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Seroprevalence of feline immunodeficiency virus and frequency of feline leukemia virus antigenemia in domestic cats of Uberlândia, Minas Gerais, Brazil

Soroprevalência do vírus da imunodeficiência felina e frequência de antigenemia do vírus da leucemia felina em gatos domésticos de Uberlândia, Minas Gerais, Brasil

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Highlights

High frequency of FeLV antigenemia (21.4%) was found in domestic cats from Uberlândia.
Male cats showed a higher risk of coinfection with FIV and FeLV.
Early diagnosis and proper management are essential to control FIV and FeLV.
This study expands our understanding of the epidemiology of FIV and FeLV.

Abstract

Feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) are retroviruses that affect domestic cats (*Felis catus*) worldwide and are associated with diseases such as lymphoma and leukemia and immunosuppression, potentially compromising both the quality of life and life expectancy of these animals. A total of 463 serum samples from domestic cats, collected between 2022 and 2024 from veterinary hospitals and clinics in the city of Uberlândia, Minas Gerais, Brazil, were subjected to lateral flow immunochromatographic testing for the detection of antibodies against FIV and FeLV antigens

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(p27). The seroprevalence of FIV and frequency of FeLV antigenemia in the evaluated population were 6.91% (32/463) and 21.38% (99/463), respectively. For FIV, the only statistically significant association was with sex, as males were 2.83 times more likely to be infected than females, and coinfection with FIV and FeLV was predominantly observed in males, who accounted for 78.95% (13/17) of the coinfected animals, suggesting a greater susceptibility of males to multiple infections. Mixed-breed cats had higher infection rates, highlighting the influence of environmental and management factors. FIV was more prevalent in older cats, whereas FeLV was predominant in younger and adult cats. The occurrence of FIV infection was lower than that reported in previous studies conducted in other regions of Brazil, whereas the prevalence of FeLV infection was consistent with the findings in the scientific literature, reinforcing the high rate of FeLV infection among domestic cats in Brazil. The accurate identification of infected animals enables epidemiological assessment to support the development of control and prevention strategies for viral dissemination.
Key words: Feline. Feline Retrovirus. Feline Immunodeficiency. Feline Leukemia. Lymphoma. Leukemia.

Resumo

O vírus da imunodeficiência felina (FIV) e o vírus da leucemia felina (FeLV) são retrovírus que acometem gatos domésticos (*Felis catus*) em todo o mundo, estando associados a doenças como linfoma, leucemia e imunossupressão, o que pode comprometer tanto a qualidade de vida quanto a expectativa de vida desses animais. Foram analisadas 463 amostras de soro de gatos domésticos, coletadas entre 2022 e 2024 em hospitais veterinários e clínicas na cidade de Uberlândia, Minas Gerais, Brasil. As amostras foram submetidas ao teste imunocromatográfico de fluxo lateral para a detecção de anticorpos contra FIV e antígenos de FeLV (p27). A soroprevalência e a frequência da antigenemia das infecções por FIV e FeLV na população avaliada foram de 6,91% (32/463) e 21,38% (99/463), respectivamente. Para FIV, a única associação estatisticamente significativa observada foi com o sexo, sendo os machos 2,83 vezes mais propensos a estarem infectados do que as fêmeas; além disso, a coinfecção por FIV e FeLV foi predominantemente observada em machos, que representaram 78,95% (13/17) dos animais coinfectados, sugerindo maior suscetibilidade dos machos às infecções múltiplas. Gatos sem raça definida apresentaram maiores taxas de infecção, destacando a influência de fatores ambientais e de manejo. FIV prevaleceu em gatos mais velhos, enquanto o FeLV predominou em gatos jovens e adultos. A ocorrência de infecção por FIV foi inferior à relatada em estudos anteriores realizados em outras regiões do Brasil, ao passo que a prevalência de FeLV foi compatível com achados da literatura científica, reforçando a elevada taxa de infecção por FeLV entre gatos domésticos no país. A identificação acurada dos animais infectados possibilita a avaliação epidemiológica, subsidiando o desenvolvimento de estratégias de controle e prevenção da disseminação viral.
Palavras-chave: Felinos. Retrovírus Felino. Imunodeficiência Felina. Leucemia Felina. Linfoma. Leucemia.

