Predicting & Mapping Vector-borne Diseases

American College of Veterinary Prevention Medicine (ACVPM) &
Clinician Outreach and Communication Activity (COCA)
Webinar
Thursday, September 1, 2016
Objectives

At the conclusion of this session, the participant will be able to:

- Describe factors associated with disease mapping
- Discuss what goes into defining factors that aid in mapping trends in biological and disease systems
- Explain the rudiments of mapping as it relates to spatial smoothing and making inferences across boundaries for punctate data
- List examples of how mapping and forecasting might be used to manage, plan, or assess disease mitigation programs
- Describe how companion animal disease surveillance can play a major part in a one-health program of disease monitoring and prevention
Continuing Education Disclaimer

CDC, our planners, presenters, and their spouses or partners wish to disclose they have no financial interests or other relationships with the manufacturers of commercials products, suppliers of commercial services, or commercial services, with the exception of Dr. Dwight Bowman. He would like disclose that he is a consultant for Bayer, Elanco, Zoetis, Merial, Merck, IDEXX, and Abaxis.

Planners have reviewed content to ensure there is no bias.

This presentation will not include any discussion of the unlabeled use of a product or products under investigational use.
Today’s Presenters

Dwight D. Bowman, MS, PhD
Professor
Department of Microbiology & Immunology
Cornell University
Today’s Presenter

Robert Lund, MS, PhD
Professor
Department of Mathematical Sciences
Clemson University
MAPPING AND PREDICTING VECTOR-BORNE DISEASES

Dwight D. Bowman, MS, PhD; Microbiology and Immunology, Cornell University, Ithaca, NY
Robert Lund, PhD, Mathematical Sciences, Clemson University, Clemson, SC
MAPPING AND PREDICTION
VECTOR-BORNE DISEASES

• Dwight D. Bowman, MS, PhD
  • Department of Microbiology and Immunology
  • Cornell University
  • Ithaca, NY

• Robert Lund, PhD
  • Mathematical Sciences
  • Clemson University
  • Clemson, SC
• The Companion Animal Parasite Council began a few years ago looking at the prevalence rates by county of certain diseases using data provided by Antech Diagnostics and IDEXX Laboratories.

• The original simple goal was to provide veterinarians with information about how many cared-for pets within a county have been identified as positive for one of several agents.

• The collected data for dogs states is whether a dog
  • Has serum positive for heartworm antigen and/or microfilariae,
  • Is shedding the eggs of the common internal helminths of dogs and cats
  • Is seropositive for the three tick-transmitted disease agents, Borrelia burgdorferi, Ehrlichia spp., and Anaplasma spp.

• Easy to use interface
USA

Tick Borne Disease Agents  Intestinal Parasites  Heartworm

Heartworm

Select a state below to see data about that state

Heartworm
United States of America

1 out of 78 Dogs tested positive for Heartworm

115,016 POSITIVE CASES  8,993,885 DOGS TESTED

Percentage of Dogs tested positive

How at risk is my Dog?

Get Updates  Share This

INFECTION RISK:  Low  Moderate  High  No Data

Learn about the data in this map
1.08% of all positive cases of Heartworm in the U.S are in the State of Oklahoma.

INFECTION RISK: Low   Moderate   High   No Data

Dogs tested positive for Heartworm:
1 out of 47
1,250
58,304

Percentage of Dogs tested positive: 2.14%
COUNTIES
NOW HAVE 5 YEARS OF DATA

• Lyme in NY State 2011-2014
  • The prevalence of dogs with positive Lyme serology is undoubtably expanding.
    • In 1987, in Ithaca, NY, there were no cases of Lyme present in people or animals.
    • Now infections occur in both.
  • If one looks at the CAPC maps from 2011 to 2014, one can see that the prevalence has gone from 9.67% to 12.54%.
  • However, of more interest perhaps is that all counties that are collecting data have moved into the high risk level (except Schuyler County which tested 1 dog in each of 2013 and 2014).
In New York State:

• Those in the area share the opinion that Lyme has now spread across the state, and this data supports this claim.

