Disease Transmission by Mating or Artificial Insemination in the Cat: Concerns and Prophylaxis  (13-Sep-2002)

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Introduction
A prerequisite for transmission of infectious diseases is that susceptible cats get into contact with the infectious agent. This might occur if the infectious agent is prevalent in the environment, but most infectious agents that infect cats are not very hardy in the environment and are transmitted mainly via direct contact between animals. When cats mate they have a very close contact. Cats living in groups share the same environment and usually also bowls and litter boxes, but when they mate, the contact between cats is closer and more intense. The queen and tom often rub their faces against each other and lick each other, facilitating transmission of infectious agents in saliva/oropharynx or the eyes (Fig. 1). When the tom grasps the neck of the queen during mating, he might also cause bite wounds, thereby getting in contact with the queen’s blood, and possible infectious agents therein. If there are infectious agents in the genital tract or in semen, these may also be transmitted during mating.

Furthermore, mating is often associated with a certain degree of stress, which might in part be attributable to transport and introduction into a new environment, when cats from different catteries mate. Stress might lead to reactivation and increased shedding of certain infectious agents, such as herpes virus. Altogether, the close contact and the stressful situation of mating leads to a situation in which infectious agents that might not be transmitted at other times are at a high risk of getting transmitted. The situation is complicated by the fact that carriers that show no signs of clinical disease can maintain many of the infectious agents in the purebred cat population. The importance of mating in the spread of infectious diseases is reflected in the fact that agents might spread and have a higher prevalence within certain breeds [1].

To reduce the risk of introducing infectious agents into the cattery, breeders might house the male with visiting queens separately (Fig. 2). This is a way of reducing transmission of infectious diseases between the male cat and other cats in the cattery, but the male is still at risk of being infected by the female, and to transmit infectious agents to other visiting females. Another measure might be to breed only within a small and defined population, such as the owner’s cattery. Such a strategy ultimately leads to inbreeding and occurrence of genetic diseases. Therefore cat breeding really involves a balancing act to avoid infectious diseases on one side and to avoid genetic diseases on the other, all the while aiming at the goal of producing and maintaining healthy cats.
Measures that should be undertaken when infectious agents are diagnosed in the cattery depend on several factors. Of importance is the severity of the disease that is caused by the agent, and if the disease can be successfully treated or not. The prevalence of the infectious agent and its potential presence in subclinical carriers influence which strategy should be chosen. The mode of transmission of the agent also affects how to manage infected cats. General recommendations are therefore difficult to give, but suggestions for strategies to utilize before matings are described at the end of this paper, after short descriptions of the most common infectious agents encountered in cat breeding.

**Virus Infections**

**Feline Panleukopenia Virus (FPV)** - Feline panleukopenia virus is a serologically homogenous parvovirus that is very hardy and can survive for months or years in the environment. The incubation time is usually 4 - 5 days, but varies between 2 and 10 days. The virus replicates preferentially in cells with high mitotic rates, such as intestinal epithelium, bone marrow stem cells and lymphoid cells, leading to diarrhea and leukopenia. During acute infection, virus is shed from all body secretions [2]. Cats usually get infected by direct contact or via the fecal-oral route. They shed virus in their urine and feces for a maximum of 6 weeks after recovery [3].

Although FPV causes severe disease and death, especially in young unvaccinated animals, most infections are probably subclinical [3]. If pregnant queens are infected, the virus might infect the embryo or fetus, leading to reproductive disturbances with no other signs of disease in the queen. Depending on when during gestation the queen is infected, infertility, resorptions, abortions and birth of mummified fetuses can be seen. The central nervous system of kittens might be damaged when infected during the prenatal or early postnatal period, cerebellar damage leading to ataxia being most commonly reported [3].

Feline panleukopenia virus has previously been reported to cause disease mainly in unvaccinated outdoor cats. However, recently it has been reported as a cause of kitten mortality in pedigree kittens [4]. The age of the kittens varied between 10 days and 7 months, some had been vaccinated and in younger ones the queen had been vaccinated [4]. Based on the finding that FPV has been detected in cardiac tissue of cats with cardiomyopathy, it has also been speculated that if kittens get infected with FPV at a young age they might develop cardiomyopathy later in life [5].

