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Risk factors for FCoV infection in client-owned cats in Zagreb and Varaždin, Croatia

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ABSTRACT –Epidemiological parameters of feline coronavirus infected cats are important for the prevention of feline coronavirus (FCoV) infection. This retrospective study aimed to determine risk factors for FCoV infection in client-owned cats in Croatia.FCoV infection was registered significantly more frequentlyin cats with access to the outdoors.FCoV infection was registered more frequently infemale cats andin multi-cat households.The results of this study confirmed that the access to the outdoor is an important risk factor for the occurrence, development and spread of FCoV infection in the owned cat population. Further research using a larger population of owned and stray FCoV+ cats from different urban areas is required because this study is underpowered for statistical analyses.

Keywords—Risk factors, feline coronavirus, cat

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1. INTRODUCTION

FCoV infection is prevalent in pet cats and is common viral pathogen in multi-cat households (Holst *et al.*, 2006; Sharif *et al.*, 2009). 5-10% of FCoV seropositive cats may develop feline infectious peritonitis (FIP), which is an immune-mediated and fatal disease (Baneth *et al.*, 1999; Almeida *et al.*, 2019). In Croatia, high prevalence rate of FCoV infection has been confirmed (Raukar, 2021), but no studies of risk factors for FCoV infection in Croatian cat population have been conducted according to the literature. Epidemiological parameters of feline coronavirus infected cats are important for the management, control and prevention of FCoV infection (Holst *et al.*, 2006; Oğuzoğlu *et al.*, 2013; Almeida *et al.*, 2019).For these reason, the aim of these study was to determine risk factors for FCoV infection in client-owned cats in Croatia.

2. MATERIALS AND METHODS

2.1. Animals

This study enrolled 79 client-owned cats that were included in a previous study (Raukar, 2021), in which those cats were tested for anti-FCoV antibodies.Blood sampling and virological laboratory method for the detection of FCoV infection have been described in this study (Raukar, 2021).Risk factors for FCoV infection were not presented in this previous study (Raukar, 2021). Therefore, risk factors for FCoV infection in client-owned cats are presented in this study.

2.2. Ethical consideration

Ethical approval (Ministry of Agriculture of the Republic of Croatia, area codes: 525-6-08-3 BBŠ; 525-6-08-5 BBŠ) was not required for this research.

2.3. Data collection of potential risk factors

Data on epidemiological factors such ofgender, housing conditions (single or multi-cat household) and lifestyle (whether the cat was housed exclusively indoors, or cat was allowed to go outside and was able to roam freely) were recorded by the veterinarian in a questionnaire at the time of blood sample collection in veterinary clinics in Zagreb and Varaždin, Croatia.

2.4. Statistical analysis

Statistical evaluation ofgender, household characteristics and lifestyle in two groups; uninfected cats (FCoV- cats) and infected cats (FCoV+ cats) was conducted with the program IBM SPSS Statistics Version 23.0. Results were presented in tabular form.

For determining whether there was statistically significant difference ($p < 0.05$) between two groups; non-infected and infected cats bygender (male cats, female cats), household characteristics (single cat households, multiple-cat households) and lifestyle (exclusively indoor cats, cats with access to the outdoors)was used non-parametric test for two independent samples – Mann - Whitney U test.

3. RESULTS

In total, 79 samples from client-owned cats were included in this study. The sampled cats were characterized by gender, household characteristics and lifestyle (Table 1). Out of the 79 cats were tested in previous study (Raukar, 2021), 55.7% (44/79) were positive for anti-FCoV antibodies and 44.3% (35/79) were negative for anti-FCoV antibodies. A total of 36 male cats (45.6%) and 43 female cats (54.4%) were included in this study.Twenty-two cats lived in single cat households (27.8%) and 57 cats lived in households with two or more cats (72.2%). Forty-two cats had outdoor access (53.2%) and 37 cats were kept strictly indoors (46.8%).

There were no statistically significant differences ($p>0.05$) related to gender and number of cats per household between FCoV+ cats and non-infected cats(Table 2).

Lifestyle (outdoor access) was significantly associated with FCoV seropositive status.The outdoor access was statistically significantly different ($p <0.05$) between FCoV+ cats and non-infected cats (Table 2).

Table 3 shows frequencies of FCoV seroprevalence classifications for gender for each group(infected cats,FCoV+ cats and non-infected cats, FCoV-cats).

Table 4 shows frequencies of FCoV seroprevalence classifications for household characteristics for each group (infected cats, FCoV+ cats and non-infected cats, FCoV-cats).

Table 5 shows the frequencies of FCoV seroprevalence classifications for outdoor accessfor each group(infected cats, FCoV+ cats and non-infected cats, FCoV-cats).

4. DISCUSSION

FCoV is spread predominantly through fecal-oral route(Sharif *et al.,* 2009) especially in cats living in multi-cat households where cats share same litter trays with a FCoV-infected cats (Bell *et al.,* 2006; Holst *et al.,* 2006). FCoV is also spread by the oro-nasal secretions and in urine(Sharif *et al.,* 2009).

In this study the prevalence of FCoV infection was registered more frequently in cats living in multi-cat households (Table 4) where cats shared same litter trays (Baneth *et al.,* 1999), because multicat environments increase the possibility for fecal-oral transmission(Bell *et al.,* 2006; Holst *et al.,* 2006; Sharif *et al.,* 2009).This result is consistent with the studies in Sweden (Holst *et al.,* 2006), Poland (Rypula *et al.,* 2014), Turkey (Tekelioglu *et al.,* 2015) and Brazil (Almeida *et al.,* 2019). Study in Australia (Bell *et al.,* 2006) reported significant association between household conditions and seropositivity to FCoV infection. In this study Bell *et al.,* (2006) reported that the seroprevalence of FCoV was significantly higher in multi-cat household than in single cat household.

