

Recommendations for management of breeding dogs: a review

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Abstract

Information on housing, diet, and management of breeding for bitches and stud dogs is reviewed. Veterinarians were surveyed and their recommendations and sources from which they derived those recommendations compiled. There is little research published in the veterinary literature supporting recommendations regarding breeding management of animals, requiring veterinarians to extrapolate from relevant related studies that have been published and to rely on their experience.

Keywords: Theriogenology, breeding management, canine, animal welfare

Introduction

Small animal theriogenologists increasingly are requested to provide information about husbandry and breeding of dogs for creation of legislation or to act as expert witnesses in legal proceedings. The literature on topics of interest is sparse, making it difficult to argue for suggested guidelines with science as a basis. The literature was reviewed and practitioners surveyed to determine current practices and their scientific basis in the management of breeding dogs, and a comparison made to breeding within wild dog populations. Note that this review will not address general veterinary care of breeding dog populations including regular physical examination by a veterinarian, vaccinations, control of internal and external parasites, and dental care. Nutrition will be addressed only for pregnant and lactating bitches.

Literature review

General breeding management

Dogs should not be bred to near relatives. Inbreeding is defined as mating between individuals with one or more common ancestor. Close inbreeding is defined as mating of siblings or parents to offspring and is associated with an inbreeding coefficient of 0.25. Moderate inbreeding is defined as mating between half-siblings, uncle and niece, aunt and nephew, or grandparent and grandchild and is associated with an inbreeding coefficient of 0.125.¹ Inbreeding is associated with decreased fertility, decreased litter size, and reduced longevity; this is called inbreeding depression.²⁻⁶ All personnel breeding dogs are encouraged to work with a veterinarian directly to create a breeding plan for each dog that includes evaluation of pedigrees and assessment of pros and cons of each animal, to permit pairing that builds on each animal's strengths and offsets their weaknesses, and to reduce inbreeding depression while maintaining breed standards.

Stud dogs

Housing. Stud dogs may be housed with other males or in mixed gender groups. Group housing is preferred to solitary housing as it is associated with decreased animal vocalization and increased resting behavior.^{7,8} Animal housing should be constructed in a manner that decreases constant stimulation, for example by not requiring constant exposure to movement of other animals or humans, and ameliorates noise.⁹ Age at onset of puberty, defined as normal breeding behaviors and semen quality, is positively correlated with body size and occurs anywhere from six to 18 months of age.¹⁰ Male dogs raised without exposure to other dogs of either gender are less likely to show normal breeding behaviors as adults.¹¹ Male dogs must be housed near enough to female dogs to be familiar to those bitches if they are likely to permit them to breed.¹² However, it has been well-demonstrated that incidences of intermale aggression increase in groups of male dogs when housed with or near estrous females. Therefore, it is recommended that a suitable location be available for housing stud dogs away from bitches in heat as needed.^{12,13} All dogs in kennel situations benefit from human interaction including petting, grooming, and observing

health and behavioral conditions.¹⁴ Human caregivers are encouraged to clearly differentiate behavior associated with distress from those traits the dogs have learned will garner attention.¹⁵

Pros and cons of castration. There is much discussion regarding the health implications of leaving male dogs intact. This question arises most commonly when a male dog develops testosterone-dependent disease, such as benign prostatic hypertrophy, or disease of the reproductive tract, such as testicular neoplasia, or is otherwise determined not to be of value as a breeding animal. There are good published reviews of benefits and detriments of castration in dogs.^{16,17} Benefits of castration include management of the disease conditions described above and decrease in sexually dimorphic behaviors, most notably mounting, roaming, and urine marking.^{18,19} Some reports also suggest that castrated males live longer than intact males.^{20,21} Detriments include increased incidence of prostatic neoplasia,²²⁻²⁶ transitional cell carcinoma,^{27,28} osteosarcoma,^{29,30} and hemangiosarcoma,^{31,32} anterior cruciate ligament injury,³³⁻³⁵ obesity,³⁶⁻³⁸ cognitive decline,³⁹ and possibly diabetes mellitus.⁴⁰

Testing before use as breeding animal. It is strongly recommended that all dogs to be used for breeding be evaluated for hereditary disorders specific to their breed. All national breed clubs in the American Kennel Club must have a health subcommittee, and information about specific conditions and available testing usually is available through those groups and several breed-associated web sites.