It is not known if FPV is shed in semen, or if female cats can get infected via the utero-vaginal route.

**Feline Herpesvirus (FHV, feline rhinotracheitis virus, FRV)** - Feline herpesvirus is a susceptible virus that survives in the environment only up to 18 hours in moist conditions [6]. It infects via the conjunctiva, nasally or orally. After an incubation period that is usually 2 to 6 days but can be longer, it can lead to severe respiratory disease in susceptible individuals [6]. Approximately 80% of recovered cats are carriers and might shed virus, usually after stress such as change of housing, parturition and lactation [7]. However, some FHV carriers might not shed virus after stressful situations [7]. Cats may show signs of clinical disease during the periods of shedding, but sometimes they do not [7-9]. Virus shedding usually starts around 1 week after the stressful situation and continues for 1 - 2 weeks. Shedding has been documented as early as 4 days after stress [7,8]. Rehousing and mating might thus lead to reactivation and shedding of virus leading to transmission of FHV if the cats are kept together for 4 days or longer. As carriers can shed virus spontaneously or after other types of stress, keeping the cats together for less than 4 days is no guarantee that FHV is not transmitted.

Abortions have occurred after experimental intravenous infection at day 42 - 50 of gestation and lesions were seen in both placenta and uterus [10]. Abortions occurred 6 - 9 days after viral inoculation except in one case where it took almost 4 weeks. In this case, FHV could be detected from a kitten with lesions in the liver. In kittens that were aborted earlier no virus could be isolated [10]. Abortions have also been provoked after intranasal infection, but neither could virus be isolated from the placenta, uterus or fetuses, nor were specific lesions seen [10]. These abortions were therefore thought to be secondary to the severe upper respiratory tract infection that the cats developed.

The role of FHV in reproductive disturbances after natural infection has not been clarified. Some authors have claimed that FHV is not an important cause of reproductive disturbances [11], whereas others have found that cats presented with both upper respiratory tract infection and reproductive disturbances are more likely to be infected with FHV than with *Chlamydophila felis* [12].

Feline herpesvirus can cause vaginitis in queens experimentally infected via the intravaginal route [13]. In kittens born to queens infected vaginally late in gestation mortality was high, due to generalized infections with lesions in the liver and
respiratory tract [13]. Feline herpesvirus is a cause of kitten mortality also in natural conditions [14]. Kittens can also be infected without showing any clinical symptoms [15], and cats can thus be FHV carriers without ever having experienced clinical disease caused by FHV.

It is not known if feline herpesvirus is shed in semen, but it is known that queens can get infected vaginally. In humans, herpesvirus is shed in semen [16].

Feline Calicivirus (FCV) - Feline calicivirus causes different disease syndromes in infected cats. The most common clinical manifestation is upper respiratory tract disease, primarily rhinitis and ulcerative stomatitis [17], and a limping syndrome [18]. All isolates belong to the same serotype, but there are differences in antigenicity and a striking difference in virulence. Often the only sign is a mild upper respiratory tract disease, but systemic infection and death can occur, especially in kittens [14,19]. A virulent strain causing hemorrhagic-like fever has been described [20]. Feline calicivirus has also caused abortions in unvaccinated cats [21,22]. Both reports on abortions caused by FCV describe unvaccinated cats, and one queen aborted with no other signs of disease [22]. Virus could be isolated from fetuses [21,22].

The incubation period is 1 - 7 days [23]. After infection the virus is shed from the oropharynx (Fig. 3). Most cats will stop shedding the virus after a month [23], but chronic asymptomatic carriers exist [24]. Carrier queens can infect their kittens that subsequently may or may not show clinical signs [25], and in this way the virus may persist in a population of clinically healthy cats. The fact that cats previously infected with field or vaccine strains are not protected against the chronic carrier state when subsequently infected with heterologous FCV strains [26], also contributes to viral persistence in the cat population.

It is not known if FCV is shed in semen, or if queens can get infected vaginally.

