

Prevention of the contagious spread of feline leukaemia virus and the development of leukaemia in pet cats

CLUSTERING of cases of feline lymphosarcoma (LSA) or leukaemia has been observed by veterinarians for many years¹⁻⁴. The first anti-feline leukaemia virus (FeLV) serum was reported in 1969⁵ and by 1970 a simple indirect immunofluorescent antibody (IFA) test for the detection of FeLV in the peripheral blood of infected cats had been developed⁶. Using this test we found that 33% of the healthy pet cats exposed to cats with FeLV-associated diseases were infected with FeLV. All the cats known not to have been exposed to cats with FeLV-associated diseases were uninfected and only 0.31% of the stray cats, with an unknown history of FeLV exposure, were infected³. Once persistently viraemic with FeLV, most cats remain infected for their entire lives. These results showed conclusively that FeLV is transmitted between cats by infection or contagion (that is, horizontally), in contrast to the oncornaviruses of inbred mice which are predominantly transmitted genetically from the parents to the offspring by means of the chromosomes (that is, vertically)⁷.

FeLV causes four fatal diseases in pet cats. The diseases are: (1) LSA^{4,5}, (2) non-regenerative anaemia^{8,9}, (3) a panleukopenia-like syndrome³, and (4) thymic atrophy¹⁰. FeLV is also associated with, but not yet proven to be the cause of, various myeloproliferative disorders¹¹ and foetal abortions and resorptions (F. Goldsmith and W. D. H., Jr, unpublished)^{12,13}. Healthy FeLV-infected cats have a greatly increased chance of developing one of the FeLV-related diseases or of developing secondary diseases due to the immunosuppressive effects of FeLV^{12,14}.

The spread of an infectious disease agent may be prevented by various methods. These are: (1) vaccination, (2) killing the infectious agent in the environment by disinfection, and (3) removal of either the infected sick animal, the healthy carrier host or the vector(s). In veterinary medicine, when vaccination is not available, removal of the carrier host is commonly used to prevent the spread of infectious disease agents¹⁵.

Our earlier epidemiological studies showed that FeLV is an infectious agent for pet cats³. The ultimate goal of any epidemiological study is to prevent the spread of a disease by identifying the aetiological agent so that it can be removed from the environment. We report here the successful use of an FeLV test and removal programme to prevent the spread of FeLV, and the diseases it causes, among pet cats. The FeLV test and removal programme consists of the identification and removal, by euthanasia or isolation, of FeLV-infected healthy cats from contact with uninfected cats¹⁶. The IFA test for FeLV detects FeLV gs antigens in the peripheral blood leukocytes and platelets of infected cats^{3,6} and we have previously reported that a positive IFA test result means that the cat is viraemic^{6,13}.

In most multiple cat households in this study an index FeLV test was performed on a sick or healthy cat to establish the FeLV status of the households. The index test-positive cat was removed and all the remaining healthy cats in the household were then tested for FeLV (initial test). In the programme, any exposed healthy cats which were found to be infected with FeLV were removed immediately. After the initial test of all the healthy cats, the household was quarantined so that no cats were allowed to leave and no new cats were brought into the household. After a 3-month interval a second test for FeLV was performed on all the remaining healthy cats in the household and any secondarily infected cats were removed. Cats which were FeLV uninfected in the initial test but which were found to be FeLV infected in the second test will be referred

to as secondarily infected cats in this paper. Two IFA tests for FeLV are required for exposed cats because the natural incubation period for the establishment of viraemia can be as long as 3 months, and there is a possibility that an FeLV infection, occurring just before the first test, would not be detected in that test¹³. If any healthy cats were positive in the second IFA test they were removed from the household and a third test was conducted 3 months later. When all the cats remaining in a household after the infected cats had been removed were negative in two consecutive IFA tests, conducted 3 months apart, the household was considered FeLV free. All new cats which were introduced into an FeLV-free household were tested for FeLV before they were allowed to have contact with the uninfected cats.

A total of 1,260 healthy cats, from 65 households in which cats had developed FeLV-related diseases and from 11 breeding catteries, have been studied (Table 1). In 51 of these households the test and removal programme was implemented, while in 25 households the owners chose not to implement the programme. These 25 households served as controls and were therefore compared with the 51 households in which the owners implemented the FeLV test and removal programme. A total of 847 cats were tested for FeLV in the 51 households in which the programme was implemented (Table 2). Of these 847 cats, 190 cats were found to be infected in the initial FeLV test (an initial infection rate of 22.4%) and were immediately removed from contact with the remaining 657 uninfected cats. Only 3 of these 657 uninfected healthy cats were found to be infected in the second test. In the 3-month period between the two IFA tests, 99.54% of the initially uninfected cats therefore remained uninfected (a secondary infection rate of 0.46%).

In the 25 households where the FeLV-infected healthy cats were not removed, and thus remained in continual contact with other cats in the households, a total of 413 cats were tested for FeLV and 129 were found to be infected in the initial test (an initial infection rate of 31.2%). Of the remaining 284 uninfected healthy cats in these households, 55 were found to be infected in the second test (a secondary infection rate of 19.3%) (Table 2). Thus only 80.7% of the initially uninfected cats remained uninfected in the 3-month period between the two tests. The secondary FeLV infection rate in the households in which the FeLV test and removal programme was not implemented was 42 times greater than that in households in which the programme was implemented. This difference is highly significant ($P \leq 0.0001$) by the χ^2 test. Thus the natural contagious spread of FeLV between cats was effectively prevented by the FeLV test and removal programme.