Introduction

The prevention and control of feline retroviral infections are crucial to animal health and represent a significant challenge for veterinary and public health. Identifying infected animals and determining the prevalence of these viruses in susceptible populations are essential for the success of any control program (Hofmann-Lehmann & Hartmann, 2020; Little et al., 2020).

Feline leukemia virus (FeLV) is an exogenous retrovirus belonging to the family *Retroviridae* and genus *Gammaretrovirus.* It is highly infectious among both domestic and wild felids and can lead to hematopoietic disorders, neoplasms, immunodeficiency, and immune-mediated diseases in infected animals (Pare et al., 2022; Ngo et al., 2024). FeLV transmission occurs horizontally through direct contact with bodily fluids, such as oronasal secretions, feces, urine, and bite wounds, and vertically from the queen to her offspring via the lactation and transplacental routes (Little et al., 2020; Pare et al., 2022). Its occurrence is associated with several risk factors, including cats aged 1–5 years, unneutered males with outdoor access, and cats living in environments with high population density and poor hygiene (Gonçalves et al., 2021).

FeLV infection is classified according to the clinical status of the host, infecting viral strain, and the number of viral particles present in the blood and tissues. Infected cats may develop one of four outcomes: abortive, regressive, progressive, or focal (Gonçalves et al., 2021). Abortive infection occurs when a robust immune response eliminates the virus, resulting in negative viral cultures, p27 antigen detection, viral RNA, and proviral DNA. In such cases, the infection does not progress, and the animal remains disease-free. Regressive infection is characterized by initial viremia, which is controlled by the host immune system through neutralizing antibodies. Although antigenemia tests such as lateral flow immunochromatography or rapid tests may produce negative results, molecular assays such as polymerase chain reaction (PCR) can detect integrated proviral DNA in the host genome. Progressive infection is responsible for viral transmission and the major clinical consequences of FeLV infection, as the host immune system fails to control viral replication. In these cases, extensive viral replication begins in local lymphoid tissues, subsequently reaching the bone marrow and spreading to the mucosal and glandular epithelial tissues. Viral presence in such cases can be confirmed through viral culture or the detection of p27 viral antigens, viral RNA, and proviral DNA. Focal infection is rare and not well characterized; it is presumed to be confined to a specific tissue and may go undetected by the diagnostic methods used for other stages (Gonçalves et al., 2021; Little et al., 2020; Pare et al., 2022).

Feline immunodeficiency virus (FIV) is also an exogenous retrovirus belonging to the family *Retroviridae* but is classified within the Lentivirus genus. FIV infection is more commonly observed in free-roaming male cats through bite wounds acquired during fights, as the virus is present in saliva. Vertical transmission from queen to kittens can occur via intrauterine or lactogenic routes in cases of high maternal viremia, potentially resulting in fetal resorption, abortion, stillbirth, and placental inflammation (Braga et al., 2023). FIV infection comprises three phases. The

first is a primary infection, during which the animal becomes viremic and may exhibit mild clinical signs or lymphadenopathy lasting weeks to months, sometimes progressing to a more severe illness. The second phase is a prolonged asymptomatic stage, during which viral replication may be low or intermittent and can lead to false-negative results in molecular assays, such as PCR. The third, or terminal, phase is marked by increased viral replication, CD4+ lymphocytopenia, and the onset of clinical disease (Westman et al., 2019). Owing to its tropism for CD4+ lymphocytes, FIV can lead to an acquired immunodeficiency syndrome in domestic cats, which closely resembles acquired immunodeficiency syndrome (AIDS) in humans. Consequently, infected cats are at increased risk of opportunistic infections, neurological disorders, and neoplasms. However, unlike FeLV, FIV infection does not typically result in severe clinical syndromes in most naturally infected cats (Acevedo-Jiménez et al., 2022).

When investigating infections caused by these viruses, the use of a diagnostic panel comprising various tests, along with repeated testing, may be necessary to accurately classify the disease stage. This is critical for guiding individual prognosis and symptomatic clinical management as these viruses lead to lifelong infections (Hartmann, 2012; Westman et al., 2019). Point-of-care tests based on lateral flow immunochromatography or enzyme-linked immunosorbent assays (ELISA) are used for the detection of FeLV p27 antigen and anti-FIV antibodies in whole blood, serum, or plasma and have high sensitivity and specificity (Parr et al., 2021). Molecular tests, such as PCR, for the detection of viral RNA or proviral DNA are also commonly employed to determine the infection stage (Accioly et al., 2023; Hofmann-Lehmann & Hartmann, 2020; Little et al., 2020). Notably, cats with regressive FeLV infection typically test negative for p27 and viral RNA in the blood. Therefore, the prevalence of FeLV and FIV infections may vary depending on the diagnostic methods used.