Feline Coronavirus (FCoV) and Feline Infectious Peritonitis - Feline coronaviruses are widespread in the cat population. The prevalence varies from 16% in single cat households to more than 50% of healthy purebred cattery-reared cats [27-29]. The endemic coronaviruses are located mainly in the intestines, and usually cause no clinical symptoms or cause a mild diarrhea. Occasionally, the enteric coronaviruses mutate, attain the ability to infect and replicate in monocytes and macrophages, and cause feline infectious peritonitis (FIP) [30]. This is a gradual phenomenon, and many healthy cats are viremic, which does not seem to predispose them to FIP [31]. Coronaviruses have a high rate of mutation for several reasons: they possess the largest known RNA genome, and their mode of replication may permit frequent "non-correctable" point mutations, deletions, and recombinations [32]. There are two forms of FIP, a wet form with abdominal and/or thoracic effusions, and a dry form with granulomatous lesions in internal organs [33]. Feline infectious peritonitis is a fatal disease. Feline coronavirus has been isolated from a four-day-old kitten that had pneumonia and hepatitis [34]. The mother did not show any signs of clinical illness. This finding indicates that transplacental transmission can occur, but FIP is considered to be an uncommon cause of reproductive disturbances.

Feline infectious peritonitis is not a common cause of early kitten mortality or fading kitten syndrome [14], but it is a common cause of mortality in kittens from 3 months of age [35] (Fig. 4).

It is estimated that 5 to 12% of cats infected with FCoV develop FIP [36]. The risk of developing FIP is no higher in households where FIP has been diagnosed than in other households with endemic FCoV [37], further supporting the finding that coronaviruses causing FIP arise by mutation from endemic enteric viruses [38], and that horizontal transmission of the virulent strain is an exception rather than the rule [30]. The composition of viral quasispecies has been shown to differ
between organs within the cats [39].

Several factors probably influence the chance of a FCoV-positive cat developing FIP. Stress has been suggested as one [40], and there is also a genetic susceptibility [41]. In a study on the epidemiology of FIP in catteries, the number of years that breeding took place in a cattery showed a positive relationship with the risk of a cattery experiencing FIP, as did the average number of cats in the cattery [42]. Interestingly, the breeding policy (extent of exchange with cats from other catteries for breeding) did not influence the risk of the cattery to experience FIP [42]. This might be because FCoV already is widespread in the purebred cat population.

Feline coronavirus is mainly shed in the feces, and rarely in saliva [43]. Most cats shed virus for a period of 3 to 9 months, but there are persistent carriers and also cats that are resistant to infection [43].

It is not known if FCoV is shed in semen, or if queens can get infected vaginally.

**Feline Leukemia Virus (FeLV)** - Feline leukemia virus is a retrovirus with three subtypes. Subtype A is the most common one and is the one that is contagious between cats [44]. The virus is susceptible to cleaning and disinfections, but in moist conditions, at room temperature, the virus may survive for 48 hours [44]. Infection is more common in outdoor than in indoor cats, and in multiple cat households than in single cat households [45]. The virus is shed mainly in the saliva in persistently viremic cats. Kittens born to a viremic cat can be infected in utero, but the risk is even higher after birth, when the queen licks the kittens [44] (Fig. 5). The virus is transmitted mainly by direct contact and licking, but iatrogenic transmission via contaminated needles, instruments, fomites, or blood transfusion might occur [44].

![Figure 5. Neonatal kittens are susceptible to FeLV. Most get persistently viremic. They are often infected when licked by the queen. - To view this image in full size go to the IVIS website at www.ivis.org. -](image)

It is believed that two thirds of all feline cancers are caused by FeLV, and infection also leads to a suppressed immune response because of infection of blood cells and the bone marrow [44]. The ability to cope with a viral infection is highly dependent on the age of the cat. In a high proportion of kittens this virus will continue to replicate in bone marrow and lymphatic tissue and the cat will be persistently viremic. Most adult cats have an efficient immune response and are able to get rid of the infection within weeks or months [44,45].

After oropharyngeal or nasal exposure, FeLV replicates in oropharyngeal lymphoid tissue. If the immune response is insufficient, the cat gets viremic and the virus spreads to the bone marrow and infects hematopoietic precursor cells. Some cats get persistently viremic and develop clinical signs after a period that can be several years long. Transiently viremic cats may develop a latent infection in the bone marrow and clear the viremia. Cats with latent infections can be viremic in cases of stress such as pregnancy [46], but usually virus is eliminated within 6 months. Latent infections with FeLV have been thought to be associated with diseases such as lymphoma, leukemia, and cytopenia, but in a recent investigation such an association could not be found [47].