Brucellosis testing should be performed in all dogs periodically, whether or not they are actively being used at stud. Some advocate testing of females only; this has no basis in science. Transmission of *Brucella canis* by ingestion or inhalation is at least as common as by sexual contact and infected males may spread the disease through marking with urine containing *Brucella* organisms.⁴¹ The screening method most commonly used for testing, the rapid slide agglutination test (RSAT), has good negative predictive value.⁴² It becomes accurate eight to 12 weeks after exposure so there is little wisdom in testing any more often than every three months.⁴³ Polymerase chain reaction (PCR) testing is accurate sooner after exposure and has very good negative and positive predictive value,³² however, testing more frequently is not recommended because incidence of canine brucellosis generally is reported as low but is gaining recognition by its occurrence in many states.

Surveillance for reproductive tract disease. Common diseases of intact male dogs are testicular neoplasia and prostate disease. Testicular neoplasia most commonly develops in dogs over three years of age and is very common, with a reported incidence of 0.9%.⁴⁴ Benign prostatic hypertrophy is reported to be present histologically in 75 to 80% of dogs aged six years or more.⁴⁵⁻⁴⁷ Morbidity of these disorders is low and castration is curative.

Bitches

Housing. There is little in the literature regarding appropriate housing for breeding bitches. Basic principles are as for the male. Bitches housed together will eventually go through estrus about the same time (the dormitory effect).⁴⁸ Breeders and veterinarians may use this event to their advantage when trying to induce estrus in another bitch. It may also be a detriment as many bitches will whelp at or about the same time, increasing the workload for human caregivers. There are some reports suggesting that interfemale aggression may be increased when bitches are in heat.¹³ Estrous bitches should definitely be housed away from intact males except when they are actively being bred on that cycle. Human interaction is required as described for the male.

There is little information in the literature regarding housing of pregnant and lactating animals. One breeding facility described significantly lower puppy mortality in bitches and litters housed in pens (10 x 20 feet or 13 x 24 feet) compared to those housed in cages (8 x 10 feet or 12 x 12 feet).⁴⁹ Most reports suggest that a specific whelping area or box be provided with absorbent, clean nesting material. One case report documents gastric impaction due to ingestion of enrichment materials in a whelping box, suggesting caution with materials used for construction and strict observation of these animals.⁵⁰ Naïve bitches exposed to canine herpesvirus in the last three weeks of gestation may develop placentitis and give birth to stillborn, macerated or weak pups that die soon after delivery.⁵¹ For this reason, many advocate housing pregnant bitches away from the rest of the kennel population.

Nutrition (pregnant and lactating). There are no specific changes in nutrition required in the first five weeks of gestation in bitches. In the last trimester, energy requirements increase by 1.25 to 1.5 times.⁵² Bitches should be fed an energy-dense commercial diet, such as a growth or performance diet, with a minimum of 22% protein.⁵³ Most diets for pregnant and lactating bitches contain about 30% protein and 20% fat on a dry matter basis.⁵² Ideally, bitches are fed several small meals daily late in gestation, recognizing lack of filling ability of the stomach as it is compressed by the gravid uterus. Supplementation with calcium is not recommended unless it is required to balance a home-made diet or the bitch is symptomatic for hypocalcemia. Vitamin supplementation is not recommended.

Energy requirement during lactation may be as high as 300% above maintenance.⁵² Lactating bitches should be free-fed the same diet they received in late gestation and have ready access to clean fresh water at all times. Energy requirement does not vary by breed but does vary by litter size.⁵⁴ Bitches should be monitored and fed to maintain her body condition.