• Also, there is data that is pretty convincing that when the prevalence of positive serology in dogs is greater than 5% that human cases begin to occur; so, now, basically, all of New York state is an at risk area for human exposure.
982,336 Data Points, 2006-2007

- Lyme Antibodies in dogs
- FOR LYME IN 2015 COLLECTED 4 MILLION DATA POINTS
- 2016 LOOKS LIKE 4 MILLION

DISPATCHES

Canine Serology as Adjunct to Human Lyme Disease Surveillance

Paul Mead, Rohan Goel, and Kiersten Kugeler

To better define areas of human Lyme disease risk, we compared US surveillance data with published data on the seroprevalence of Borrelia burgdorferi antibodies among domestic dogs. Canine seroprevalence >5% was a sensitive but nonspecific marker of human risk, whereas seroprevalence ≤1% was associated with minimal risk for human infection.

Lyme disease is caused by Borrelia burgdorferi and transmitted in North America by Ixodes spp. ticks. Routine surveillance for human illness indicates that risk for infection within the United States is highly localized. Residents of 10 states accounted for >93% of the ≈248,000 cases reported to the Centers for Disease Control and Prevention (CDC) during 1992–2006 (1). Annual county-level incidence ranged from 0 to >1,000 cases per 100,000 population (1).

The Study

State and territorial health departments report Lyme disease cases to CDC as part of the National Notifiable Diseases Surveillance System (1). Data on canine seroprevalence of B. burgdorferi antibodies were obtained from a 2009 publication by Bowman et al. that reported results for 982,336 dogs tested throughout the United States by using a commercial C6-based assay during 2001–2006 (5). We obtained state-specific seroprevalence from Table 1 of this publication and county-specific seroprevalence as categorical values (0%, 0.1%–0.5%, 0.51%–1%, 1.1%–5%, ≥5.1%) from Figure 2 of this publication after digital enlargement. We excluded counties too small for the value to be determined reliably. We calculated average annual human Lyme disease incidence for 2001–2006 and 2007–2009 using US Census Bureau population estimates for 2004 and 2008, respectively. To evaluate county-level emergence of Lyme disease among humans, we stratified counties by the mean observed annual incidence for all counties during 2001–2006 of 4.7 cases per 100,000 population. We defined an emergent county as a county in which incidence was below this value during 2001–2006 and above this value during 2007–2009.

Detailed canine seroprevalence data were available for 46 US states in linear regression analysis, state canine seroprevalence and human Lyme disease incidence were positively correlated (Figure 1; r² 0.75, p<0.001). On the
CONCLUSIONS

• Findings suggest that canine seroprevalence >5% can be a sensitive but nonspecific marker of increased risk for human Lyme disease.
  • Because dogs do not transmit infection directly to humans (or humans to dogs), this association reflects similar susceptibilities to tick-borne infection.
  • In some circumstances, high canine seroprevalence appears to anticipate increasing rates of human infection at the county level.

• Conversely, canine seroprevalence <1% is associated with little to no local risk for human infection.

• Canine seroprevalence is a useful adjunct to human surveillance for Lyme disease.

Mead et al 2011 Canine serology as adjunct to human Lyme disease surveillance. EID 17
1710-1712
The people in Michigan, are watching Lyme disease march across the state from three directions, from Wisconsin into the Upper Peninsula, from Indiana in the southwest corner, and from Ontario on the east.

The spread of Lyme positive dogs across Michigan is well known, but on the maps it becomes much simpler to visualize.

- One can just watch the prevalence march across the state
- Soon, Michigan will probably all red like New York State has become.

2011-2014
Hamer et al., 2009. Use of tick surveys and serosurveys to evaluate pet dogs as a sentinel species for emerging Lyme disease. AJVR 79: 49-56.
**Key factors influencing canine heartworm, *Dirofilaria immitis*, in the United States**


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**Quantitative factors proposed to influence the prevalence of canine tick-borne disease agents in the United States**

Roger W Stich, Byron L Blagburn, Dwight D Bowman, Christopher Carpenter, M Roberto Cortinas, Sidney A Ewing, Desmond Foley, Janet E Foley, Holly Gaff, Graham J Hickling, R Ryan Lash, Susan E Little, Catherine Lund, Robert Lund, Thomas N Mather, Glen R Needham, William L Nicholson, Julia Sharp, Andrea Varela-Stokes and Dongmei Wang

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**Abstract**

An examination of the Companion Animal Parasite Council's (CAPC) canine heartworm data to clarify the spatial prevalence of heartworm in the United States. Factors thought to influence the spatial risk of disease, as identified in a recent CAPC workshop, are discussed.

