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Prevalence of feline infectious peritonitis in specific cat breeds[☆]

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Although known that purebreed cats are more likely to develop feline infectious peritonitis (FIP), previous studies have not examined the prevalence of disease in individual breeds. All cats diagnosed with FIP at a veterinary teaching hospital over a 16-year period were identified. Breed, sex and reproductive status of affected cats were compared to the general cat population and to mixed breed cats evaluated during the same period. As with previous studies sexually intact cats and purebreed cats were significantly more likely to be diagnosed with FIP; males and young cats also had a higher prevalence of disease. Abyssinians, Bengals, Birmanians, Himalayans, Ragdolls and Rexes had a significantly higher risk, whereas Burmese, Exotic Shorthairs, Manxes, Persians, Russian Blues and Siamese cats were not at increased risk for development of FIP. Although additional factors doubtlessly influence the relative prevalence of FIP, this study provides additional guidance when prioritizing differentials in ill purebreed cats.

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Date accepted: 14 April 2005

Feline infectious peritonitis (FIP) is a progressive systemic disease with a wide spectrum of clinical signs and high mortality (Hartmann 2005). It is caused by a mutation in the feline enteric coronavirus, a common pathogen of cats that may cause no clinical signs or transient diarrhea (Pedersen 1995, McReynolds and Macy 1997, Hartmann 2005). The mutated FIP virus disseminates via the monocyte phagocytic system, and variations in an individual cat's immune response produce one of two recognized forms of disease (Pedersen 1995, McReynolds and Macy 1997, Hartmann 2005). The 'wet' form of FIP, seen in approximately 75% of cases, is caused by complement-mediated vasculitis initiated by immune complex deposition in vessel walls, and typically results in body cavity effusions (Pedersen 1995, McReynolds and Macy 1997, Hartmann 2005). The 'dry' form of FIP,

found in the remainder of cases, results when a cell-mediated immune response dominates and granulomas form in various organs (Pedersen 1995, McReynolds and Macy 1997, Hartmann 2005).

Epidemiologic studies of cats with FIP have identified several risk factors for development of disease. The highest prevalence is in young cats (3 months to 3 years of age) with the majority of cases (75%) in multi-cat environments (Kass and Dent 1995, Pedersen 1995, Foley et al 1997a, McReynolds and Macy 1997, Rohrbach et al 2001). Males and sexually intact cats are also at increased risk for development of FIP (Robison et al 1971, Rohrbach et al 2001). Other factors that have been less commonly reported to be associated with an increased disease prevalence include season (more cases are typically diagnosed in winter), FeLV infection, an increase in factors associated with 'stress', high coronavirus antibody titer, regular introduction of new cats to a cattery, and increased frequency of coronavirus shedding (Kass and Dent 1995, Pedersen 1995, McReynolds and Macy 1997, Foley et al 1997a, Rohrbach et al 2001).

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Two studies have reported that FIP is more common in purebreed cats (Robison et al 1971, Rohrbach et al 2001). Although the relative prevalence of FIP in different cat breeds has been reported in at least one study, statistical differences were not calculated (Scott 1991). Therefore, to the authors' knowledge, whether a specific breed predisposition exists has never been thoroughly investigated. The purpose of this study was to determine whether such a breed predilection exists in cats. Sex and age of affected cats were also examined in order to allow some comparison between the current study population and those in previous studies.

Materials and methods

The final diagnosis was reviewed for all cats entered in the computerized patient database of the North Carolina State University College of Veterinary Medicine (NCSU-CVM) between December 22, 1986 and December 22, 2002. Cats with FIP were identified using the coding terms 'feline infectious peritonitis' or 'FIP'. Final diagnosis in all cases had been determined by the attending clinician; criteria used for diagnosis and results of antemortem or post-mortem diagnostic test results were not reviewed.

Breed, sex, and reproductive status of all cats evaluated at the NCSU-CVM during the 16-year study period were reviewed; all cats of unknown breed were excluded. Mixed breed cats of all hair lengths (domestic shorthair, mediumhair and longhair) were considered a single breed (termed 'mixed breed') for data analysis purposes. Descriptive statistics were calculated for each variable studied for the FIP population and for the total cat population. Descriptive statistics for cat age at time of evaluation were calculated only for FIP-affected cats. Breed, sex, and reproductive status differences were compared using the Fisher's exact test; values of P less than or equal to 0.05 were considered significant. Odds ratios (OR) and 95% confidence intervals (CI) were also calculated for each variable.

Results

During the 16-year study period, 11,535 cats of known breed were examined at the NCSU-CVM. Cats examined included mixed breed cats (9511 cats) and 36 different purebreed varieties (2024 cats). Sixty cats (0.52%) had a final diagnosis of FIP; breed was known for all affected cats. Sex and reproductive status information was avail-

able for 57 of the 60 FIP cats and 11,303 of the 11,475 non-FIP cats. Age information was available for 58 of the 60 FIP cats.