We have reported previously that FeLV-infected cats have a significantly higher chance of developing one of the FeLV-related diseases³ and a much higher mortality rate than uninfected cats¹⁷. There was a marked difference in the occurrence of the disease and the mortality rate of cats living in the two household groups. The development of FeLV-related diseases was prevented in healthy cats living in the 51 households in which the test and removal programme was implemented. In contrast, in the 25 households where the programme was not implemented, 7 cats have developed LSA, 4 cats have developed FeLV non-regenerative anaemia and 13 cats have developed other FeLV-associated diseases within the 2-yr observation period (Table 3).

The natural mortality rate for the 3 healthy initially uninfected cats which became secondarily infected in those households in which the programme was implemented was not determined since the cats were euthanised immediately after they were found to be infected and thus did not have a chance to develop disease. In the 25 households in which the programme was not implemented 24 of the 55 secondarily infected cats subsequently died resulting in a mortality rate of 52%.

Table 1 Disease and FeLV status of household groups before the FeLV test and removal programme

Household groups	Number of households	Number of cats with FeLV diseases				Index FeLV test*		Total cats remaining after diseased cats died
		Total cats	Lymphosarcoma	FeLV anaemia	Other	Household status FeLV infected	Not tested	
Households where FeLV-infected healthy cats were removed	51	923	42	6	28	37	14†	847
Households where FeLV-infected healthy cats were not removed	25	472	37	4	18	23	2‡	413
								Total 1,260

*An index FeLV test was the first IFA test of a cat in a household

†Index FeLV tests were not performed in 10 breeding catteries because no cats had previously developed an FeLV disease. No index tests were performed in the other 4 households where cats had developed FeLV diseases because these cats had died before our study began

‡An index FeLV test was not performed in 1 household (a breeding cattery) because no cat had previously developed an FeLV disease. An index test was not performed in the other household where a cat had developed an FeLV disease because this cat had died before our study began.

Table 2 Summary of the test and removal programme to prevent the contagious spread of FeLV in healthy pet cats

Household groups	Number of households	Number of healthy cats in households	Number of healthy cats tested	Initial test of healthy cats FeLV results		Initial infection rate	Number of healthy cats removed	Second test* of healthy cats FeLV results		Number of healthy cats which became secondarily† infected	Secondary infection rate of healthy cats
				Infected	Uninfected			Infected	Uninfected		
Households where FeLV-infected healthy cats were removed	51	847	847	190	657	22.4%	190	3	654	3	0.46%
Households where FeLV-infected healthy cats were not removed	25	413	413	129	284	31.2%	0	184	229	55	19.3%

*The second FeLV test was performed at least 3 months after the initial FeLV test.

†A secondarily infected cat is one which was FeLV uninfected in the initial test but was found to be infected in the second test.

Table 3 Summary of disease development in household groups

Household groups	Number of households	Number of initial test FeLV-uninfected cats	Disease development in secondarily* FeLV-infected healthy cats				Number of cats which became secondarily infected	Number of cats which died naturally	Natural mortality rate in secondarily FeLV-uninfected healthy cats	Natural mortality rate in secondarily FeLV-infected healthy cats
			Lymphosarcoma	Other FeLV† caused diseases	Other non-FeLV‡ caused diseases	Euthanised				
Households where FeLV-infected healthy cats were removed	51	657	—	—	—	3	—	—	—	—
Households where FeLV-infected healthy cats were not removed	25	284	7	6	11	9	22	24	8.5%	52%

*A secondarily infected cat is one which was FeLV uninfected in the initial test but was found to be infected in the second test.

†4 cats with FeLV non-regenerative anaemias; 2 cats with the panleukopenia-like syndrome.

‡3 cats with feline infectious peritonitis; 8 other diseases—these diseases occur frequently in FeLV-infected cats due to the immunosuppressive effects of the virus.

§These cats subsequently became secondarily infected with FeLV.

These 24 deaths represent a natural mortality rate of 8.5% of the 284 initially FeLV-uninfected healthy cats (Table 3).

Some healthy cats living in households where the control programme was not implemented remained uninfected even though they were continually exposed to viraemic cats. To ensure that the test and removal programme, rather than FeLV neutralising antibody, was responsible for the protection of uninfected cats, cats living in selected households which implemented the programme were examined for neutralising antibody. Forty-one per cent of these cats tested had protective ($\geq 1:10$) neutralising antibody titres. Fifty-nine per cent of the cats thus had non-protective antibody titres and were susceptible to FeLV infection. Because of the implementation of the test and removal programme, however, these susceptible cats were not continuously exposed to FeLV and thus remained uninfected and did not develop any FeLV related diseases.

Pet cats of all ages are susceptible to FeLV infection in their natural household environments. The median age when FeLV was first detected in 49 of the secondarily infected pet cats in our study was 24.0 months. The median age at which these cats were last tested and found to be uninfected was 18.0 months. Therefore, between 18 and 24 months these adult pet cats became infected with FeLV in their household environments.

The FeLV test and removal programme is currently being used by many veterinarians to protect FeLV-uninfected cats from FeLV infection and disease development¹⁶. The diseases caused by, or associated with, FeLV can be prevented by the test and removal programme. This is significant since diseases caused by and associated with FeLV are probably the most common killer of pet cats.

The results obtained by identifying and removing the healthy inapparent FeLV-infected carrier cats show for the first time that it is possible to prevent the contagious spread of a mammalian oncornavirus in the natural environment. FeLV and the diseases it causes may ultimately be controlled by a combination of the test and removal programme and vaccination.

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