Influence of endoparasites in dog breeding kennels

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All over the world, kennels are held by different kind of breeders: occasional, regular hobby and professional breeders. Even if these dog breeders have various breeding practices, manage canine populations of very different sizes, and with various final purposes (i.e., companion, working dogs), all conscientious breeders of dogs have the same priority: the health and wellbeing of their animals. Even if parasites are extremely common pathogens in all dogs, they are particularly problematic in breeding kennels as they can interfere with breeding performances and health of dogs. The aim of this synthesis is to explain why breeding kennels are predisposed to parasitic infestations, how parasites can influence dog breeding performances and health, and how to treat and prevent parasite infestations in this specific environment.

Dog breeding kennels: favorable environments for parasite infestations

Prevalence of parasites varies from one study to another and is influenced by the geography, the detection methods, whether the dog is symptomatic or not, deworming protocol, age of animals, and housing conditions. Dogs living in breeding kennels are more frequently infested by intestinal parasites (*Toxocara canis*, *Giardia* sp, *Cystoisospora* spp.) than household dogs. For example, prevalence of *Giardia* sp in dogs living in breeding kennels or shelters is twice as high as in pet dogs. Prevalence of intestinal parasites increases along with the size of the kennel (1). Prevalence of *Giardia* sp for example is 3.5 times higher in kennels producing more than 30 puppies per year than kennels producing less than 30 puppies per year (63.2 % vs 17.7 %) (1).This higher prevalence can be explained by several factors which can have an influence alone or if associated: the lifestyle of parasites, their contagiousness, their stability in the environment, the presence of particularly sensitive animals with low immunity, the density of animals, and hygiene protocols applied in the kennels.

Some parasites have a life cycle strictly related to the reproduction cycle of dogs. For example, dog fetuses can be infected *in utero* by *T. canis* somatic larvae from day 42 of gestation (most important mode of transmission in dogs). Factors inducing this reactivation of somatic larvae and the intra-uterine infection are still unknown. A modification of the hormonal status of pregnant bitches is suspected. The activated somatic *Toxocara* larvae can also be transmitted to neonates via colostrum and milk (table 1). Transplacental transmission is also a route of infection of other parasites like *Neospora caninum*, *Toxoplasma gondii*, and *Leishmania infantum* (table 1). Moreover, some parasites are particularly resistant in the environment. *Giardia* sp can survive several months outside the host in wet and cold conditions. This environmental resistance is even more important in other intestinal parasites like *T. canis* whose eggs can survive under optimal circumstances for at least one year. Breeding kennels host also very young puppies with an immunity which is not fully developed. The age of dogs influences the risk of infection which is higher in very young puppies. Indeed, a retrospective study on 3590 faecal samples demonstrated that most *Cystoisospora* infections (78 %) were found within the first 4 months of life, whereas dogs older than 1 year rarely (1%) shed oocysts (2).

Table 1: Ways of transmission of different parasites found in canine breeding kennels

	Semen	Transplacental	Milk	Feces	Urine
Toxocara canis	-	+	+	+	-
Giardia sp	-	-	-	+	-
Cystoisospora ohioensis / C. canis	-	-	-	+	-
Toxoplasma gondii	+	+	+	+	-
Neospora caninum	?	+	?	+	?
Leishmania infantum	+	+	-	-	-
Encephalitozoon cuniculi	?	+	?	+	+

Which parasite to suspect depending on the clinical signs observed

Depending of the clinical signs observed in the breeding kennel, different parasites can be suspected.

Resorption and abortion

The actual risk of resorption and abortion due to parasite infestation seems very low. Even if a transplacental transmission of *N. caninum* was observed in dogs, only three studies have evaluated the consequences of experimental infection with this parasite in pregnant bitches (3–5). A total of 13 bitches were inoculated in these studies. Five out of 6 bitches presented resorption or macerated fetuses in one of these studies (4) whereas no effect was observed during gestation in the other two studies (3,5). The variability of the clinical signs observed can be linked to the strain of *Neospora*, the way of inoculation, the quantity of tachyzoites administrated and the moment of administration during gestation. Among the 34 puppies born alive in these 3 studies, the mortality rate during the first 21 days of age was 56 %. However, the limit of these studies is the lack of control groups (non infested). A recent epidemiological study failed to demonstrate any relationship between *N. caninum* seropositivity and reproductive disorders in dogs (6). Even if a high frequency of transplacental transmission of *Leishmania infantum* was observed in puppies (32 % of foetus infected in naturally infected bitches), abortion due to this parasite in dogs seem rare. Indeed only one case of *Leishmania* associated placentitis and abortion was described in a dog.