In persistently viremic queens, reproductive disturbances may be the only clinical manifestation of a FeLV-infection. In earlier studies, 70 - 90% of queens with reproductive disturbances were positive for FeLV [48]. The percentage is now much lower due to the use of testing procedures which have identified carriers and allowed them to be removed from the breeding population. In FeLV-viremic queens, resorptions are reported to be common. It can be noted that the fetal swellings decrease in size in week 4 to 5 of pregnancy, and after 7 weeks a bloody vaginal discharge is seen [49]. Abortions and infertility (probably early embryonic death) can also be seen [49]. Sometimes it is evident that aborted fetuses have died after different gestation periods [49]. Viremic queens often experience repeated abortions and resorptions [50]. Feline leukemia virus can pass the placenta, but it is thought that lesions in the contact between maternal and fetal tissue are the major cause of abortions [50]. Bacterial endometritis can occur after abortions, probably a reflection of the immunosuppressive action of FeLV. Kittens born to viremic queens usually have thymic atrophy and die within 2 weeks [44].

It is not known if FeLV is shed in semen, or if queens can get infected vaginally.
**Feline Immunodeficiency Virus (FIV)** - Feline immunodeficiency virus is a lentivirus within the family of retroviruses. Virus is present in saliva and blood of infected cats, and the main route of infection is thought to be by bites or wounds, which probably is the reason why infection is 2 - 3 times more common in male than in female cats [51].

Newly infected cats can have a short period of mild clinical illness with lymphadenopathy, fever and malaise. In many cats, this acute phase is probably not observed. After the acute phase the virus establishes, but the cat is clinically healthy. This phase is usually at least 3 - 5 years long. Finally the cat gets clinically ill, with symptoms caused by infectious agents that would not give these symptoms in a cat with a normal immune defense. The most common syndromes that are associated with FIV are inflammation in the oral cavity and respiratory tract [51]. The presence of clinically healthy cats that are DNA positive but seronegative for FIV has been reported [52], but the clinical consequences of this type of latent infection are unknown at present.

In the first report on FIV, abortions were mentioned as a clinical manifestation [53]. Experimentally-infected pregnant queens aborted, or had stillborn kittens, kittens with low birth weight and kittens that died within 48 hours [54]. Half of the kittens were infected in utero. Feline immunodeficiency virus could be detected also in colostrum, milk and vaginal secretions, and overall 70% of the kittens were infected either prenatally or postnatally [54]. The presence of FIV in vaginal washings of pregnant queens suggests that intrapartum FIV transmission is possible [54]. Colostral antibodies seem to have a protective role: All kittens were infected from the colostrum and milk when it did not contain antibodies, compared to 40% when antibodies were present in the colostrum [54]. Maternal antibodies are not transferred in utero [55]. Maternal antibody levels have been shown to be undetectable in kittens by eight to eleven weeks of age [54,55], and have by others been found to persist to the age of 5 months [56]. As maternally derived antibodies in kittens younger than 6 months of age might confound interpretation of positive test results, the recommendation is that kittens that test positive before 6 months of age should be retested at 60-day intervals [57].

Feline immunodeficiency virus is shed in the semen of both chronically and acutely infected cats [58,59]. Virus can be detected in semen even before the cat has seroconverted [59]. The time from infection to seroconversion can be as long as 8 weeks. It has been shown experimentally that queens can be infected via the intravaginal route, and that kinetics of early FIV infection differs with route of exposure [60,61]. Feline immunodeficiency virus has been transmitted from the male to the female via artificial insemination with fresh semen using laparoscopy [62]. When queens were infected via artificial insemination, vertical transmission could not be detected [62]. In chronically naturally infected queens, vertical transmission also appears to occur less frequently [56,63].

**Bacteria**

*Chlamydia psittaci variety felis* is a bacterium that lives and replicates within cells, but also has an extracellular phase, as elementary bodies. The elementary bodies, that are infectious to other cats, can survive for a couple of days in the environment but are susceptible to standard cleaning [6].

