normal fertility and semen quality. Novice breeders or aged dogs may have difficulty achieving a normal copulatory lock (inside tie) and sperm numbers delivered to the cervix are

significantly reduced during an outside tie. Bitches with strictures may also only be able to achieve partial intromission. Significant size discrepancies between the dog and bitch may preclude normal mating. Fear or anxiety of either the bitch or dog may prevent a successful mating as well.

When any of the above situations is presented, if semen quality is compromised or if the bitch has a fertility issue, an alternative form of insemination may be desirable. It has been shown that the percent motility or percent morphologically normal sperm in an ejaculate is not the limiting factor for successful pregnancy, but rather the total number of motile, morphologically normal sperm inseminated. This means that the type of insemination chosen must be such that adequate sperm numbers are delivered to the oviductal reservoirs.

Vaginal artificial insemination may be used when semen quality and bitch fertility are adequate but a breeding cannot be physically accomplished. Vaginal artificial insemination is also commonly used when excellent quality chilled semen with adequate sperm numbers is shipped to the bitch. Alternatively, if chilled semen of lesser quality or lower numbers are shipped or if semen quality is somewhat diminished, sperm may be deposited in the uterus via TCI. Frozen semen is also sometimes inseminated via TCI. However, in many cases, if semen quality is poor, if bitch fertility is poor or questionable, or if frozen semen is being used, intrauterine insemination may be more desirable using SAI. Surgical artificial insemination allows the clinician to get his/her hands on the uterus to assess it for pathology, to manually rupture any cysts that are present, and to equally divide a small or poor dose of semen between both horns closer to the ovaries and oviductal reservoirs.

A large Scandanavian study evaluated type of insemination performed and showed that uterine insemination, whether by natural mating, TCI or SAI, and regardless of the type of semen used, resulted in about 20% higher whelping rates than VAI.

Number of inseminations

Ensuring that the entire fertile window is covered by fresh, viable semen will greatly increase litter size. Multiple matings during a single cycle will increase litter size and pregnancy rates. With natural breeding, bitches are ideally bred every other day from one to two days post-ovulation until five to six days post-ovulation. Breeding is not recommended on a daily basis as this may result in depletion of sperm from the male's reproductive tract and thereby decreasing numbers of sperm are present in each subsequent ejaculate. By the time the fertile window is reached, there may not be adequate sperm numbers for conception. Allowing 48 hours between matings allows for replenishment of the epididymal tail (the sperm storage site) with adequate numbers of sperm. In cases where the male is young or old (so sperm numbers may be decreased) or sperm numbers are low, it is even more important to allow for this time for replenishment of the sperm numbers.

With VAI or TCI, two inseminations are usually recommended. Ideally, the first is done two days after ovulation and the second, two days later. Depending on availability of semen, alternate days would be one and three days post-ovulation. When frozen semen is used with TCI, two inseminations are performed on each of days three and four post-ovulation. With SAI, often a single breeding is performed. With fresh or fresh-chilled semen, a single SAI would be performed on either day two, three or four post-ovulation. With frozen semen, a single SAI would be performed on day three or four post-ovulation. If frozen semen quality is diminished, adding a second insemination may increase litter size by expanding the amount of time oocytes are exposed to viable sperm during the fertile window. In these cases, both a TCI and a SAI may be performed (in no particular order) on days three and four post-ovulation.

Type of semen

Historically, breeders felt that conception rates were best with natural breeding, but with good quality semen and a fertile bitch, the use of fresh chilled or frozen semen with good ovulation timing now results in much more comparable pregnancy rates. However, when semen quality is diminished, pregnancy rates and litter size will decrease accordingly. Generally speaking, the less manipulation that occurs in semen handling and processing, the better the quality will be. So, fresh semen typically has better success over fresh-chilled, which in turn has better success over frozen semen. When offered the

choice of excellent quality frozen semen or moderate to poor quality fresh or fresh-chilled semen, the preference to maximize litter size would be to use the frozen semen. A large Scandanavian study evaluated the different types of semen and found that either fresh, fresh-chilled or frozen semen had comparable whelping rates, but they were all about 20% lower compared to natural mating when similar insemination techniques were used.