The aim of this study was to evaluate the seroprevalence of FIV and frequency of FeLV antigenemia as well as the risk factors associated with these feline viral infections, in domestic cats whose blood samples were submitted by veterinary clinics and hospitals to a clinical pathology laboratory in the city of Uberlândia, Minas Gerais, Brazil.

Materials and Methods

Sample analysis

A total of 463 feline serum samples obtained from the bank of the Laboratory Veteri were tested. These samples originated from veterinary clinics and hospitals in the municipality of Uberlândia, Minas Gerais, Brazil, and were collected between 2022 and 2024. No exclusion criteria for age, sex, or breed were applied. The animals underwent either elective or emergency consultations under the supervision of a licensed veterinarian. Among the total sample, sex data for 428 animals were available. Blood samples were collected in microtubes with or without EDTA, stored at 2-8 °C, and delivered to the clinical pathology laboratory within 48h post collection. Subsequently, the samples were centrifuged at 2,500 rpm for 2 min, and the resulting

sera were tested using the FIV Ac/FeLV Ag lateral flow immunochromatographic test kit (ALERE, Brazil), following the manufacturer's instructions. According to the technical documentation of the kit, the clinical sensitivity and specificity of the ALERE kit for FIV Ac were 96% and 98%, respectively, whereas the sensitivity and specificity for FeLV Ag were 100%.

Statistical data

The sample size was calculated based on the Thrusfield (2005) formula: $n = \frac{Z^2 P(1-P)}{e^2}$. A confidence level of 95% was adopted (Z = 1.96), with an expected proportion of 0.17 (P = 0.17) and a margin of error of 0.05 (e = 0.05). Based on these parameters, the minimum required sample size was calculated to be 217 individuals. This represented the minimum sample size required to ensure a 5% margin of error with 95% confidence in an infinite population. No finite population correction was applied, because the population was assumed to be sufficiently large for such an adjustment to be unnecessary.

Statistical analyses were performed using Stata® software, version 14.0 (StataCorp LP, College Station, TX, USA). Proportion tests were used to compare groups, and logistic regression models were used to identify factors associated with viral infections. In addition, prediction functions based on the fitted models were employed to estimate the adjusted probabilities of infection according to the evaluated independent variables.

Results

The rate of retroviral infection was calculated by dividing the number of positive results by the total number of tested animals and was expressed as a percentage. The seroprevalence of FIV and frequency of FeLV antigenemia was 6.91% (32/463) (95% confidence interval (CI): 4.92–9.62%) and 21.38% (99/463) (95% CI: 17.87–25.36%), respectively. Coinfection with both viruses was observed in 3.67% (17/463) of the tested animals.

Females accounted for 44.28% (205/463) and males for 48.16% (223/463) of the samples. Among the females, 3.90% (8/205) (95% CI: 1.25–6.55%) tested positive for FIV and 20.00% (41/205) for FeLV, and 1.46% (3/205) were coinfected. Among the males, 10.31% (23/223) (95% CI: 6.32–14.30%) tested positive for FIV, 22.86% (51/223) for FeLV, and 5.82% (13/223) for both viruses. For FIV, the only statistically significant association found was with sex: males were 2.83 times (95% CI: 1.23–6.48) more likely to be infected than females. Of the FIV- and FeLV-coinfected animals, 17.65% (3/17) were female, 76.47% (13/17) were male, and 5.88% (1/17) had no sex information available (Table 1).