The major clinical symptom is conjunctivitis, which is most severe in kittens. Cats with upper respiratory tract disease caused by *Chlamydia* are usually less than 1 year old [1,12]. In contrast, clinically healthy adult cats are significantly more often seropositive than cats under one year of age [64]. Kittens are usually affected either during the first two weeks of life, before they have opened their eyes, or after weaning, at 6 - 12 weeks of age. Cats may also snore, sneeze and cough, but most of them have a rather mild disease.

*Chlamydia* is more common in multiple cat households than among pet cats [65,66]. Cats can be infected without showing any signs of disease, but clinical manifestation also tends to be a bigger problem in multiple cat households than in single-cat households. This may be because stressful situations such as social stress, parturition and lactation make asymptomatic carriers develop clinical disease and shed the organism. The immune defense to *Chlamydia* is weak, and after infection cats may get reinfected when their immune response wanes. Infections with *Chlamydia* can be treated with doxycycline [67], clavulanic acid-potentiated amoxycillin [68] or azithromycin [69].

*Chlamydia* is mainly shed in ocular secretions, but can be detected also in vagina and rectum. *Chlamydia* has been detected in the vagina up to 5 months after ocular infection [67,70]. The importance of this localization for spread of the organism is not known, but interestingly, cats with *Chlamydia* infection were more commonly not spayed than cats with upper respiratory tract disease due to other causes [12]. If the queen carries *Chlamydia* in the vagina, it is possible that kittens get infected during parturition. It is not clear if *Chlamydia felis* can cause reproductive disturbances, but it has
been suggested as a causative agent of abortions in cats [71]. There was no significant association between presence of reproductive disease and upper respiratory tract disease caused by *Chlamydophila* in a study by Sykes et al., [12].

It is not known if *Chlamydophila felis* is shed in semen or if queens can get infected vaginally. It is known that *Chlamydia* is shed in semen in humans [72].

**Bacterial Flora in The Genital Tract of Cats** - Bacteria are normally found in the genital tract of healthy female and male cats [73-75]. In female cats, the most common aerobic bacteria that are isolated are *Escherichia coli*, *Staphylococci* and beta-hemolytic *Streptococci*. Anaerobic bacteria are seldom isolated. *E. coli*, *Staphylococcus* spp and *Streptococcus* spp have also been isolated from cats with pyometra [76]. In male cats, the most common aerobic bacteria have been shown to be *E. coli*, *Pseudomonas aeruginosa* and *Proteus mirabilis* [74] and in another study *Pasteurella multocida* and *E. coli*. Anaerobic bacteria are also commonly isolated, *Bacteroides* spp, *Fusobacterium* spp and *Streptococcus* spp being the most common ones.

The normal microbial flora is thought to defend the host against potentially pathogenic bacteria [77]. In healthy bitches treated with antibiotics, the vaginal flora was often altered during and after treatment, with growth of potentially pathogenic bacteria that had not been isolated before treatment [78]. The normal bacterial flora contains antibiotic resistance genes, even in animals that have not been treated with antibiotics. Exposure of the flora to antibacterial drugs increases the number of resistant bacteria [79]. As the bacteria that might cause infections, such as pyometra, are the same as those present in the indigenous bacterial flora, treatment with antibiotics to eradicate the normal flora might lead to future problems with antibiotic resistance when treating genital infections.

In the canine species, the genital flora of dogs and bitches is similar [80,81]. It has been shown that bacteria in the genital tract are transferred between dog and bitch at mating, but in healthy breeding dogs this does not affect fertility [81]. Preliminary data show that the vaginal flora in cats that have mated does not differ from cats that have not mated, suggesting that transfer of the normal flora at mating is not a problem in cats either.

**Other Infectious Agents**

Of course there are many agents that do not affect reproduction, that are readily transmitted at mating because of the close contact between cats. The most important ones are probably ectoparasites, such as *Cheyletiella* spp, fleas and lice, as well as dermatophytes. Due to the presence of asymptomatic carriers, dermatophytes can be a real problem. To avoid transmission of dermatophytes, testing might be recommended for cats at risk.