Pros and cons of gonadectomy. There is much discussion regarding the health implications of leaving female dogs intact. There are good published reviews of the benefits and detriments of gonadectomy in bitches.^{16,17,55} Current research suggests that there is no significant difference in intra-operative or post-operative complications, or long-term side-effects when comparing ovariectomy to ovariohysterectomy.⁵⁶⁻⁵⁸

The greatest reported benefit of gonadectomy is a substantial decrease in incidence of mammary neoplasia.⁵⁹ Mammary neoplasia is the most common tumor in female dogs, with an incidence of 3.4%,⁶⁰⁻⁶³ and the most common malignancy of female dogs, with 50.9% of mammary tumors found to be carcinomas.^{60,64-66} The largest advantage in decreasing its incidence is achieved by spaying before the first heat.⁵⁹ There is a decreasing benefit over time, with some benefit up to nine years of age.^{59,67} As bitches age, the benefit may be only in decreasing incidence of benign mammary tumors but because even benign mammary tumors may be associated with lymphangiogenesis and changes in local microscopic anatomy, a benefit still exists.⁶⁸

A second advantage is in decreasing incidence of reproductive tract disease, most notably pyometra. Cystic endometrial hyperplasia-pyometra complex (CEH-P) occurs in 15 to 17% of dogs greater than four to five years of age and in up to 24% of bitches by ten years of age.⁶⁹⁻⁷¹ It is associated with endotoxemia and significant secondary renal dysfunction potentially leading to renal failure,⁷²⁻⁷⁷ anemia,⁷⁸ passage of bacteria into the abdominal cavity,⁷⁹ and decreased immune function.⁸⁰ Breeds at increased risk for developing pyometra include Airedale terrier, cavalier King Charles spaniel, Irish terrier, Bernese mountain dog, English cocker spaniel, golden retriever, Leonberger, miniature schnauzer, rough collie, rottweiler, and St. Bernard.^{71,81} Ovariohysterectomy is curative in most cases, but reported mortality rates are 0 to 17%.⁸²

Detriments of gonadectomy include increased incidence of transitional cell carcinoma,^{27,28} osteosarcoma,^{29,30} hemangiosarcoma,^{31,32} cutaneous mast cell tumors,⁸³ anterior cruciate ligament injury,³⁶⁻³⁹ obesity,³⁶⁻³⁸ urethral sphincter mechanism incompetence,^{57,84-88} heightened reactivity or aggression in some breeds,⁸⁹⁻⁹³ and possibly diabetes mellitus.⁴⁰ Finally, intact female dogs may live longer than spayed female dogs, at least when considering death from natural causes.^{94,95}

Testing before use as breeding animal. Recommendations for testing for hereditary disorders and brucellosis testing are the same as for the male.

Age and frequency of breeding. Three questions often posed to veterinarians regarding breeding management of bitches are the youngest age at which a bitch should be bred, the oldest age at which a bitch should be bred, and the frequency with which she should be bred. Bitches enter puberty on average at nine to ten months of age.⁹⁶ Age at onset of puberty, defined as the first visible signs of proestrus and estrus, is positively correlated with body size. It has been demonstrated that concentration of reproductive hormones is lower and periods of sexual receptivity shorter in the first estrous cycle than in the second, when hormone concentrations and durations of sexual receptivity reach average adult values.⁹⁷

There are no studies evaluating health considerations of breeding bitches when very young. One could consider “maturity” as the earliest age at which a bitch should be bred. Sexual maturity is the onset

of puberty. Physical maturity, defined as closure of the growth plates of the major long bones, occurs about the time of puberty in dogs.⁹⁸ Behavioral maturity occurs at an age approximately twice that of sexual maturity.⁹⁹

Considerations for oldest age at which to breed bitches revolve around identified health detriments including decreased conception rate, decreased litter size with coincidental increase in puppy size and risk of dystocia. One author defined a “critical age” as that at which litter size decreased by 15% or more from the average for that breed.⁵³ Critical age is negatively correlated with body size, with toy breeds reaching critical age at ten years of age or older, medium breeds at eight to nine years of age, large breeds at five to six years of age, and giant breeds at less than five years of age.⁵³ Evaluation of breeding productivity in large commercial kennels usually identifies five years of age or five litters as the cut-off point for breeding in bitches.^{100,101}