Cats diagnosed with FIP included mixed breed cats (33 cats) and 13 different purebreeds (27 cats). Prevalence of FIP in the mixed breed cat population was 0.35% versus 1.3% in the purebreed cat population (Fig 1). Purebreed cats were significantly more likely to be diagnosed with FIP than were mixed breed cats (OR 4.5, CI 2.7–7.5; $P < 0.001$). Breeds with a prevalence of FIP significantly greater than mixed breed cats included the Abyssinian, Bengal, Birman, Himalayan, Ragdoll, and Rex (including Cornish and Devon varieties) breeds (Table 1, Fig 2). The prevalence of FIP in Burmese, Exotic Shorthair, Manx, Persian, Russian Blue, and Siamese cats was not significantly different from mixed breed cats. The two Havana Brown cats evaluated at the NCSU-VTH during the study period were both diagnosed with FIP, but this small number precluded statistical analysis.

Twenty-three cat breeds had an FIP prevalence of zero. These included the Angora (11 cats evaluated during study period), Balinese (25 cats), Belgian (two cats), Bombay (four cats), British Blue (two cats), British Shorthair (three cats), Chartreux (four cats), Colorpoint Shorthair (one cat), Egyptian Mau (one cat), Japanese Bobtail (six cats), Korat (five cats), Maine Coon (151 cats), Maltese (two cats), Norwegian Forest Cat (five cats), Ocicat (16 cats), Ragamuffin (one cat), Scottish Fold (15 cats), Siberian (one cat), Snowshoe (two cats), Somali (three cats), Sphinx (one cat), Tonkinese (18 cats), and Turkish Van (two cats) breeds. Unfortunately, the low prevalence of FIP in the mixed breed cat population prevented determination of significance or relative risk in these purebreed cat varieties.

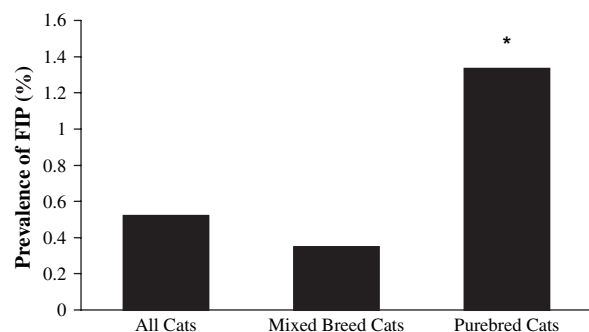


Fig 1. Prevalence of feline infectious peritonitis (FIP) in cats by cat group. *Statistically significant difference from mixed breed cats.

Table 1. Prevalence, odds ratios, and confidence intervals for purebreed cats with feline infectious peritonitis (FIP)

Breed ^a	Cats diagnosed with FIP/total number cats seen (% affected with FIP)	Odds ratio	Confidence interval	P-value (Fisher's exact test)
Abyssinian	3/99 (3.0%)	8.98	2.71–29.77	0.006
Bengal	1/8 (12.5%)	41.03	4.91–342.85	0.028
Birman	4/18 (22.2%)	82.06	26.66–262.44	<0.001
Burmese	1/37 (2.7%)	7.98	1.06–59.91	0.124
Exotic Shorthair	1/62 (1.6%)	4.71	0.63–34.98	0.199
Havana Brown	2/2 (100%)	– ^b	– ^b	– ^b
Himalayan	4/364 (1.1%)	3.19	1.12–9.06	0.046
Manx	1/67 (1.5%)	4.35	0.59–32.29	0.213
Persian	4/481 (0.5%)	2.41	0.85–6.83	0.101
Ragdoll	2/13 (15.3%)	52.22	11.14–244.79	0.001
Rex (Cornish and Devon)	2/17 (11.7%)	38.29	8.42–174.15	0.002
Russian Blue	1/39 (2.6%)	7.56	1.01–56.68	0.130
Siamese	1/536 (0.2%)	0.54	0.07–3.93	1.00

^aBreeds with 0.0% prevalence of feline infectious peritonitis not listed.

^bInsufficient number of cats to allow statistical calculations.

Cats with FIP were significantly more likely to be sexually intact when compared to the general cat population, regardless of whether the cats were male or female (intact male versus castrated male, $P < 0.001$; intact female versus spayed female, $P = 0.002$; all intact cats versus all altered cats, $P < 0.001$; prevalence of intact cats in the general population was 15.8%, versus 45.6% in the FIP population). Although more cats with FIP were male than female, the difference in prevalence was not statistically significant ($P = 0.425$; 53.6% of the total cat population was male, versus 59.6% of the FIP population). At the time of last evaluation the median age of cats with FIP was 0.96 years (25th percentile 0.5 years, 75th percentile 2.0 years). Sixty-seven percent of cats with FIP were less than 2 years of age.

