Potential risk factors as age, sex, and regionality in 37,975 cats tested serologically for *Toxoplasma*-specific antibodies (2008-2022)

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KEY POINTS

- More than a third of the cats included in the study tested positive for IgG- (37%) and 4% tested positive for IgM-antibodies
- Wide variation of positive serological test results for *Toxoplasma* spp. between individual countries in Europe
- Statistically significant association of sex, age, seasonality, and regionality with serological results

INTRODUCTION

- *Toxoplasma gondii* = obligatory intracellular protozoan pathogen affecting wild felids and domestic cats as final hosts[1]
- Shedding of oocysts in seronegative cats mainly between July and December (not age-dependent)[2], unlikely in seropositive cats (time needed for seroconversion)[1]
- High geographical variation of antibody prevalence[3,4]
- Development of IgG-antibodies in all infected cats for at least 6 years p. i., detection of IgM in approximately 80% for 16 weeks p. i.[1,5,6]
- Clinical significance in immunosuppressed cats (e. g. FeLV, FIV)[7]
- Zoonosis = ingestion of oocyst contaminated soil, water, and/or meat by humans[8]

AIMS OF THE STUDY

1. Evaluation of the percentage of seropositive domestic cats tested from 2008-2022
2. Identification of potential risk factors for positive serological test results

MATERIAL AND METHODS

- Screening of the database for serological test results of *Toxoplasma* spp. in cats January 2008 – March 2022: MegaFLUO® TOXOPLASMA IFAT (MEGACOR Veterinary Diagnostics, Hörbranz, Austria)
  - April – December 2022: NovaTec VetLine Toxoplasma ELISA (IgG), Nova Tec VetLine Toxoplasma IgM ELISA (IgM) (NovaTec Immundiagnostica GmbH, Dietzenbach, Germany)
- Fisher's exact test and chi-square test for statistical impact of age (< 5 years, ≥ 5 years), sex, season, and regional distribution on serological results
- Binary multiple logistic regression to evaluate potential risk factors

RESULTS

- Inclusion of 37,975 cats from 33 European countries (Figure 1)
- 14,188/37,975 (37.4%) tested IgG and 1,544/37,972 (4.1%) tested IgM positive
- Age (IgG, IgM), sex (IgG), castration status (IgG), breed (IgG, IgM), seasonality (IgM) and regionality (IgG, IgM) with statistically significant impact ($P < 0.001$, each) (Table 1 - 3)
- Pure-bred cats with statistically significant lower odds for positive serological test results compared to all other cats in IgG- and IgM-testing (Table 3)
- Statistically significant impact of almost all regions in Europe on serological results (Table 3)

Table 1:Sex of cats tested for *Toxoplasma* spp. by serological detection methods from 01/2008 till 12/2022 (*n* tested positive/*N* total (%) [95% CI lower bound, 95% CI upper bound])

Sex	IgG ELISA	IgM ELISA
Male intact	1,548/5,342 (29.0 [27.8, 30.2])	217/5,342 (4.1 [3.6, 4.6])
Male castrated	5,193/12,006 (43.3 [42.4, 44.1])	524/12,006 (4.4 [4.0, 4.7])
Female non-spayed	1,505/5,387 (27.9 [26.8, 29.2])	222/5,386 (4.1 [3.6, 4.7])
Female spayed	4,030/10,015 (40.2 [39.3, 41.2])	414/10,013 (4.1 [3.8, 4.5])
Total	12,276/32,750 (37.5 [37.0, 38.0])	1,377/32,747 (4.2 [4.0, 4.4])
P	$P < 0.001$	$P = 0.742$

Table 2: Seasonal distribution of serological test results for *Toxoplasma* spp. in cats from 01/2008 till 12/2022 (*n* tested positive/*N* total (%) [95% CI lower bound, 95% CI upper bound])

Season	IgG ELISA	IgM ELISA
Spring (March – May)	3,484/9,213 (37.8 [36.8, 38.8])	387/9,210 (4.2 [3.8, 4.6])
Summer (June – August)	3,406/9,212 (37.0 [36.0, 38.0])	472/9,212 (5.1 [4.7, 5.6])
Autumn (September - November)	3,590/9,734 (36.9 [35.9, 37.8])	366/9,734 (3.8 [3.4, 4.2])
Winter (December – February)	3,708/9,816 (37.8 [36.8, 38.7])	319/9,816 (3.2 [2.9, 3.6])
Total	14,188/37,975 (37.4 [36.9, 37.9])	1,544/37,972 (4.1 [3.9, 4.3])
P	$P = 0.379$	$P < 0.001$

Table 3: Binary multiple logistic regression analysis in cats with known age, sex, castration status, breeds, and regions tested for *Toxoplasma* spp. by IgG and IgM ELISA