Frequency of breeding is not addressed with specific studies in the literature. All bitches go through a prolonged diestrus after every estrus, regardless of pregnancy status, and then go into an anestrus period such that most bitches cycle about every seven to eight months.¹⁰² The period between estrous cycles may or may not be prolonged by pregnancy and lactation.¹⁰³⁻¹⁰⁵ Estrous cycling is not seasonal in most breeds of domestic dog; exceptions are the Basenji and Tibetan mastiff.^{96,98,101,106-110} Seasonality of whelping may be due to human interaction and only breeding bitches at times most desirable for raising or selling puppies.¹⁰⁷ Many are concerned about breeding bitches on consecutive cycles, assuming that the risks of pregnancy and whelping and the metabolic demands of pregnancy and lactation should not be imposed on a bitch sequentially.

Because all bitches go through a prolonged luteal phase with subsequent decline in progesterone and rise in prolactin, bitches may experience false pregnancy, defined as lactation in the absence of whelping. It has been reported that a history of overt false pregnancy three or more times in a bitch’s life may be associated with increased incidence of mammary neoplasia,⁶⁷ suggesting that there is no benefit in not breeding a bitch on every cycle in this regard.

The other consideration is uterine health. It has been well-demonstrated that CEH-P is most common in nulliparous bitches and that pregnancy is protective against these pathologic changes on a given cycle.^{69,81,111,112} Pregnancy is not protective long-term, suggesting that it is the physiologic and immunologic aspects of pregnancy that are protective, not alterations in development of endometrial pathology.¹¹² The infection component of pyometra is due to invasion of the bitch’s own fecal flora, and not necessarily exposure to bacteria from an animal to whom she is bred.^{113,114} Involution of the uterus after whelping requires anywhere from three to 4.5 months,^{110,115,116} which usually falls well within the normal anestrus period in bitches. One review of a population of dogs in Europe stated that pyometra was more likely to occur in household pets than in “country dogs” that were permitted to breed freely.¹¹⁷ Studies demonstrating increased interestrous interval in bitches that whelp compared to non-bred bitches suggests a natural mechanism to ensure proper duration between pregnancies.^{104,105} Again, this suggests that bitches can be bred sequentially.

Wild dog populations

Wild canid populations are unlikely to be inbred and suffer from inbreeding depression unless geographic limitations on dispersal of pack members or other ecological factors prohibit mating of genetically diverse individuals.^{1,2,118} Animals sense relationship through olfaction, most likely by identifying major urinary proteins or proteins of the major histocompatibility complex (MHC), and use that information to select unrelated mates.¹¹⁹

Wild dogs are more likely to cycle seasonally, with variation in seasonality associated with latitude.^{120,121} In packs of wild dogs, the bitches will cycle together and many of the subordinate bitches will not bear young. Because they may go through false pregnancy, they participate in raising of offspring from the dominant pack members, to which they most likely are related, giving them an opportunity to pass on their genetics even if they are not bred.^{122,123} Incidence of CEH-P in one population of adult stray dogs was 5.4%,¹²¹ much lower than the 9% incidence of CEH-P described for a

similarly aged population of owned bitches.¹²⁴ Average lifespan of wild dogs is much less than that of domestic dogs, as they succumb to predation and disease.¹²³

Survey and results

A survey was distributed electronically to veterinarians who are members of the American College of Theriogenologists or members of the Society for Theriogenology. A large number of participants received the survey as members of both organizations, making it difficult to know to exactly how many unique individuals the survey was sent. Forty-nine people responded to questions about management of breeding animals and where they got the information guiding their decisions about management, and provided demographic information. For the purposes of this survey, “the literature” refers to published materials and information provided through continuing education, “experience” refers to personal experience, and “anecdote” refers to knowledge gained through others’ experience.

Forty-two of the respondents practiced in the United States and three in Canada. Others practiced in Australia and countries in Europe; some respondents practiced in more than one country. Those practicing in the United States were from 30 states, representing all of the country except the southwest. Some respondents practiced in more than one state and two were not in small animal practice at the time of this survey. When asked about specific laws in their country, state, or other municipality regarding management of breeding animals, 11 of 46 respondents (23.9%) were unaware of any such laws and 15 (32.6%) were sure there were no such laws. Laws described revolved around housing (n = 1); limiting or controlling size of facilities or number of animals housed there (n = 7); restricting breeding, usually by mandating maximum number of litters per bitch over a given time period (n = 2); and regulations on veterinary care, including use of surgical artificial insemination (n = 1) and reporting of brucellosis (n = 1). Fifteen of 48 veterinary respondents (31.2%) were dog breeders.