Discussion

Although the increased prevalence of FIP in purebreed cats has been previously reported, this is the first time that a predisposition of specific breeds to the development of disease has been examined (Robison et al 1971, Rohrbach et al 2001). Our results show that certain breeds may in fact be more likely to develop FIP, particularly the Birman, Ragdoll, Bengal, Rex, Abyssinian, and Himalayan breeds. Other breeds of cats, the Burmese, Exotic Shorthair, Manx, Persian, Russian Blue, and Siamese, did not appear to be at

increased risk as compared to mixed breed cats. Our results on the effects of sex, reproductive status, and age on the relative prevalence of FIP are similar although not identical to previous studies (Robison et al 1971, Horzinek and Osterhaus 1979, Kass and Dent 1995, Rohrbach et al 2001).

Previous evidence supports an influence of host genetics on mutation of the feline enteric coronavirus or on susceptibility to FIP. Cheetahs, whose genome has become more homozygous with minimal allelic diversity due to an evolutionary bottleneck, have a very high prevalence of FIP (O'Brien et al 1985). Similarly, the increased prevalence we found in some purebreed varieties could be due to a concentration of

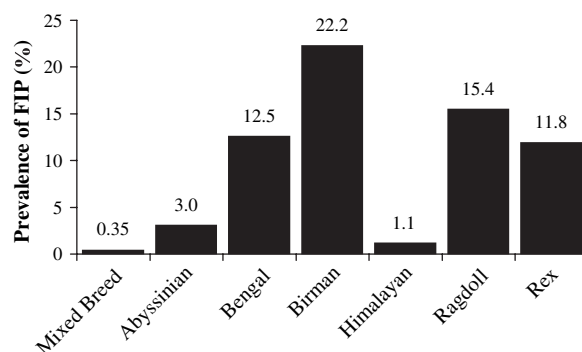


Fig 2. Prevalence of feline infectious peritonitis (FIP) in mixed breed cats and in breeds with FIP prevalence significantly different ($P < 0.05$) from mixed breed cats.

inherited factors through in-breeding or small founder populations. Given a common environment and viral strain, Foley and Pedersen (1995) calculated that slightly greater than 50% of FIP susceptibility in purebred cats from six catteries could be attributed to inherited differences between individuals. Interestingly, in this study one of the catteries with numerous closely related FIP-affected cats was a Birman cattery (Foley and Pedersen 1995). Birmans were by far the most commonly affected in the study reported here, and therefore we may not be the first to provide evidence of an increase in susceptibility to FIP in this breed.

Other investigators have questioned whether the increased prevalence of FIP in purebred cats may actually be due to confounding factors. Purebred cats are more likely to be raised in catteries, which may be inherently more stressful because of the multi-cat environment, regular introduction of new cats, and frequent breeding (Kass and Dent 1995, Pedersen 1995). Additionally, cattery cats presumptively have greater exposure to feline enteric coronavirus (a requirement for development of FIP) due to increased population density (Foley et al 1997a, 1997b, McReynolds and Macy 1997). Finally, the possible increased willingness of owners of expensive purebred cats to pursue advanced diagnostics and supportive treatment at a referral veterinary facility such as the NCSU-VTH may skew the apparent prevalence of disease. However, these factors would be expected to falsely increase the prevalence of FIP in all purebred cats and not just those breeds we report to be at increased risk of disease development.

In this report we chose to include cases based on final diagnosis entered into our computerized medical database rather than by review of records and histopathology reports. As a result, we must acknowledge that future investigations that are limited to cases with confirmed diagnoses could yield different results. However, because the ante-mortem diagnosis of FIP at our tertiary care treatment hospital is expected to be similar to diagnostic algorithms proposed by other authors, we feel that our results, particularly in breeds with larger numbers or particularly strong associations with disease, are unlikely to conflict with future studies (Sparkes et al 1991, Rohrer et al 1993, Addie and Jarrett 1998).

Multivariate analysis of the variables studied here would further define specific breed susceptibility to FIP. For example, it is unknown if the

breeds with an increased prevalence of FIP actually had larger numbers of intact cats evaluated, thus influencing our calculations. Furthermore some breeds had very few individuals examined, and the large CI reflect the lack of precision in determining risk. We doubt that the absence of cats diagnosed with FIP in 23 breeds indicates an absolute resistance to disease, although it is possible that some of these breeds (such as Maine Coon cats, which were seen at the NCSU-VTH in relatively larger numbers) possess unrecognized protective factors that influence susceptibility. Unfortunately, because of the low prevalence of FIP in all cats a much larger population would need to be examined to determine if lack of disease in these breeds is statistically significant.

The predisposition of certain breeds to the development of FIP demonstrated here warrants further research. Our results suggest that the index of suspicion for FIP should possibly be increased in some ill purebred cats. A multi-center study that includes cases from primary as well as referral facilities with multivariate analysis is likely necessary to definitively answer the question of individual breed susceptibilities to FIP.

Acknowledgements

The authors thank Cavell Brownie, PhD (Department of Statistics, North Carolina State University) for performing the statistical analyses and Malcolm Roberts, BVSc, PhD, MPH, FRCVS, FACVSc (Department of Clinical Sciences, North Carolina State University) for manuscript review.

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