Outdoor owned cats can be infected with the FCoV virus from interaction with infected owned or infected stray cats (Bell *et al.,* 2006; Suba *et al.,* 2015).Territorial fighting behaviors also increase the possibility of FCoV transmission, because, stressful environments and cat density increase the contact with FCoV strains (Suba *et al.,* 2015; Almeida *et al.,* 2019).

Stress increases the risk of FCoV shedding and the development of FIP (Suba *et al.,* 2015; Klein-Richers *et al.,* 2020). A stress associated increase in glucocorticoid release could be responsible for the suppression of cell-mediated immunity, resulting in higher FCoV replication (Klein-Richers *et al.,* 2020). Overcrowdingwith cats in multi-cat households might be also stressful environments for cats (Bande *et al.,* 2012; Suba *et al.,* 2015; Rocha *et al.,* 2019; Klein-Richers *et al.,* 2020).

Outdoor access was significantly associated with the FCoV infection in this study.FCoV infection was significantly more frequently registered incats with access to the outdoors in presented study(Tables 2 and 5).In contrast with my result, study in Brazil (Almeida *et al.,* 2019) reported that the seroprevalence of FCoV infection in indoor cats was significantly higher than the seroprevalence in outdoor cats. Almeida *et al.,* (2019) observed that indoor cats are 4 times more likely to be seropositive than cats with access with outdoors. On the other hand, Bell *et al.,* (2006) observed no significant association between lifestyle and seropositivity to FCoV. Study in Australia (Bell *et al.,* 2006) reported that FCoV seroprevalence was more frequently registered in exclusively indoor cats. According to this study (Bell *et al.,* 2006) outdoor access reduces the risk of FCoV infection,

because cats with outdoor access have the opportunity to bury their feces outside and so minimize fecal-oral contact and FCoV transmission.

The gender of FCoV-infected cats in presented study was not significantly different compared to non-infected cats(Table 2). This result is in agreement with (Rodgers & Baldwin, 1990; Baneth *et al.,* 1999; Moestl *et al.,* 2002; Bell *et al.,* 2006; Sharif *et al.,* 2009; Oğuzoğlu *et al.,* 2010; Taharaguchi *et al.,* 2012; Oğuzoğlu *et al.,* 2013; Rypula *et al.,* 2014; Tekelioglu *et al.,* 2015; Almeida *et al.,* 2019), who observed no significant association between gender and FCoV infection.In this study FCoV infection was more frequently registered in female cats (Table 3). This result is in accordance with studies in Israel (Baneth *et al.,*1999), Czech Republic (Moestl *et al.,* 2002) and Malaysia (Sharif *et al.,* 2009), but inconsistent with studies in the United States (Rodgers & Baldwin, 1990), Austria (Moestl *et al.,* 2002), Australia (Bell *et al.,* 2006), Japan (Taharaguchi *et al.,* 2012), Turkey(Oğuzoğlu *et al.,* 2010; Oğuzoğlu *et al.,* 2013; Tekelioglu *et al.,* 2015)and Brazil (Almeida *et al.,* 2019), in which FCoV infection was registered more frequently in male cats. Based on the above literature data, it can be concluded that therehas not been a strong agreement or conclusion among the researchers which gender is more susceptible to FCoV infection.Thesedifferences between studies might be related to male and female cats having different lifestyle and FCoV exposure (Tekelioglu et al., 2015).

5. CONCLUSION

The results of this study confirmed that the access to outdoor is an important risk factor for the occurrence, development and spread of FCoV infection in the owned cat population. Further research using a larger population of owned and stray FCoV+ cats from different urban areas is required because this study is underpowered for statistical analyses.

Conflict of Interest Statement

The author declares that there is no conflict of interest.

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Table 1: Descriptive data on the prevalence of FCoV, gender, household characteristics and lifestyle of the client-owned cats in Zagreb and Varaždin, Croatia

Variables	**N**		**%**	
	Yes	No	Yes	No
Cats positive for anti-FCoV antibodies	44	35	55.7%	44.3%
	Male	Female	Male	Female
Gender	36	43	45.6%	54.4%
	Single cat household	Multi-cat household	Single cat household	Multi-cat household
Number of cats per household	22	57	27.8%	72.2%
	Yes	No	Yes	No
Outdoor access	42	37	53.2%	46.8%

N – total number of cats; % - percentage

Table 2: Results of Mann -Whitney U test of risk factors for infection with FCoV

Variable	Cats positive for anti-FCoV antibodies	Mean Rank	Mann-Whitney U test	p
Gender	Yes	40.05	768	.98
	No	39.94		
Number of cats per household	Yes	42.02	681	.26
	No	37.46		
Outdoor access	Yes	35.86	588	**.04***
	No	45.20		

p – value level of significance;* - statistically significant at the 5%

Table 3: Frequencies of FCoV seroprevalence classifications for gender		
FCoV seropositive status	Gender	N
FCoV+ cats	Male	20
	Female	24
FCoV- cats	Male	16
	Female	19

N – total number of cats

Table 4: Frequencies of FCoV seroprevalence classifications for household characteristics		
FCoV seropositive status	Number of cats per household	N
FCoV+ cats	Single cat household	10
	Multi-cat household	34
FCoV- cats	Single cat household	12
	Multi-cat household	23

N – total number of cats

Table 5: Frequencies of FCoV seroprevalence classifications for outdoor access		
FCoV seropositive status	Outdoor access	N
FCoV+ cats	Yes	28
	No	16
FCoV- cats	Yes	14
	No	21

N – total number of cats

LIST OF ABBREVIATIONS

FCoV: feline coronavirus

FIP: feline infectious peritonitis

N: total number of cats

p: value level of significance

*: statistically significant at the 5%