Table 1
Seroprevalence of FIV antibodies, FeLV p27-antigenemia, and FIV/FeLV coinfection by sex in domestic cats (N = 463) from Uberlândia, Minas Gerais

Sex	N	FIV+, n/N (%) [95% CI]	FeLV+, n/N (%)	FIV+/FeLV+, n/N (%)	OR [95% CI]
Female	205	8/205 (3.90) [1.25–6.55]	41/205 (20.00)	3/205 (1.46)	Ref.
Male	223	23/223 (10.31) [6.32–14.30]	51/223 (22.86)	13/223 (5.82)	2.83 [1.23–6.48]
Unknown	35	1/35 (2.86)	7/35 (20.00)	1/35 (2.86)	—
Overall	463	32/463 (6.91) [4.92–9.62]	99/463 (21.38)	17/463 (3.67)	—

Values are n/N (%). FIV+: cats seroreactive for feline immunodeficiency virus antibodies. FeLV+: cats testing positive for feline leukemia virus p27 antigenemia. FIV+/FeLV+: coinfection (both tests positive). OR compares males vs. females (reference = female), as reported in the Results.

Mixed-breed cats (MBCs) accounted for 74.95% (347/463) of the samples. Samples from Brazilian Shorthair (Pelo Curto Brasileiro [PCB] in Portuguese) cats accounted for 4.97% (23/463), Persian cats for 2.38% (11/463), Siamese cats for 1.51% (7/463), Maine Coons for 0.86% (4/463), and unreported breeds for 15.33% (71/463). Among the MBCs, 12.00% (21/175) were males positive for FIV, and 24.57% (43/175) were males positive for FeLV. In contrast, 2.66% (4/150) were females positive for FIV, and 20.00% (30/150) were females positive for FeLV. No MBCs without sex information tested positive for FIV, and 1.44% (5/347) of MBCs without sex information tested positive for FeLV. Coinfected males and females represented 3.75% (13/347) and 0.58% (2/347) of MBCs, respectively.

Among the PCB cats, no males tested positive for FIV, but 4.35% (1/23) were male cats positive for FeLV. In contrast, 4.35% (1/23) were female cats positive for either FIV or FeLV. None of the PCB animals were coinfected, and none of the animals without sex information tested positive for either virus.

Both male and female Siamese cats tested negative for FIV. However, FeLV was detected in one male and one female, each representing 14.29% (1/7) of the total number of Siamese cats. No coinfection was observed in this group.

Among animals with no breed information, 2.82% (2/71) were females positive for FIV, 12.68% (9/71) were females positive for FeLV, and only 1.41% (1/71) were coinfected. No male cats were coinfected. However, among animals with no breed information, 2.82% (2/71) of those FIV-positive and 8.45% (6/71) of those FeLV-positive were males. In addition, 1.41% (1/71) that tested positive for FeLV and 1.41% (1/71) that were coinfected were among those with no reported sex. No positive cases of FIV, FeLV, or coinfection were identified in Persian or Maine Coon cats (Table 2).

Table 2
Breed distribution and frequency of FIV (serology), FeLV (p27-antigenemia), and coinfection in domestic cats (N = 463) from Uberlândia, Minas Gerais

Breed	n (%)	FIV+, n/N (%)	FeLV+, n/N (%)	FIV+/FeLV+, n/N (%)
MBCs	347 (74.95)	25/347 (7.20)	78/347 (22.48)	15/347 (4.32)
PCB	23 (4.97)	1/23 (4.35)	2/23 (8.70)	0/23 (0.00)
Persian	11 (2.38)	0/11 (0.00)	0/11 (0.00)	0/11 (0.00)
Siamese	7 (1.51)	0/7 (0.00)	2/7 (28.57)	0/7 (0.00)
Maine Coon	4 (0.86)	0/4 (0.00)	0/4 (0.00)	0/4 (0.00)
Not informed	71 (15.33)	4/71 (5.63)	16/71 (22.54)	2/71 (2.82)
Total	463 (100.00)	32/463 (6.91)	99/463 (21.38)	17/463 (3.67)

Values are n/N (%), where N is the total number of cats within each breed category. FIV+: cats seroreactive for feline immunodeficiency virus antibodies; FeLV+: cats testing positive for feline leukemia virus p27 antigenemia; FIV+/FeLV+: coinfection (both tests positive). MBCs: mixed-breed cats. PCB: Pelo Curto Brasileiro (Brazilian Shorthair).

