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Original Article

Comparison of the prevalence of *Toxocara* egg shedding by pet cats and dogs in the U.S.A., 2011–2014

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ABSTRACT

County based prevalence maps were produced using the annual data from the years 2011 through 2014 of the prevalence of *Toxocara* egg shedding in more than 500,000 pet cat and 2.5 million pet dog fecal samples submitted to centralized testing laboratories. Fecal examination results were obtained at these centers through examination of the samples by centrifugal floatation and microscopy, and were previously reported as annual data on the Companion Animal Parasite Council (CAPC) website. The county maps were generated with mapping and spatial analysis software, and statistical comparisons made using two data analysis packages. The national prevalence of eggs in the feces of pet cats and dogs during this four-year period was 4.6–5.1% and 1.8–2.0%, respectively. Thus, *Toxocara cati* and *Toxocara canis* remain considerably prevalent and geographically distributed in our pet populations in spite of the availability of effective and safe treatments. Furthermore, pet cats are found to be shedding *Toxocara* eggs more commonly than pet dogs. This trend was especially evident in the Northeastern, Midwestern and Southern regions of the U.S.A. when prevalence rates of fecal shedding for cats and dogs in different regions were compared using general linear modeling. In spite of this, fecal endoparasite examination tests for cats comprise only 16–17.6% of the total number of samples annually requested in this data set. This high prevalence of egg shedding poses a significant public health risk, as emphasized by the recent naming of toxocariasis to the list of the top five neglected parasitic infections of Americans. Therefore, it is essential for veterinarians to continue to stress to owners the importance of routine anthelmintic treatment for pets of all ages, and to place greater emphasis on the importance of testing and treatment of parasitic infections in cats.

1. Introduction

Examination of fecal specimens for the detection of parasitic infections in companion animals has been, and remains, an integral part of their care. Recently, the historical in-house processing of fecal samples at veterinary clinics has increasingly shifted toward the use of centralized (nation-wide) diagnostic testing centers for such purposes (e.g. Antech Diagnostics, IDEXX). This new norm, combined with the ability of such companies to process large numbers of samples using standardized procedures, and to collect and store results, has generated large data sets that can facilitate valuable insights into regional testing practices and prevalence of important parasites of companion animals such as *Toxocara*. This common parasite of felids and canids may cause ill-thrift in cats and dogs, deaths in puppies from intestinal perforation and impaction (Bowman, 2014) and has been recently named to the list of the top five neglected parasitic infections of American citizens (CDC, 2014). As there is good evidence that most people in the U.S.A. acquire toxocariasis through ingestion of eggs passed into the environment in the feces of infected canids and felids (Jones et al., 2008), *Toxocara* infection in pets and fecal egg shedding are of great public health importance.

Maps reflecting the annual detection of *Toxocara* eggs in fecal samples of cats and dogs tested at centralized diagnostic centers for the years 2011 to 2014, are currently available on the Companion Animal Parasite Council (CAPC) website ("Parasite Prevalence Maps" CAPC, 2015). These maps offer a broad picture of the percentage of positive samples in a given area, but do not facilitate side-by-side or year-to-year graphical or statistical comparisons between counties, states, or other specific areas. The CAPC maps do clearly show that *Toxocara cati* and *Toxocara canis* are parasites that remain commonly present even in animals receiving some level of veterinary care. Thus, the objective of this study was to use the existing CAPC map data to generate detailed prevalence maps to allow for a closer examination of the trends associated with canine and feline toxocariasis. These are well known zoonotic

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agents, and while it is clear that infections in some hosts, e.g., wildlife, are beyond the reach of veterinarians, the veterinary community is well placed to minimize the prevalence of this infection within owned pets in the U.S.A.

2. Materials and methods

2.1. Data set

For the generation of the county maps, the percentage of fecal samples from companion animals containing *Toxocara* eggs for each year between 2011 and 2014 was recorded for each county from which data are available from the CAPC website (www.capcvet.org). These fecal samples were submitted to commercial laboratories for identification of parasitic infections from animals receiving veterinary care. As shelters commonly have limited funds and are unlikely to submit fecal samples for analysis to a commercial laboratory, these samples are assumed to represent mainly those of owned animals, i.e., pets. Although the specifics on the fecal examination protocols used in the laboratories are not available, the CAPC website has the following statement regarding the generation of the data: "The roundworm, hookworm, and whipworm data are acquired for the maps via centrifugal fecal flotation. Because sensitivity and specificity are variable, all fecal results that follow procedures which include centrifugation and minimum sample size of one gram are accepted. The resultant data must be interpreted understanding these limitations." (CAPC, 2015). The apparent prevalence of infection is represented here by the percentage of fecal samples recorded as containing *Toxocara* eggs at examination. The recorded county data (total number of samples tested and number of samples containing *Toxocara* eggs) were then linked to the five digit Federal Information Processing Standard (FIPS) code (USGS, 2015) which assigned the county areas to location on the mapping program. The completed and verified data set appears as Supplemental Data. Additionally, state prevalence data was collected from the state tallies given on the CAPC web site for each year. Factors influencing the results in the CAPC data set are outlined in an expert article on the organization's website (http://www.capcvet.org/expert-articles/understanding-the-maps-key-factors-that-influence-the-results/). These United States Postal Service (USPS) codes are often unfamiliar to many living outside the U.S.A., and the choice of abbreviation is not always intuitive from the spelling of the state's name. For the purpose of clarity in the text, table, and figures, the states and the District of Columbia are represented at first mention by the name of the state and the USPS two-letter abbreviation, e.g., Alaska (AK), Ohio (OH).