When asked about brucellosis testing recommendations for bitches and stud dogs, the majority of respondents recommended bitches be tested at time of breeding (27 of 48, 56.3%) and males be tested at the time of breeding (27.1%) or twice yearly (29.2%). Some felt that there should be no hard-and-fast regulation but that instead testing should be based on potential exposure, including at entry into a new kennel or after travel of a given dog or its kennel-mates to shows or other outside venues. For male dogs, recommendations also varied with how frequently the dog was used for breeding, perhaps as a reflection of potential exposure, and many people recommended testing at the time of semen collection for immediate use or for storage as chilled or frozen semen (20.8%). Finally, some respondents specifically noted that brucellosis testing should be performed for all bitches and stud dogs presented for infertility. Few respondents gave information about source for their recommendation; four stated that it was based on the literature and three based it on their own experience.

Recommendations for housing of intact male dogs was almost uniformly split between individual housing separate from all other dogs (11 of 48, 22.9%) and housing with other males and females unless the females were in heat (25.0%). Many noted that it depends on the breed in question and their possible dog-aggressive tendencies (20.8%) and on the individual male dog and his temperament (16.7%). Five people noted that they had never been asked to give a recommendation regarding housing of intact male dogs. When questioned about resources guiding recommendations, one person noted use of the literature (2.1%) while 25 (52.1%) noted personal experience and six (12.5%) noted anecdote as their source.

Youngest age at which bitches should be bred was noted to vary by breed (10 of 48, 20.8%), but most respondents felt that the second heat or two years of age was the earliest a bitch should be bred (56.3%), with most including the proviso that all appropriate testing for hereditary disease be done by this time. Other recommendations included at the first heat (8.3%) or at the third heat (6.2%), or at ten to 12 months of age (8.3%), 12 to 18 months of age (4.2%), or 18 to 24 months of age (4.2%). One person stated that they follow recommendations of that breed’s national club. Oldest age at which bitches should be bred was widely noted to depend on breed, health of the bitch, and number and quality of the pups produced in earlier breedings (16.7%). Responses for specific ages included five to six years of age (6.2%), six to seven years (12.5%), seven to eight years (8.3%), and eight to ten years (16.7%). One person referenced the critical age, as described earlier, and two people suggested it should not be based on

age but on maximum number of litters in a lifetime, with either two or three litters suggested as that maximum. The recommendation for frequency with which bitches should be bred overwhelmingly was every cycle as long as the bitch and pups were healthy and the bitch had regained body condition after lactation (54.2%). Other responses included no more than once per year (10.4%), two cycles in a row and then skip a cycle (12.5%), and every other cycle (6.2%). One person noted that veterinarians and breeders may be limited by regulations outside of their control, for example, breed club requirements in some countries permitting only one litter per bitch to be registered annually. Sources for all of these recommendations were experience (45.8%), followed by the literature (29.2%), and anecdote (20.8%).

Diet of pregnant and lactating bitches was strongly recommended to change in the last trimester of confirmed pregnancy and throughout lactation (12 of 47, 25.5%) to a diet higher in calories, protein and fat, such as a puppy, growth, or performance diet (51.1%). Six respondents (12.8%) changed diet earlier, at one month of gestation. Other diets recommended included any Association of American Feed Control Officers (AAFCO) or balanced diet appropriate for this life stage (14.9%), a high quality adult food (12.8%), a named specific diet (6.4%), and a mixed of dry and canned food (2.1%). Two respondents specifically stated that raw diets should not be fed. There was no clear agreement on supplements, with three people each suggesting vitamin or fish oil supplements, and two people stating that no supplements should be used. Respondents also noted that diet and feeding recommendations may be based on the bitch's body condition at the time of breeding and throughout pregnancy and lactation (10.6%), on litter size (6.4%), and on breed (4.3%). Diet and feeding recommendations were based largely on the literature (55.3%), followed by experience (27.7%), anecdote (12.8%), and consultation with a nutritionist or food company representative (6.4%).