Neurological signs in puppies

Some parasite infestations can induce neurological signs. This is the case of *Neospora caninum, Toxoplasma gondii* and *Encephalitozoon cuniculi. Neospora caninum* can induce ataxia and hind limb paresis that develops into a progressive ascending paralysis in congenitally infected puppies. Generally, dogs are born asymptomatic and begin to develop clinical signs three or more weeks after birth. In the same litter, only some puppies may be congenitally infected and only some of them may develop clinical signs. Four different studies evaluated the serological status and clinical signs in a total of 156 puppies born from serological positive bitches (7–10). In these studies, 7.3 % (10/137) of puppies were found seropositive during their first weeks/months of age, and 6.4 % (10/156) developed clinical signs of neosporosis (7–10). Even if congenital infections were suspected in these studies, a postnatal infection cannot be ruled out as the majority of serologic tests were performed several weeks after birth. The seroprevalence of *Neospora caninum* seems low in adult breeding bitches, with 7.3 % of dams seropositive. *Toxoplasma gondii*, an intracellular coccidian parasite, can induce clinical signs similar to *Neospora caninum* (seizures, ataxia, and paresis or paralysis). In young dogs under 1 year of age, a generalized toxoplasmosis can be observed, with icterus, fever, dyspnea and diarrhea. A third intracellular parasite, *Encephalitozoon cuniculi*, can induce neurologic problems in puppies between 4 and 10 weeks of age. Puppies show signs of renal failure and neurologic signs such as depression, ataxia, blindness and convulsions.

Digestive troubles before weaning

Different digestive parasites, like *Giardia sp*, *T. canis*, *Cystoisospora sp*, can induce digestive troubles in puppies (diarrhea, vomiturition). However, their pathogenicity depends on age, immunity of puppies and of co-infection by other enteropathogens. For example, *Cystoisospora ohiensis* (coccidiosis) can cause enteric disorders in very young animals (<7 days of age) but does not affect puppies at weaning, whilst *C. canis* mainly induces clinical signs in puppies at weaning and, more particularly, after stress. However, the pathogenic power of one given parasite is difficult to evaluate per se since several parasites are simultaneously present within the digestive tract. A study on 316 puppies revealed that 40 % of them excreted at least 2 different digestive parasites underlying the necessity of a global evaluation of parasites excreted (1). In the same study, a strong impact of canine parvovirus on weaning diarrhea was observed (61.5% of puppies infected presented abnormal feces compared to 15.2% of puppies not infected by this virus). That's why a transdisciplinary approach associating parasitology and virology is mandatory for an optimal management of weaning diarrhea. Finally, veterinarians should be aware of the possible emergence of new parasites. Indeed, various enteropathogens have recently been isolated in puppies living in breeding kennel like *Pentatrichomonas hominis*, or astrovirus.

Evaluation of parasites circulation in the kennel

Management of parasites in breeding kennels includes the identification of risk factors of parasite contamination in the kennel, good hygiene practices, the active monitoring of parasite circulation, and an appropriate deworming strategy.

When a group of dogs present parasitic problems in a kennel, not all troubles may be resolved with a single treatment, and it is sometimes better to target the contributory factors rather than the causative agent(s) directly. In this case, it is essential for the vet to visit the kennel in order to evaluate the environmental factors. This visit allows to understand the breeding establishment as a whole, paying particular attention to the cleaning and disinfection procedures, the organization of the kennel, the animals' housing, the management of the dogs, and feeding practices. The visit of the kennel will be also an opportunity to collect some biological samples (feces, blood…) for complementary analyses. In order to identify the parasites present in the kennel and to quantify the parasite load if any, microscopic evaluation of pooled fecal samples can be performed in three different populations of dogs: bitches in anoestrus and stud dogs, pregnant and nursing animals and puppies around weaning. To decrease the cost of analyses and to limit the number of false negative results due to intermittent excretion of parasites, stools from 3 to 5 dogs can be pooled into one sample for the lab. When several litters of different ages are present simultaneously in the kennel, two distinct pooled fecal samples can be submitted for coproscopy, one sample from puppies aged between 4 and 6 weeks and another sample from puppies aged between 6 and 9 weeks.

Management of parasite contamination in the kennel

Parasite prevention and control measures can be divided into two main categories: to prevent the introduction of the parasite and to limit the transmission.