The mean age of the animals was 38.66 months (3 years and 2 months). Males had a mean age of 40.58 months (3 years and 4 months), and females had a mean age of 38.26 months (3 years and 2 months). The mean age of FIV-positive animals was 51.73 months (4 years and 3 months), and that of FeLV-positive animals was 44.97 months (3 years and 9 months). Among coinfected animals, the mean age was 55.73 months (4 years and 7 months). The mean age of FIV-positive females was 49.14 months (4 years and 1 month), while FIV-positive males had a mean age of 50.55 months (4 years and 2 months). Regarding FeLV-positive animals, the mean age of males was 46.68 months (3 years and 10 months), and that of females was 43.03 months (3 years and 7 months). Among coinfected animals, the mean age was 48.67 months (4 years) for males and 78 months (6 years and 6 months) for females (Table 3).

Table 3
Mean age (months) of domestic cats from Uberlândia, Minas Gerais by sex and retroviral (FIV serology and FeLV p27-antigenemia) test outcome (N = 463)

Category	Overall mean age	Male mean age	Female mean age
All cats	38.66	40.58	38.26
FIV+	51.73	50.55	49.14
FeLV+	44.97	46.68	43.03
FIV+/FeLV+	55.73	48.67	78.00

Values are mean age (months). FIV+: cats seroreactive for feline immunodeficiency virus antibodies; FeLV+: cats testing positive for feline leukemia virus p27 antigenemia; FIV+/FeLV+: coinfection (both tests positive). Sex-specific means were calculated among cats with recorded sex; animals with missing sex information are included only in the overall mean ages.

For FeLV, only statistically significant associations were observed with the year of sample collection and immediate diagnosis. The proportion of animals that tested positive for FeLV showed a decreasing trend over the evaluated period: 30.34% (95% CI: 22.86–37.82) in 2022, 20.51% (95% CI: 14.84–26.18) in 2023, and 12.19% (95% CI: 6.41–17.97) in 2024. The distribution of the number of animals tested per year was 145 in 2022, 195 in 2023, and 123 in 2024, with no statistically significant differences in the sample size between the years. Compared with those in 2022, the odds of testing positive for FeLV were 0.59 in 2023 and 0.31 in 2024.

Discussion

The data obtained in this study indicate a high prevalence of FIV (6.91%) and FeLV (21.38%) infections among cats of Uberlândia, Minas Gerais, Brazil, with coinfection in 3.67% of the tested animals. These findings suggest substantial viral circulation within the studied feline population and are consistent with the existing literature in Brazil. In a study conducted in shelter cats in Belo Horizonte, Teixeira et al. (2007) reported an FeLV positivity rate of 32.5% using ELISA, whereas 4.14% of the samples tested positive for FIV via conventional PCR. Similarly, Coelho et al. (2011) analyzed cats from hospitals and clinics and, using nested PCR, detected FeLV proviral DNA in 47.5% of cats in the same city and identified the presence of subgroups A, AB, and B. Conversely, Almeida et al. (2004) found FIV antibodies in 16% and 21% of samples from a zoo using two different serological tests in cats in Rio de Janeiro, and Reche et al. (1997) detected an FIV positivity rate of 11% using ELISA at a veterinary hospital in São Paulo. In a recent study, Diesel et al. (2024) reported that approximately 30% (109/366) of the domestic cats from veterinary clinics in Caxias do Sul were infected with FeLV, indicating a significant prevalence in urban feline populations in that city. The FIV/FeLV coinfection rate was 4.9% (16/325), which is comparable to the results observed in the present study.

Regarding the association between sex and FIV infection, a significantly higher prevalence was observed in male (23/224, 10.27%) than in female cats (8/205, 3.90%). This pattern is consistent with previous studies reporting greater susceptibility among males, possibly due to risky behaviors such as increased fighting among unneutered males, facilitating transmission through bite wounds (Little et al., 2020). Although the prevalence of FeLV was also higher in males (51/224, 22.77%) than in females (41/205, 20.00%), the difference was less pronounced than that observed for FIV. Jorge et al. (2011) reported that male cats also exhibited higher FeLV infection rates. In the same study, 92.8% (13/14) of the FIV-positive samples were male, compared to only 7.2% (1/14) female.