**Artificial Insemination**

Artificial insemination (AI) is a technique that is used in many other species, and is a way of reducing spread of infectious agents. The technique is described in the chapter by Axnér and Linde-Forsberg. If performed with semen collection and insemination well separated in room and/or in time, so that infectious agents can not be transmitted by persons handling the cats, artificial insemination is a means of avoiding spread of infectious agents from the queen to the tom (Fig. 6). Transmission from the tom to the queen is also reduced, and completely avoided if the infectious agent is not shed in semen and able to infect genitaly. In cats it is not know whether or not any infectious agent other than FIV is transmitted via semen. It is only for feline immunodeficiency virus that transmission via AI has been clearly shown to occur. At present, therefore, it is only for ectoparasites, dermatophytes and other external agents that AI can be used as a means of eliminating the spread of infectious agents from the tom to the queen during mating.

![Figure 6. Artificial insemination can be used to avoid spread of infectious agents from the queen to the tomcats. - To view this image in full size go to the IVIS website at www.ivis.org. -](image)

**Measures to Prevent Spread of Infectious Diseases in Connection with Mating or AI: Testing and Vaccinations**

To be able to prevent transmission of infectious diseases, knowledge is needed of which diseases that are present and how they are transmitted. Only clinically healthy cats should be used for breeding. To prevent spread of infectious agents, cats that
are going to be mated are often tested for the presence of different infectious agents, in order to find healthy carriers. However, the healthy carriers are often difficult to detect, especially those carrying the upper respiratory tract pathogens. The usefulness of an etiologic diagnosis in acute cases of upper respiratory tract disease should therefore not be underestimated (Fig. 7). In most testing procedures, the ability to detect the infectious agent is generally higher in acute infections than in chronic or latent infections. Routinely used clinical procedures are not able to confirm an etiologic diagnosis in most cats with chronic conjunctivitis [82]. Vaccinations are also performed in connection with mating, to ensure a high level of maternal antibodies in the colostrum to protect the kittens (Fig. 8).

Figure 7. The chance of detecting agents causing upper respiratory tract disease is greatest if samples are taken from cats with acute clinical signs. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 8. Queens are often vaccinated just before mating to ensure high levels of protective antibodies in colostrum and milk. - To view this image in full size go to the IVIS website at www.ivis.org . -

Testing for Subclinical Carriers

FIV - It should be assured that breeding animals are not infected with FIV. This infection has a low prevalence in the purebred cat population, and does not spread readily in socially stable groups of cats. Mating leads to an increased risk because of potential spread via semen or blood, when the male grasps the neck of the queen. There are several in-house tests available that can be used for FIV screening of breeding animals [83], such as RapidFIV Test (SinovusBiotech), SpeedCat FeLV/FIV, Snap® (IDEXX, USA), DUO Speed® (BIO VETO TEST, France), FASTest® (MegaCor, Germany) and Witness® (Synbiotics, USA). As FIV has such a low prevalence, and due to the dramatic consequences for both the cat and the breeder if a breeding animal should be infected, positive test results should be interpreted with care and always confirmed with another test, preferably a Western blot [57].

FeLV - Breeding animals should be tested for the presence of FeLV. Although this infection has been a concern causing reproductive problems in catteries [49], the prevalence is now low, thanks to the possibility to test the breeding animals. Due to the low prevalence of the virus, cat breeders have become less prone to test their animals. This creates a risky situation, as FeLV spreads easily, or is easily transmitted in a group of cats and may not be noticed because of the fact that very few symptoms might be seen initially other than reproductive disturbances. If FeLV is not routinely excluded by testing in cases of resorptions, abortions and kitten mortality, it may take years before FeLV is diagnosed. By that time, when the cats have developed tumors, leukemia and disorders related to a suppressed immune response, the virus has spread not only within the cattery, but also to catteries that have bought infected kittens or mated to carrier cats. Therefore, breeders should ensure that their catteries are free from FeLV. In-house tests are available also for FeLV, and suitable for screening of breeding animals [83]. As for FIV, positive tests should be confirmed, preferably using virus isolation or indirect immunofluorescent antibody (IFA) tests [83,57]. There are several in-house tests available that can be used for detecting FeLV, including Rapid FeLV Test (SinovusBiotech), SpeedCat FeLV/FIV, Snap® (IDEXX, USA), DUO Speed® (BIO VETO TEST, France), FASTest® (MegaCor, Germany) and Witness® (Synbiotics, USA).