As the data were transcribed and examined, minor discrepancies on the CAPC website became apparent and were resolved to the best of our ability before performing the data analysis, as follows. The first discrepancy observed dealt specifically with the data compiled for the Commonwealth of Virginia (VA). For the District of Columbia (DC) and all states except Virginia, the totals of tested samples and total of positive samples presented for the states were equal to the numbers graphed each year by county on the map. The total number of tests provided on the CAPC website for the state of Virginia, however, was higher than that obtained by adding the totals for each individual county in that state. Virginia has 95 counties and 38 independent cities that are considered county equivalents, each having its own FIPS code. It is possible that some of the smaller counties in the state were not represented on the map. Some of these independent cities appear on the map, but counties are not recognized by the CAPC program unless they contain data. Thus, there may have been data obtained from small independent cities in Virginia that were not reported on a county basis, but that were included within the total data file for the state. For this reason, while the state totals for Virginia are presumed to be correct, only data verified by association with a visible county and hence a FIPS designation, were included in our analyses. In the case of dogs, with approximately 85,000 cases tested in Virginia each year between 2011 and 2014, the average differences between the annual total given on the website and the numbers verified on the maps by county were 11 positive canine fecal samples out of 770 tested canine fecal samples. The average annual differences between the total given on the website and the numbers verified on the maps for cats in Virginia, where approximately 20,000 animals are tested annually, was 11 positive feline samples out of 552 tested feline samples for the same time interval. The specific data for the Commonwealth of Virginia is included in the supplementary data.

The other minor discrepancy that was noted was between the total number of U.S. positive tests tallied by summing the data from the state maps and the respective total number presented each year by CAPC. This discrepancy could not be accounted for solely by the magnitude of the inconsistencies observed for Virginia. Utilizing just the state totals presented for each year, including the CAPC data for Virginia and the other state maps where there is 100% congruence for all other states, the sum total of all tests by state did not equal the "grand" national totals that are produced when one clicks on the national CAPC map for a given year. For the maps showing county-by-county canine roundworm prevalence based upon analysis of approximately 2.5 million fecal samples from 2011 through 2014, for example, an average annual discrepancy of 1118 positive tests and 68,796 total tests performed was seen. The analogous average annual discrepancy for feline roundworm testing for the same time period was 453 positive tests and 12,365 total tests performed. Regardless, these inconsistencies do not have any direct bearing on the results presented in this study, because data reported as national numbers were not used in any of the map preparations or calculations. The numerical comparisons of the two sets of numbers are provided in the Supplementary Data.

2.2. Map creation

Mapping was performed using MapViewer Version 8.3.311 (64-bit), Golden Software, LLC, Golden, Colorado 80401-1866). The state and county boundaries were defined using the files supplied by the software, Us50alb.gsb for state boundaries and CT201.gsb for the county boundaries, and identified to county using the FIPS code. The maps are presented with the Albers Equal Area Conic projection. The majority of U.S. counties are not represented in the data set for each map because from these counties there were no samples submitted; thus, on the maps they appear within the figure legend category of "no data."

2.3. Graphs and statistical comparisons

The graphs were generated using Minitab® 17.2.1, Minitab Inc., State College, Pennsylvania, 16801. States were coded into geographic regions using the precedent set by Blagburn et al. (1996): Northeast (CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT); South (AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA, WV); Midwest (IA, IL, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI); and West (AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY). The state two-letter USPS abbreviation and full state name, color coded to the geographical region appear in Table 1. General linear modeling with SAS 9.4, Cary, North Carolina, was used to compare the prevalence rates of eggs in the feces of dogs and cats in the different regions of the U.S.A. In the case of both dogs and cats, South Dakota (SD) and North Dakota (ND) were removed from the analysis because of the lack of data in some years (all years for cats from North Dakota). This modeling was performed on data from individual years. Within a year, the model estimated the egg prevalence means the different regions by considering the overall mean of all counties (a constant equal to the average annual national prevalence) and two other factors, host species and geographic region. The magnitude of change due to "dog" relative to "cat" gives an indication of the effect of host species on the prevalence rate, and is constant within a year. For estimation of the effect of region, the West region was selected as the region to which all others were to be compared in the analyses. The estimated effect for each region was constant between