FIV and FeLV coinfection was predominantly observed in males, accounting for 78.95% (13/17) of coinfected animals. This finding suggests that males are more vulnerable to multiple infections than females. Braga et al. (2023) tested 37 cats from Manaus and found a higher rate of coinfection in males (3%) and higher FIV prevalence (13%). FIV/FeLV coinfection may

exacerbate clinical conditions, accelerating the progression to severe illnesses such as lymphoma and leukemia (Hofmann-Lehmann & Hartmann, 2020; Little et al., 2020). The higher rate of coinfection in males reinforces the hypothesis that behavioral risk factors, such as increased exposure to other infected animals, play a key role in viral transmission.

In terms of breed distribution, most cats tested were mixed breed, representing 74.95% of the sample. Among them, 25.65% (89/347) tested positive for at least one infection. The prevalence of FIV and FeLV was notable in mixed-breed males, with positivity rates of 6.05% and 12.39%, respectively. The same study reported that all FIV-positive cats were mixed breed. Similarly, Zanutto et al. (2023) reported higher infection rates in MBCs, with 31/40 FIV-positive and 11/14 FeLV-positive cats. This elevated infection rate in MBCs may be attributed to greater exposure to high-risk environments such as shelters and streets, increasing their contact with infected animals. Conversely, no infections were detected among purebred cats, such as Persian and Maine Coon, likely because of reduced environmental exposure and more controlled management practices.

The age analysis also provided valuable insights. The mean age of the tested animals was 38.66 months, indicating that most of them were adults. This is when FIV and FeLV infections are typically more prevalent, owing to longer exposure times. Zanutto et al. (2023) reported a mean age of 46.65 months, with FIV-positive cats averaging 29.38 months and FeLV-positive cats 30.28 months. In the present study, FIV-positive animals were older on average than FeLV-positive animals, with both males and females averaging approximately 4 years of age. This difference may reflect the longer latency period associated with FIV before clinical signs become apparent. Jorge et al. (2011) found that most FeLV-infected cats (74%) were between 3 and 6 years old, an age range identified as a significant risk factor.

Cats coinfected with FIV and FeLV were older, particularly females, with a mean age of 78 months (6.5 years). This may indicate the cumulative effects of dual infections and a tendency toward a later-stage clinical diagnosis. Furthermore, the absence of infection in Siamese, Persian, and Maine Coon cats may be due to their low representation in the sample, particularly Siamese cats. Only 2.38% of the tested animals were Persian cats, thus limiting broader conclusions regarding breed-related susceptibility.

The observed decrease in the number of FeLV-positive cases over a short period (2022-2024) may be attributed to multiple factors. Routine screening, increased awareness of early diagnosis, and proper management of infected animals likely contributed to the reduction in viral transmission during the study period.

Notably, cats with regressive FeLV infection may not test positive in p27 antigenemia assays, such as lateral flow immunochromatographic tests. Therefore, the true prevalence of FeLV, which relied solely on antigen detection, may have been underestimated. Additional testing, including PCR to detect proviral DNA integrated into the host genome, is essential for determining infection status and disease stage. Moreover, RT-PCR may also be used to quantify viral RNA load.

Conclusion

The results of this study revealed a high seroprevalence of FIV (6.91%) and frequency of FeLV antigenemia (21.38%), with coinfection occurring in 3.67% of cases in cats from Uberlândia, Minas Gerais, Brazil, between 2022 and 2024. These findings are in accordance with data from the literature, highlighting the high infection rates of these viruses in feline populations in Brazil. A greater susceptibility of males to FIV and FeLV infections, as well as FIV/FeLV coinfection, was observed, possibly due to risky behaviors. Furthermore, mixed-breed animals showed significantly higher prevalences, reinforcing the impact of environmental and management factors on the spread of these viruses. Age analysis revealed that FIV infection was more prevalent in older animals, whereas FeLV infection was predominant in younger and adult animals.

The absence of positive cases in specific breeds, such as the Persian and Maine Coon, underscores the influence of management and confinement characteristics on mitigating the risk of infection. However, the limited representation of these breeds in the present study hindered robust conclusions. Additionally, relying solely on antigenemia-based tests may underestimate FeLV prevalence, underscoring the need for more sensitive diagnostic methods, such as PCR and RT-PCR, to accurately assess viral load and infection status.

This study highlights the importance of early diagnosis and proper management as key strategies for the prevention and control of FIV and FeLV infections in regions where they are prevalent. This study also contributes to our understanding of the epidemiology of these feline viral infections.

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