**Keywords:** Canine heartworm, *Dirofilaria immitis*, Mosquito vectors, Spatial prevalence

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**Abstract**

The Companion Animal Parasite Council hosted a meeting to identify quantifiable factors that can influence the prevalence of tick-borne disease agents among dogs in North America. This report summarizes the approach used and the factors identified for further analysis with mathematical models of canine exposure to tick-borne pathogens.

**Keywords:** Anaplasma, Ehrlichia, *Borrelia burgdorferi*, Tick-borne infections, Prevalence map factors, Ticks, ixodidae, Prostratiota, Metastratiota
GOALS

• Our overall objective is to further animal health by tracking disease occurrences in the United States (disease mapping).
• In this talk, spatial baseline and forecast prevalence maps for two (heartworm and Lyme) US canine parasitic diseases will be constructed.
• The problem resides in statistical epidemiology.
• Forecasts alert pet owners and veterinarians a priori to high disease levels.
• The Companion Animal Parasite Council (CAPC) has compiled a data set of test results, spanning 2011-2015.
• The end product is analogous to a “flu forecast map” for heartworm and Lyme.
Decided to Forecast

• We needed to determine what measured factors might prevalence rates and their changes.

• An Atlanta meeting was held with three groups of expertise (metastriate and prostriate ticks and heartworm) to suggest measurable factors that could be used in our ensuing work.

• The results of this meeting have been published.
## The Data

The data have form:

<table>
<thead>
<tr>
<th>County</th>
<th>Breed</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oconee</td>
<td>Australian Shepherd</td>
<td>-</td>
</tr>
<tr>
<td>Oconee</td>
<td>Cocker Spaniel</td>
<td>-</td>
</tr>
<tr>
<td>Oconee</td>
<td>Boxer</td>
<td>+</td>
</tr>
<tr>
<td>Pickens</td>
<td>Mutt</td>
<td>-</td>
</tr>
</tbody>
</table>

...  
...  
...  

- Tests results are available for heartworm, Lyme, anaplasmosis, and ehrlichiosis.
- This is big data: millions of test results are annually reported.
- The data are organized by the county of the vet practice conducting the test
A Baseline is Needed to Forecast

• Forecasts should be based on departures from normal conditions.

• We will spatially smooth the raw prevalences to obtain estimates of an average prevalence (baseline) for each county.

• Many statistical smoothing options exist for this purpose: Kriging, thin-plate splines, head-banging.

• Weighted head-banging is used because of the numerous outliers and definitive edges in our subsequent data.
Construction of Baseline Maps

Figure: Raw Reported Heartworm Prevalence for 2011-2015
Construction of Baseline Maps

Heartworm Raw Prevalence 2011-2015

Figure: Raw Reported Heartworm Prevalence for 2011-2015
Figure: Heartworm Baseline

Heartworm Baseline Prevalence 2011-2015
ASIDE: HEAD-BANGING

• Head-banging is a median polished robust smoothing algorithm that eliminates outliers and preserves spatial edges.
• Head banging works with triples. A triple contains prevalence from three adjacent counties.
• Head-banging (Tukey, Hansen) takes many sets of triples and infers local prevalence by taking medians.
• Median(.04, .10, .06) = .06.
• Outliers are identified and omitted, but “ridge” features are preserved. Forty-five triples are used in future smoothings.
• The algorithm is named from a popular child’s game with pins and face impressions.
• Mungiole et al. (1999, Stat. Med.) is a good reference. Our methods weight for the number of tests taken in the counties.
Our fundamental modeling tool is a Poisson regression:

\[ Y_s(t) \mid n_s(t), p_s(t) \sim \text{Poisson}(n_s(t)p_s(t)). \]

\( Y_s(t) \) is the number of positive tests in county \( s \) at year \( t \).
\( n_s(t) \) is the number of tests conducted in county \( s \) at time \( t \).
\( p_s(t) \) is the probability of a positive test in county \( s \) at time \( t \) and is related to factors:

\[
\ln(p_s(t)) = \beta_0 + \sum_{i=1}^{L} \beta_i X_{s,i}(t) + \xi_s(t).
\]