Semen quality

The higher the quality of the semen, the better the chances of optimizing litter size. When assessing semen quality it is critical to get a recent semen evaluation. Semen should be evaluated for motility (both total and progressive), velocity, concentration, morphology and the presence of other cells (white blood cells, red blood cells or immature germ cells). Partial semen evaluation or evaluations performed more than two weeks prior to semen collection may not correctly reflect on semen quality at the time of the breeding. Particular attention should be paid to semen morphology (shape and size of individual sperm cells) since many times motile sperm may have defects that will prevent them from fertilizing the eggs properly. Again, it is the total number of morphologically normal, motile sperm delivered that seems to be the critical factor. In some cases, a dog may have high numbers of abnormal or immotile sperm, but if sperm numbers are high enough this problem may be overcome (compensable).

Acceptable breeding doses for fresh or fresh chilled semen for VAI in medium sized bitches seems to be around 200 to 225 million normal, motile sperm, while acceptable breeding doses for intrauterine insemination of fresh, fresh-chilled or frozen semen seem to be between 100 to 150 million normal, motile sperm.

Season

Litter size and pregnancy rates are increased in spring compared to summer in latitudes that have distinct changes in season and daylight hours.

Nutrition

Once pregnant, bitches will do everything in their power to provide for the growth and development of their litters including removing their own body mass and nutrients to nurture the growth and development of their puppies. Therefore, bitches should be in good body condition prior to breeding. Pregnancy diagnosis via ultrasound is recommended to determine first if the bitch is pregnant, and then to estimate fetal numbers. Bitches should be fed differently based on litter size. Bitches with large litters that are not fed adequately will pull from their own fat and protein stores to provide for fetal growth. If this nutritional deficiency is large enough fetal resorption or even abortion may occur. Bitches should be fed a diet that is 30% protein, 20% fat with 20 - 30% carbohydrates. Important supplemental nutrients in the diet include omega 6 and 3 fatty acids which should be at a ratio of 5:1 to 15:1. Calcium and phosphorus are the two most important minerals in the diet. Feeding of too much calcium or an improper Ca:P ratio may result in improper functioning of the bitch's mechanism for provision of calcium for fetal development, labor and lactation. The Ca:P ratio should be between 1.2:1 to 1:1.

When choosing a diet the numbers of kcal/cup metabolizable energy is also important. Bitches with large litters should be fed diets with at least 450 kcal/cup so that when the bitch approaches term and stomach capacity is decreased due to increased pressure from an ever-enlarging uterus, adequate caloric intake with the proper ratio of all nutrients can be provided. Bitches with smaller litters may be fed diets that are at least 350 kcal/cup and still be able to provide adequate calories. Breeders should ensure that the diet they chose is manufactured according to Association of American Feed Control Officials (AAFCO) standards.

Feeding other supplements is generally not required unless specifically recommended by your veterinarian. Supplementation of foods like cottage cheese or other dairy products or beef liver will significantly alter calcium, phosphorus and protein content in the diet. So care should be taken when adding supplements to the diet.

Prior litter size should also be accounted for here. If a bitch has become overly thin after nurturing a large litter and she is bred during the subsequent cycle, her next litter may be smaller because she has not had enough time to recondition herself to feed another large litter. So, her energy stores are still being diverted towards replenishing her own body condition, and are not directed at the fullest potential for ovarian function resulting in decreased ovulation rate and subsequent litter size.

Summary

It is clear that there are many factors involved in determining litter size in the bitch. Some are easily controlled, some less so. It is important for the breeder to try to maximize bitch health, promote excellent genetics (including breeding animals with superior reproductive performance), maintain proper nutrition and spend time selecting the dog, type of semen used and form of breeding in order to maximize reproductive efficiency in the kennel.

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Table 1. Summary of AKC registrations and litter size*

Breed	Numbers of litters registered over 3 years	Litter size (range)†	Average Litter Size	Most commonly reported litter size (% reported of total registrations)
Labrador Retriever	85113	5 – 10	7.6	8 (16.54%)
Poodle	69755	2 – 5	3.4	3 (25.01%)
Dachshund	59935	2 – 6	3.9	4 (24.04%)
Pomeranian	56976	2 – 4	3.0	3 (26.90%)
Chihuahua	55513	2 – 5	3.3	3 (23.99%)
Yorkshire Terrier	53141	2 – 5	3.3	3 (24.08%)
Shih Tzu	48667	2 – 6	4.1	4 (23.69%)
Rottweiler	46805	4 – 10	6.6	7 (12.44%)
German Shepherd	44537	4 – 9	6.6	8 (14.08%)
Beagle	42823	3 – 7	5.0	5 (17.67%)
American Cocker Spaniel	39019	3 – 7	5.0	5 (18.62%)
Golden Retriever	38233	5 – 10	7.6	8 (16.17%)
Miniature Schnauzer	32235	3 – 6	4.6	5 (21.01%)
Shetland Sheepdog	28421	2 – 6	4.3	4 (20.03%)
American Boxer	27098	4 – 8	5.8	6 (16.17%)