FCoV - Although it is true that a large proportion of cats in multiple-cat households are endemically infected with FCoV and that only a minority of cats infected with FCoV will develop FIP, it is also a fact that if a cat is not infected with FCoV there is no risk of developing FIP. Therefore, breeders should ensure that their catteries are free from FCoV. In-house tests are available also for FCoV, and suitable for screening of breeding animals [83]. As for FIV, positive tests should be confirmed, preferably using virus isolation or indirect immunofluorescent antibody (IFA) tests [83,57]. There are several in-house tests available that can be used for detecting FCoV, including Rapid FCoV Test (SinovusBiotech), SpeedCat FCoV/FIV, Snap® (IDEXX, USA), DUO Speed® (BIO VETO TEST, France), FASTest® (MegaCor, Germany) and Witness® (Synbiotics, USA).

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FCoV can be eliminated from a group of cats if the cats can be housed separately, repeatedly tested for antibodies to FCoV and only those with low or no antibody titers are brought together [84].

FHV - Because of the capacity of a latent FHV to reactivate, FHV can persist in small populations [85]. The presence of healthy carriers that are detected is relatively low, 4.2% in a British study [86], but the true incidence is probably higher, as latent carriers often do not shed the virus. Serology cannot be used, as most cats are routinely vaccinated against FHV. Conjunctival swabs are of a very limited value due to the periodic shedding pattern. The presence of FHV in a cattery is therefore best diagnosed in cases of clinical disease.

FCV - Carriers are prevalent in the cat population [87], but acute clinical disease due to FCV is uncommon in vaccinated cats. A role for FCV in chronic stomatitis has been implicated [88], but the relationship is unclear [23]. Due to the high prevalence of clinically healthy carriers and low prevalence of disease in vaccinated cats, vaccination is recommended for control of the infection rather than elimination of subclinical carriers.

Chlamydophila - There are two ways of testing for subclinical carriers: Conjunctival swabs for detection of Chlamydophila (Fig. 9), or blood samples for serology. In cats without signs of upper respiratory tract disease, Chlamydophila is usually not detected from conjunctival swabs [1,89].

However, in one study Chlamydophila was detected in one out of 95 cats (1.1%) and this cat had recovered from conjunctivitis 2 months earlier [12], indicating that cats without clinical symptoms might transmit the infection to other cats. It can be argued that cats from which Chlamydophila cannot be detected in conjunctival swabs are unlikely to transmit the organism to other cats. Chlamydophila has since long been present as a recurrent infection [90]. This indicates that immunity to the organism is short-lived, and that infection in subclinical carriers can be reactivated, leading to spread of the organism and to clinical symptoms in the carriers. It cannot be excluded that Chlamydophila in some cases can be isolated only intermittently from the conjunctiva of clinically healthy cats that carry the organism.

The alternative to conjunctival swabs is serology. With serology, endemic infections in multiple cat households can be detected. Serology is of limited value in cats that are vaccinated against Chlamydophila. The relationship between levels of antibody titers and shedding of Chlamydophila is not clear. In an early investigation, antibody levels varied from not detectable to high in cats with chronic conjunctivitis and rhinitis from which Chlamydophila could be isolated [90]. In a more recent study, Chlamydophila could not be detected in conjunctival swabs from cats with no or low antibody levels [91]. From cats with high antibody levels, Chlamydophila could be detected from 41% of the cats [91]. Titers have been found to remain elevated for longer than 27 weeks after infection [92].

FPV - As cats do not become chronic carriers of FPV, and as the virus is present and stable in the environment, there is usually no reason to look for FPV in the feces of healthy cats.

Bacteria in the Genital Tract - Bacteria are normal inhabitants of the genital tract and swabs for bacteriological culture are of very limited value in cats without signs of reproductive disease (Fig. 10). Treatment with antibiotics in the attempt to eliminate the normal bacterial flora is not recommended.