Factors: \( X_{s,1}(t), \ldots, X_{s,L}(t) \) for county \( s \) at time \( t \). There are about 3050 USA counties. The model regression coefficients are \( \beta_0, \ldots, \beta_L \).
• The random effects $\xi_s(t)$ are used to induce temporal and spatial correlation.
• Adjacent counties tend to report similar prevalences, suggesting positive spatial correlation.
• Spatial correlation is modeled via a conditional autoregressive (CAR) paradigm. CAR spatial structures have a parameter that controls the correlation between two counties that border one and other.
• Positive temporal correlation (fix the location) is also present in the test data. Once a reservoir of infection sets up, it tends to stay.
• Temporal correlation is accounted for with a temporal correlation parameter via a time series autoregressive method.
<table>
<thead>
<tr>
<th>Factors</th>
<th>Data period</th>
<th>Scale</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual temperature</td>
<td>Last century</td>
<td>Division</td>
<td>National Climate Data Center (NCDC)</td>
</tr>
<tr>
<td>Annual precipitation</td>
<td>Last century</td>
<td>Division</td>
<td>NCDC</td>
</tr>
<tr>
<td>Annual relative humidity</td>
<td>Last century</td>
<td>Station</td>
<td>NCDC</td>
</tr>
<tr>
<td>Percentage forest coverage</td>
<td>2007</td>
<td>County</td>
<td>United States Department of Agriculture (USDA)</td>
</tr>
<tr>
<td>Percentage surface water coverage</td>
<td>2010</td>
<td>County</td>
<td>U.S. Census Bureau</td>
</tr>
<tr>
<td>Population density</td>
<td>Last decade</td>
<td>County</td>
<td>U.S. Census Bureau</td>
</tr>
<tr>
<td>Median household income</td>
<td>Last decade</td>
<td>County</td>
<td>U.S. Census Bureau</td>
</tr>
<tr>
<td>Aedes aegypti</td>
<td>2008</td>
<td>County</td>
<td>by Moore, CG.</td>
</tr>
<tr>
<td>Aedes albopictus</td>
<td>2012</td>
<td>County</td>
<td>by Hynes NA</td>
</tr>
<tr>
<td>Aedes canadensis</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
<tr>
<td>Aedes sierrensis</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
<tr>
<td>Aedes trivittatus</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
<tr>
<td>Anopheles punctipennis</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
<tr>
<td>Anopheles quadrimaculatus</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
<tr>
<td>Culexquinifasciatus</td>
<td>2004</td>
<td>County</td>
<td>Book by RF Darsie, Jr. and RA Ward</td>
</tr>
</tbody>
</table>

**Table:** Heartworm Factors Considered
FACTOR COMMENTS

• For Lyme: mosquitoes are not considered, but deer strikes rates with cars are. Lyme case counts in humans were also added to the Lyme analyses.

• Important factors are admittedly missed (e.g., preventative sales).

• Some are due to data record deficiencies; some are due to our ignorance. This said, the models do reasonably well.

• Most “vectors” do not come with abundances.

• The forecasts are annualized — there are only five years of data.

• Quantities like heartworm development units are not particularly useful on an annual scale.
• A forecast of next year’s prevalence is obtained by forecasting the factors into next year and plugging into the model:

\[
\ln(\hat{p}_s(t)) = \hat{\beta}_0 + \sum_{i=1}^{L} \hat{\beta}_i \hat{X}_{s,i}(t) + \hat{\xi}_s(t).
\]

• There are details with the modeling and forecasting of the \(\xi_s(t)\) terms that we omit.
FACTOR FORECASTING

• The factors are forecasted into next year via simple methods for each county.

• The climate variables temperature, precipitation, and relative humidity are forecasted with simple autoregressive (AR) time series methods using the last century of data.

• Societal factors are forecasted via simple linear regression with the last decade of data.

• Environmental and geographic factors like mosquito presence/absence and county elevation do not change from year to year and do not influence the forecast.

• This is a big data effort!
Figure: 2011 U.S. Temperature (Degrees F)
Figure: 2011 Annual U.S. Precipitation (Inches)
Figure: 2011 U.S. Relative Humidities (Percent)
Figure: U.S. County Elevations (Feet)
Figure: 2011 U.S. County Surface Water Coverage (Percent)
Figure: 2010 U.S. Population Density (People per Square Mile)
Figure: 2011 U.S. Median Household Income (Dollars)
Figure: Presence of *Aedes canadensis*
Figure: 2016 Heartworm Forecast
Figure: 2016 Heartworm Forecast
Lyme Baseline Prevalence 2011-2015

Figure: Lyme Baseline
Forecasted Lyme Prevalence 2016

Figure: 2016 Lyme Forecast
Forecasted Lyme Prevalence 2016

Figure: 2016 Lyme Forecast
• The forecasted and observed prevalences have an squared correlation ranging from 60% - 90%.
• CAPC supports two PhD students and a post-doc working full-time on this project.
• Traveling dogs and spatially varying testing protocols are problematic.
• CAPC used to argue about disease homeranges and baselines. Five years later, the data were always right!
• Lyme’s home-range and its spread is a huge issue.
• Many of the other diseases we study are also zoonotic.
FORECASTING COMMENTS

• There are four published papers in Parasites & Vectors on this project. More are in preparation.