*Adapted from Kelley RL, Proc Annu Meet Soc Therio 2002 and Root-Kustritz MV, Proc Soc Therio Breeders Symposium 2006.
†The number of puppies within +/- 1 standard deviation of the mean

Figure 1. Effect of litter number on litter size in Beagles

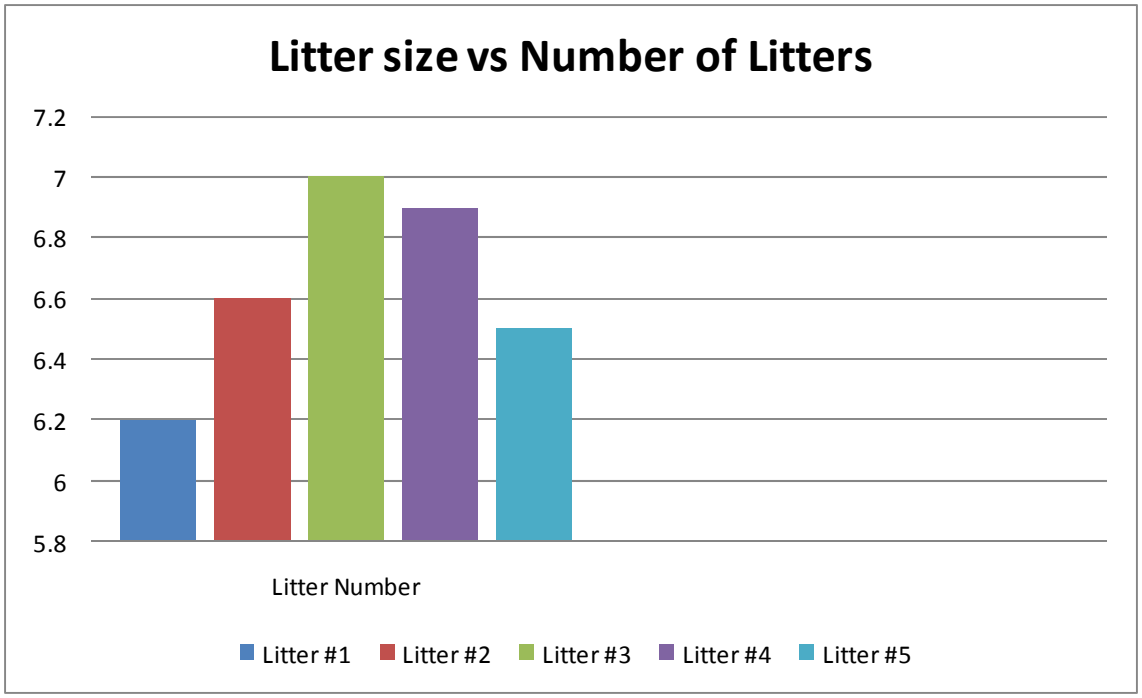

Table 2. Effect of age on litter size[‡]

Breed	Age (yrs) at peak litter size[§]	Critical age[**]
Labrador Retriever	1 - 3	5
Poodle	1 – 5	9
Dachshund	1 - 4	8
Pomeranian	1 – 4	10+
Chihuahua	1 – 4	10+
Yorkshire Terrier	1 - 7	8
Shih Tzu	1 - 4	8
Rottweiler	1 - 3	5
German Shepherd	1 - 3	5
Beagle	2 - 3	6
American Cocker Spaniel	1 - 3	6
Golden Retriever	1 - 3	5
Miniature Schnauzer	2 - 3	6
Shetland Sheepdog	1 - 4	8
American Boxer	1 - 2	5

[‡]Adapted from Kelley RL, Proc Annu Meet Soc Therio, 2002
[§]Based on number of puppies reported born
[**] The year when litter size decreases below 15% of breed average