Other Infectious Agents - Testing for subclinical carriers of other common infectious agents, such as dermatophytes, is recommended when such infections create a problem.
Vaccination

FIV - Much effort on a vaccine against FIV has lead to the development of a dual-subtype FIV vaccine [93] that is available in the USA. This vaccine might be useful for the protection of outdoor cats in endemic areas, but should not be used instead of FIV testing in breeding catteries.

FeLV - FeLV vaccines are available and suitable for preventing young outdoor cats in FeLV-endemic areas (Fig. 11). Although these vaccines are efficient [94] they do not provide 100% protection, and should therefore not be used for breeding animals instead of FeLV testing. FeLV vaccines have also been associated with the development of vaccine-associated feline sarcomas [95]. It should be borne in mind, that in environments where only cats that have tested free from FeLV meet, the risk of getting a tumor from the vaccination is larger than that of getting ill from FeLV.

Figure 11. Vaccination against FeLV is not recommended for indoor cats before breeding, but is useful for young outdoor cats in areas where there is a high prevalence of FeLV. - To view this image in full size go to the IVIS website at www.ivis.org.

FCoV - The FCoV vaccine that is available (Primucell FIP®) cannot be used in kittens younger than 16 weeks, and can therefore not be used for protection of kittens in a cattery with an endemic infection, as these kittens most probably are already infected with FCoV at this age. Vaccination is not recommended as a way of preventing transmission of FCoV at mating. Vaccination against FCoV is primarily recommended when kittens reared in FCoV-free environments are going to be introduced into an environment where FCoV is endemic.

FHV, FCV and FPV - Vaccines protect against disease but not infection with these viruses [96,97]. Cats do not become chronic carriers of FPV. It has been shown that vaccinated cats can become chronic carriers of FCV [26]. Kittens are usually vaccinated at 9 and 12 weeks, but an extra vaccination at 6 weeks is recommended for kittens in high-risk environments [98]. If maternal immunity is suspected to be high, it is advisable to give the kittens an additional vaccination after 12 weeks of age [4].

Chlamydophila - Chlamydophila vaccines can be useful in catteries that have problems with severe clinical disease caused by Chlamydophila, but they do not have any effect on shedding of the organism [1].

Suggestions for Implementing a Disease Prevention Strategy Before Breeding - The potential strategies, diseases, testing, treatments and vaccinations that should be considered are summarized in Table 1, Table 2 and Table 3.

<table>
<thead>
<tr>
<th>Infectious Agent</th>
<th>Only Breed Cats that Have Tested Negative</th>
<th>Only Breed Cats of the Same Serological Status (+/-)</th>
<th>Vaccination Generally Recommended</th>
</tr>
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<tbody>
<tr>
<td>FeLV</td>
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<td></td>
<td></td>
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<tr>
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<td>FPV</td>
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<td>FHV &amp; FCV</td>
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<td>FCoV</td>
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<tr>
<td>Chlamydophila</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
### References


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### Table 2. Suggested Disease Testing to Apply Before Breeding in Cats.

1. All cats intended for breeding should be tested negative for FeLV and FIV.
2. In order to prevent spread of the virus, cats can be tested for antibodies against FCoV. If cats that have antibodies mate only to other seropositive cats, and cats without antibodies mate with other seronegative cats, a reduction of viral spread is achieved.
3. To prevent spread of *Chlamydia*, serology can be used and the same measures undertaken as for FCoV.
4. Cats with other infectious diseases, such as dermatophytosis, should be treated before being bred.

### Table 3. Suggested Vaccination Considerations Before Breeding in Cats

Vaccinations generally do not prevent spread of infections; they are performed to protect the cats and kittens against clinical disease. To ensure high levels of maternal antibodies to protect the kittens, vaccine boosting can be performed in connection with mating.

1. Cats should be vaccinated against FPV, FHV and FCV.
2. FPV is a virus that is prevalent in the environment, and that has the ability to cause fatal disease. FCV and FHV can also cause severe illness, and are both prevalent in the cat population.
3. Vaccination with FCoV can be used if seronegative cats are going to mate seropositive cats, however, this should be avoided.
4. Vaccination against *Chlamydia* is recommended if there is a clinical problem, but does not prevent spread of the infection.
5. Vaccination against FeLV and FIV is not a general recommendation for cats intended for breeding.
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