• Our forecasts are shown to about 250 million USA TV viewers via a CAPC satellite media tour each spring. CAPC is trying to get this information shown on The Weather Channel, The Animal Planet Channel, etc.

• Currently, our forecasts are yearly. We will be moving to real time (daily) in a few years. Social media factors (Google Trends, Twitter) will then become important.
The reason to map disease is to have an impact on the disease itself.

Maps allow one to be able to examine whether or not interventions are reducing disease prevalence.
GUINEA WORM CASES...

- At a Glance: 2016 Reported Cases of Guinea Worm Disease by Country

- Chad: 4*
- Ethiopia: 1*
- Mali: 0*
- South Sudan: 2*

- Note: Additional cases are expected in 2016. These numbers are *provisional until certified.
MALARIA ERADICATION USA

- Malaria in USA once fairly common
PLAYED AN IMPORTANT ROLE IN THE CIVIL WAR

• Due to the Blockades – Confederacy could get no quinine from South America
• Malaria's effect on Confederate Army manpower depended on where troops were posted but could be profound.
• In the 9-month period starting July 1, 1861, for example, there were, on average, 38 reported malaria cases per month per 1,000 men in the Confederate Army of the Potomac.
• In contrast, the monthly average was 118 cases per 1,000 men serving near Mobile, Alabama, for the year starting July 1, 1862. and 255 cases per 1,000 men serving in the river batteries below Savannah, Georgia, in 1863.
• One report for 1861 and 1862 showed 819,286 cases of disease or injury, excluding gunshot wounds, among Confederate troops east of the Mississippi River, Malaria accounted for 115,415 (14.09%) of the cases, of which 1,333 (1.15%) ended in death.

**MALARIA IN USA NOW**

- Cases are all imported from overseas
SHELTER VS CARED-FOR PETS

Blagburn BL 2009. Shelter Survey update NAVC Proceedings
Little et al 2009 Prevalence of intestinal parasites in pet dogs in the United States. Vet Parasitol 166 144-152
DISEASE INTERVENTION

• In the world of veterinary medicine, two important papers have recently shown very clearly what is already known, that if you treat or prevent disease, you have less disease.
• But showing it works is important.
• A great paper
• Validation of a job well done
ROUTINE TREATMENT MAKES A DIFFERENCE!

Gates and Nolan 2014 Declines in canine endoparasite prevalence associated with the introduction of commercial heartworm and flea preventatives from 1984 to 2007 doi: 10.1016/j.vetpar.2014.05.003

Vertical lines indicate the dates when (a) Heartgard® (ivermectin), (b) Interceptor® (milbemycin oxime), (c) Heartgard Plus® (ivermectin + pyrantel pamoate), (d) Program® (lufenuron), and (e) Frontline® (fipronil) were introduced to the market.
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• Drs. Eschner & Mugna have shown that.....

• Keeping dogs on tick preventives reduces their risk of seroconverting to Lyme (Borrelia burgdorferi)!!!!
Recently, Eschner and Mugnai (2015) reported some obvious but very important results from a clinical study performed in Maine, USA.

Their work verified that if you vaccinate client-owned dogs for Lyme disease, you have less *Borrelia burgdorferi* acquired by dogs.

- Again, this is an obvious statement, but to have the results verified in a real world situation is critically important.

Using a recombinant subunit OspA vaccine, it was shown that only around 1% of the vaccinated dogs seroconverted while around 20% of the non-vaccinated or poorly compliant dogs seroconverted.

Thus, the results can be easily interpreted.

- Dogs living in areas with Lyme disease need to be vaccinated against Lyme disease and on year round tick prevention.

Yes, year round tick protection.

*Ixodes* will bite in the dead of winter if given the opportunity.
HEARTWORM FLORIDA SHELTER VS CARED-FOR PETS

• **BEFORE** Monthly Preventives…….