Housing of pregnant and lactating bitches was strongly based on disease control concerns, with 25 of 46 respondents (54.3%) recommending that from late pregnancy through lactation bitches be housed separate from other dogs in the facility. Most noted that the environment, whether it be a home environment or a kennel, should have appropriate temperature controls, be easily cleaned to minimize spread of disease, and provide minimal stress to the bitch and pups. Housing recommendations were largely based on experience (56.5%), followed by the literature (30.4%), and anecdote (13.0%).

Conclusions

There is little literature to support many of the recommendations made by veterinarians regarding management of breeding dogs. This limits our ability to guide legislators uniformly and may result in inappropriate legislation or legal findings. From this literature review and responses from the survey, it is clear that nutrition during pregnancy and lactation is the topic that is best researched and documented. Much work remains to be done better defining appropriate housing, management of breeding frequency, and testing for brucellosis.

Many of the regulations in place govern breeding to try to control "puppy mills," broadly defined as breeding facilities with large numbers of animals geared toward production without appropriate management of the individual breeding animals and their needs. Because of this, many laws limit the number of breedings or litters per year or over a lifetime. It is clear that it may be in a given bitch's best interest to be bred consecutively and legislation perhaps should be geared more toward maximum number of litters in a lifetime followed by mandated ovariohysterectomy than toward limiting number of litters per year.

Veterinarians responding to this survey largely were unaware of local laws regarding management of breeding animals despite there being such laws in 25 of the 30 states represented.¹²⁵ Efforts should be made by veterinarians to be aware of and to participate in creation of such laws locally and nationally.

The chair of the Advisory Council on the Welfare Issues of Dog Breeding in the United Kingdom sums up concerns about indiscriminate dog breeding by stating, "Breeding excessive numbers of dogs in conditions that are far from ideal is only profitable because of the ignorance and attitudes of a significant number of potential purchasers."¹²⁶ It is essential that veterinarians to educate the public about the dogs they purchase and to assist legislators and court officials in developing and upholding laws that promote

animal welfare without unfairly penalizing conscientious dog breeders. The Farm Animal Welfare Council in the United Kingdom defines five freedoms, ideal states of maintenance for animals. These are (1) freedom from hunger and thirst, (2) freedom from discomfort, (3) freedom from pain, injury and disease, (4) freedom to express normal behaviors, and (5) freedom from mental distress and fear.¹²⁷ We may promote these freedoms and animal welfare in regards to housing and breeding management of stud dogs and bitches by resolving the following:

- All breeding animals should be housed in a manner that permits them to show normal behaviors and does not promote mental distress, with specific attention paid to individual dog's temperaments. This includes housing male and female dogs in appropriate social units except for those times when bitches are in estrus, and ensuring clean facilities of appropriate size for the animal's stage of life. Human observation of and interaction with dogs must take place regularly.
- Dogs should have access to a balanced diet that is appropriate for their life stage and fed to them in such a manner as to readily permit them to maintain body condition. Clean fresh water should be available (or easily accessible).
- All dogs intended for breeding should be evaluated for hereditary disorders before being bred and should be regularly tested for canine brucellosis, either at the time of breeding or every six months. All breeding dogs should have a breeding plan developed with help of a veterinarian to ensure pairings to promote production of pups that are healthier than the parents.
- All dog owners should recognize the pros and cons of elective gonadectomy and work with a veterinarian to make the best decision regarding timing of castration or spay for individual animals. All male dogs left intact should be regularly evaluated for prostate and testicular disease. All bitches should undergo ovariectomy or ovariohysterectomy when they are no longer to be used for breeding.
- Bitches should not be bred before they are physically mature and should not be bred on the first estrous cycle.
- Bitches should not produce more than five litters or be bred beyond the critical age for dogs of their breed, defined by body size.
- Bitches may be bred on consecutive estrous cycles if they maintain or regain body condition after whelping and lactation before onset of the next proestrus.

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