The quarantine plays an important role to prevent the introduction of some digestive parasites. All the newly introduced dogs need to be housed in a specific place separated from the other dogs before being introduced into the kennel. During this period, these dogs can be dewormed and groomed (9 % of privately owned dogs presenting eggs of *T. canis* in their hair). Food is a potential way of parasite introduction into the kennel. Indeed, up to one third of breeders fed their dogs with raw diets or bones, and raw meat products can be potentially contaminated with parasites like *Giardia* spp, *Neospora spp*, *Toxoplasma* spp, *Echinococcus* spp,

Cryptosporidium spp. However, the prevalence of these parasites in raw diet seems low. Moreover, raw meat is most often frozen for preservation: negative temperatures (<-10°C) rendered non-viable cysts of different parasites like *N. caninum* and *T. gondii*.

In order to decrease risks of parasitic transmissions, the excretion, the persistence in the environment and the exposition to parasites need to be limited. To decrease excretion, an deworming program adapted to parasites observed in the kennel has to be proposed. As *T canis* present a zoonotic risk and since it is considered that almost 100% of dogs have been in contact with this parasite, a systematic deworming program targeting this parasite has to be proposed. In order to prevent transmission of *T canis* to fetuses during gestation, the European Specialist Counsel Companion Animal Parasites (ESCCAP), recommends to treat pregnant females with macrocyclic lactones (ivermectin, milbemycin oxime, selamectin, moxidectin) on the 40th and 55th day of pregnancy or fenbendazole daily from the 40th day of pregnancy until the 14th day postpartum. Puppies need to be treated from the age of 2 weeks and then every 2 weeks until the age of 2 months with fenbendazole/febantel, pyrantel, flubendazole or nitroscanate. Lactating bitches must be treated at the same time as their puppies. For the other dogs in the kennel, a every month treatment against roundworms and tapeworms should be proposed. In case of clinical coccidiosis due to *C. canis* or *C. ohioensis*-complex, the use of emodepside plus toltrazuril suspension was described as effective (reduction of oocysts excretion and number of days with diarrhea).

Environmental conditions have an impact on the survival of parasites. Surface porosity, environmental temperature and presence of organic material are three factors influencing the survival of parasites. This underlines the importance of adapted surfaces, i.e.resistant and with a low porosity, in the kennel. To limit the persistence of parasites in the kennel, efficient cleaning and disinfection are mandatory. It is specially important to keep in mind that cleaning and disinfection are two separate tasks. Cleaning involves the removal of visible organic material with soap or detergent, whereas disinfection consists in the application of a chemical or any other procedure in order to kill the remaining microbes. The disinfectant should be adapted to the parasite. For example, sodium hypochlorite is fully effective against infective *T. canis* eggs, but it is known to enhances excystation of *Cystoisospora* spp oocysts.

To limit the exposition to parasites, the kennel has to organized into separate sectors based on the differing vulnerability of the different animals determined by their physiological status. So the optimal solution is to create the following areas in the kennel: maternity, nursery, area for adult dogs, quarantine, infirmary. Specific cleaning equipment for each sector should be available. The design should be arranged so that the movement of the staff through the facility should proceed from the areas housing animals the most susceptible to disease (puppies) and/or healthiest animal (healthy adult dogs) to those who are likely to be a source of infectious disease (quarantine, infirmary).

Conclusion

A breeding kennel needs to be considered as an ecosystem with an interaction between host (dogs; age, genetics, immunity…) and pathogens (parasites; virulence, strain, dose…), both influenced by breeding kennel management (breeder) and environment (population density, stress, hygiene levels, temperature/humidity…). To evaluate this ecosystem, a global approach of the problem is essential. A systemic approach needs to be used. This method is the opposite of a Cartesian approach that breaks down a complex system into components parts that can be isolated and measured. The systemic method is an global evaluation including multidisciplinary approaches (parasitology, virology, immunology, ambiance analysis..) and pluritechnical approaches (PCR, coproscopy, kennel data analysis…). This way of thinking may improve not only the management of parasitic and infectious diseases in breeding kennels but also the interpretation of clinical studies. From a scientific point of view,

due to the complexity of breeding kennels, studies taking into account a single effect in the statistical analyses (univariate analysis) to understand the effect of parasites are not adapted. Multivariate models taking into account various parameters in a single model should be used to address the parasitic infections in clinical studies. Specific statistic tools have been developed to evaluate this complexity like generalized linear mixed or Bayesian models. From a practical point of view, management of parasitic diseases needs a global evaluation including a precise identification of the different pathogens excreted taking into account their interaction together with an evaluation of the environment.

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Editors: Sabine Schäfer-Somi, George Mantziaras, Sebastian Arlt