• **FLORIDA: 1984-1989**
  - 876 dogs from pounds were examined at necropsy for heartworms
  - 520 (59.4%) of the dogs had heartworms

Courtney CH, Zeng QY 1989 The structure of heartworm populations in dogs and cats in Florida. AHS 1989
## % Dogs Positive for HW Antigen in Southeastern USA

<table>
<thead>
<tr>
<th>State</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>3.00%</td>
<td>2.84%</td>
<td>2.90%</td>
<td>3.19%</td>
<td>3.44%</td>
</tr>
<tr>
<td>Arkansas</td>
<td>3.71%</td>
<td>3.49%</td>
<td>3.75%</td>
<td>4.18%</td>
<td>4.63%</td>
</tr>
<tr>
<td>Florida</td>
<td>1.39%</td>
<td>1.31%</td>
<td>1.40%</td>
<td>1.32%</td>
<td>1.33%</td>
</tr>
<tr>
<td>Georgia</td>
<td>2.41%</td>
<td>2.29%</td>
<td>2.28%</td>
<td>2.50%</td>
<td>2.52%</td>
</tr>
<tr>
<td>Kentucky</td>
<td>1.04%</td>
<td>1.14%</td>
<td>1.00%</td>
<td>1.03%</td>
<td>1.19%</td>
</tr>
<tr>
<td>Louisiana</td>
<td>6.08%</td>
<td>5.26%</td>
<td>6.20%</td>
<td>6.58%</td>
<td>6.98%</td>
</tr>
<tr>
<td>Mississippi</td>
<td>9.33%</td>
<td>8.14%</td>
<td>8.82%</td>
<td>8.09%</td>
<td>8.47%</td>
</tr>
<tr>
<td>Missouri</td>
<td>1.32%</td>
<td>1.45%</td>
<td>1.31%</td>
<td>1.47%</td>
<td>1.62%</td>
</tr>
<tr>
<td>North Carolina</td>
<td>1.98%</td>
<td>1.83%</td>
<td>2.04%</td>
<td>2.11%</td>
<td>2.16%</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>2.67%</td>
<td>2.63%</td>
<td>1.95%</td>
<td>2.24%</td>
<td>2.14%</td>
</tr>
<tr>
<td>South Carolina</td>
<td>2.44%</td>
<td>2.00%</td>
<td>2.15%</td>
<td>2.48%</td>
<td>2.44%</td>
</tr>
<tr>
<td>Tennessee</td>
<td>3.09%</td>
<td>2.65%</td>
<td>2.40%</td>
<td>2.71%</td>
<td>3.16%</td>
</tr>
<tr>
<td>Texas</td>
<td>1.63%</td>
<td>1.25%</td>
<td>1.18%</td>
<td>2.85%</td>
<td>3.12%</td>
</tr>
<tr>
<td>Virginia</td>
<td>0.78%</td>
<td>0.78%</td>
<td>0.90%</td>
<td>0.79%</td>
<td>0.77%</td>
</tr>
<tr>
<td>West Virginia</td>
<td>1.18%</td>
<td>1.12%</td>
<td>1.21%</td>
<td>0.38%</td>
<td>0.39%</td>
</tr>
</tbody>
</table>
• Dogs positive for heartworm
• 1.32%
14.6% in shelter dogs
Remember: Prevalence in pet dogs living in the same area was 1.4% (Tzipory et al 2010)
• So, by providing good chemoprophylaxis –
• Are Floridians even succeeding in protection other dogs by the herd effect, i.e., reducing transmission amongst all dogs in the state?
CATS AT CLINICS IN EU VS US

- EU Veterinarians not big on Prevention
- EU clinic cats vs US shelter cats vs US clinic cats

Lucio Forster A and Bowman DD 2011 Prevalence of fecal-borne parasites detected by centrifugal flotation in feline samples from two shelters in upstate New York J Fel Med Surg 13 300-
Thanks to CAPC, (Julia Sharp, Dongmei Wang, Yan Liu, Stella Watson; Clemson), Bill Stich (Missouri), Michael Yabsley (Georgia), and about five other parasitologists.

As this project has “gone viral”, it troubles us that we are not professional epidemiologists (and could say wrong things).

Phrased another way, your comments are most welcome.

Thank you for listening.
Thank you for joining!
Please email us questions at coca@cdc.gov

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