	N cats	B	SE	Wald	*P*	Odds Ratio	95%-CI for Odds Ratio	
							Lower bound	Upper bound
IgG ELISA								
Age (≥ 5 years)	**29,963**	**0.953**	**0.024**	**1513.152**	**< 0.001**	**2.593**	**2.471**	**2.720**
Sex (male)	**32,750**	**0.125**	**0.023**	**29.686**	**< 0.001**	**1.133**	**1.083**	**1.185**
Castration male (yes)	**17,348**	**0.625**	**0.035**	**312.708**	**< 0.001**	**1.868**	**1.743**	**2.002**
Castration female (yes)	**15,402**	**0.552**	**0.037**	**227.910**	**< 0.001**	**1.737**	**1.617**	**1.866**
Breed (ESH, mix, U)	**30,278**	**1.344**	**0.037**	**1342.827**	**< 0.001**	**3.835**	**3.569**	**4.121**
Region (North)	**37,975**	**-0.265**	**0.041**	**41.658**	**< 0.001**	**0.768**	**0.708**	**0.832**
Region (South)	**37,975**	**-0.643**	**0.042**	**236.438**	**< 0.001**	**0.525**	**0.484**	**0.570**
Region (Central)	**37,975**	**0.375**	**0.024**	**241.020**	**< 0.001**	**1.455**	**1.388**	**1.526**
Region (West)	**37,975**	**-0.223**	**0.046**	**23.405**	**< 0.001**	**0.800**	**0.731**	**0.876**
Region (East)	37,975	0.049	0.044	1.197	0.274	1.050	0.962	1.145
IgM ELISA								
Age (≥ 5 years)	**29,961**	**0.669**	**0.061**	**119.984**	**< 0.001**	**1.952**	**1.732**	**2.200**
Sex (male)	32,747	0.035	0.055	0.404	0.525	1.036	0.929	1.154
Castration male (yes)	17,348	0.075	0.082	0.826	0.363	1.078	0.917	1.267
Castration female (yes)	15,399	0.003	0.085	0.001	0.970	1.003	0.849	1.185
Breed (ESH, mix, U)	**30,272**	**0.763**	**0.094**	**66.373**	**< 0.001**	**2.145**	**1.785**	**2.577**
Region (North)	**37,972**	**0.380**	**0.084**	**20.367**	**< 0.001**	**1.463**	**1.240**	**1.725**
Region (South)	**37,972**	**0.568**	**0.076**	**56.167**	**< 0.001**	**1.764**	**1.521**	**2.047**
Region (Central)	**37,972**	**-0.486**	**0.054**	**82.641**	**< 0.001**	**0.615**	**0.554**	**0.683**
Region (West)	37,972	0.071	0.107	0.433	0.511	1.073	0.869	1.325
Region (East)	**37,972**	**0.277**	**0.098**	**8.018**	**0.005**	**1.320**	**1.089**	**1.599**

B: unstandardized regression weight; ESH: European Shorthairs; mix = mixed bred cats; SE: standard deviation to the mean; U = unknown. Degrees of freedom were 1 for all Wald statistics

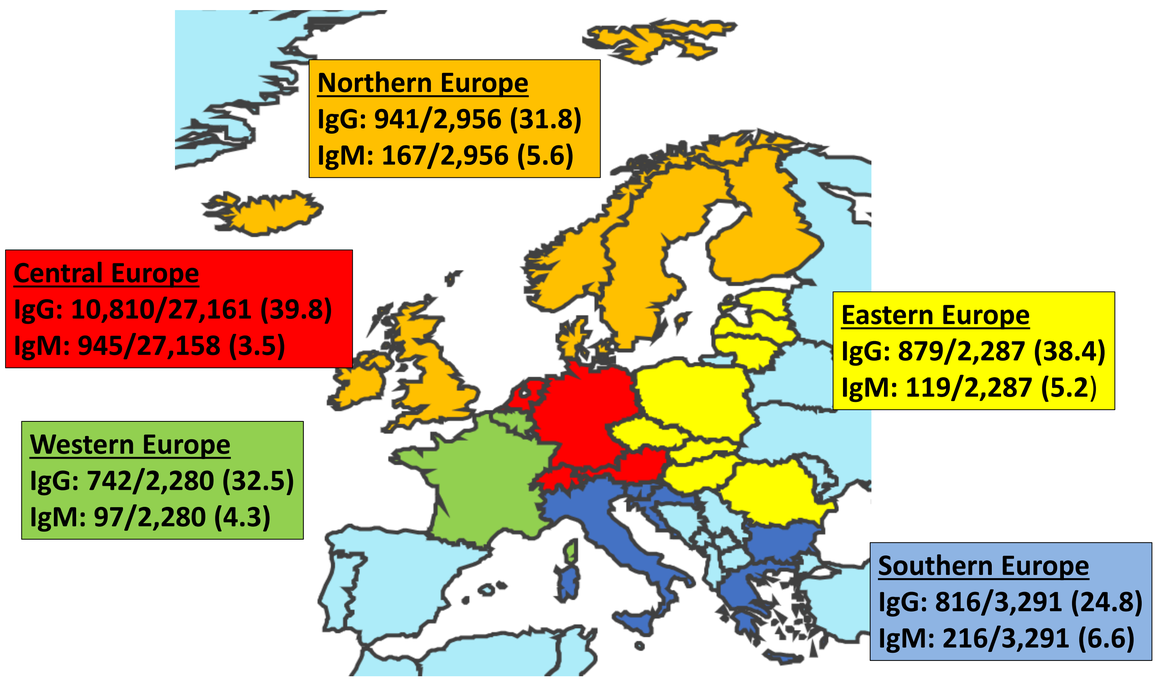

Figure 1: Regional distribution of serological results of IgG and IgM ELISA-testing for *Toxoplasma* spp. in cats in Europe from 01/2008 till 12/2022 (*n* tested positive/*N* total (%))

DISCUSSION

- Exposure to *Toxoplasma* spp. in more than one third of cats in Europe in accordance with a systematic review covering 1967-2017 with a global prevalence of 35%[4]
- Increasing seroprevalence with age, most likely due to increased risk of exposure over time and immunosuppression[1] with about 2-time higher odds in IgM and IgG testing in our study (identification of rising age as a risk factor in humans as well)[9]
- Outdoor cats more likely to contact intermediate hosts as e.g. rodents (pure-bred cats may be more often kept inside, 2 to 4-time higher odds for mixed breeds and European Shorthair cats in our study)
- Limitations: no information regarding anamnesis, clinical signs, and outcome

References

Guidelines feline toxoplasmosis