Why Was West Nile Virus Where it Was in Contra Costa County?

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ABSTRACT: We examined the association of dead bird reports with human population density, microclimate and the distribution of human and equine West Nile virus cases in Contra Costa County during 2005. The incidence of dead bird reports (reports per 1000 residents) was strongly correlated with average high summer temperatures and was roughly predictive of the actual distribution of human and equine cases. Currently available risk assessment models such as DYCAST do not take population density or microclimate variation into account.

INTRODUCTION

During 2005, the Contra Costa Mosquito and Vector Control District (CCMVCD) relied heavily on mapping dead bird reports received by the California Department of Health Services (CDHS) Statewide West Nile virus (WNV) hotline to identify areas of our county at higher risk for WNV transmission. It became apparent early in the season that higher numbers of calls were being received from areas of the County with the highest human population, and therefore that human population density might be confounding our efforts to estimate actual differences in the risk of human cases. In addition to fairly large variations in population density, the San Francisco Bay area, where our District is located, has large variations in microclimate as one moves from the Bay towards inland. During midsummer, there may be as much as a 20° F difference in average high temperatures from the west side to the east side of Contra Costa County. Since ambient temperature is known to have a strong influence on the extrinsic incubation rate of West Nile virus (Reisen et al. 2006), it might have a significant effect on virus transmission rates across the County. We therefore decided to examine the distribution of dead bird reports during 2005, with regard to variations in human population density, temperature and evidence of actual virus transmission as indicated by human and equine WNV cases and sentinel chicken seroconversions.

MATERIALS AND METHODS

Information on the location of dead bird reports was compiled and reported to us weekly by the staff of the CDHS WNV hotline. Human population data for incorporated municipalities was obtained from 2000 United States Census data (U.S. Census Bureau 2000). The incidence of dead bird reports for each of eleven cities was calculated by dividing the number of dead bird reports for the season by the total human population. Average summer high temperatures for various cities were obtained from The Weather Channel Interactive (2005). The relationship between temperature and dead bird report incidence was examined by regression of log (incidence) vs. published average high temperature. Monthly climate maps from the Western Regional Climate Center California Climate Data Archive (2005) were used to identify specific microclimate zones within the county which were then overlaid on maps of WNV positive human, equine and sentinel chicken locations. Information on the location of human cases was provided by the Contra Costa County Department of Health Services (CCCDHS), and equine case locations by the California Department of Food and Agriculture (CDFA). Sentinel chicken serum samples were collected biweekly from five flocks of 10 chickens each and tested at the CDHS Viral and Rickettsial Disease Laboratory (VRDL) in Richmond, CA.

RESULTS AND DISCUSSION

A comparison of the number of dead bird reports received from each of 10 cities with the incidence of reports (number of reports per 1000 residents) revealed some interesting differences (Fig. 1). Although the highest numbers of reports were received from Concord and Walnut Creek, which are located in the central part of the county, the incidence of reports from those communities was relatively low compared with the incidence in Brentwood and Oakley, located in the east. Communities on the west side including Richmond, Pinole and San Pablo showed a very low incidence of reports suggesting that incidence increased as one moved inland from the Bay and hence from areas of cooler to warmer microclimate. Linear regression analysis indicated that the log of dead bird report incidence was strongly correlated ($r^2 = 0.72$, $p<0.05$) with average summer high temperatures for each of the 10 cities (Fig. 2).

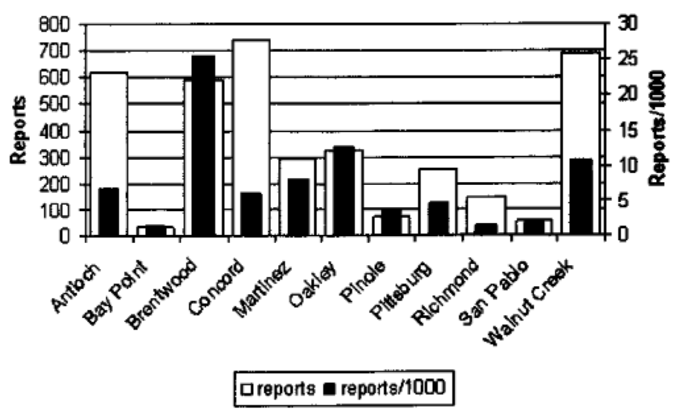

Figure 1. Number of dead bird reports per city during 2005 (left axis) vs. reports per 1,000 residents (right axis) for 11 cities on Contra Costa County

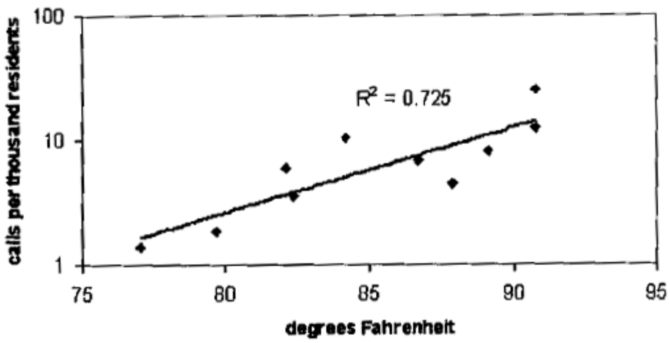

Figure 2. Log of dead bird calls per thousand residents vs. average summer high temperature for ten cities in Contra Costa County.

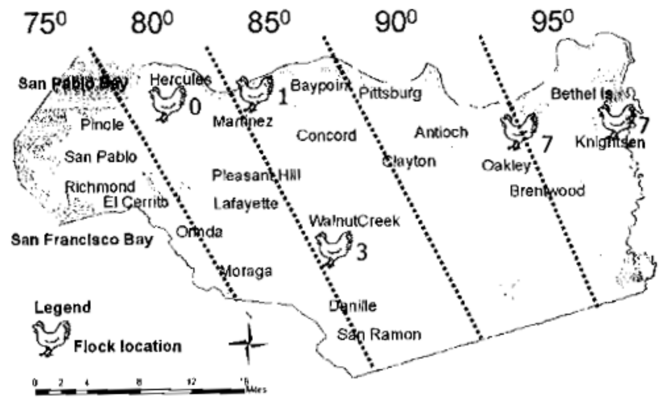

Figure 4. Number of seroconversions at five sentinel chicken flock locations in Contra Costa County, 2005 in relation to average daily temperatures (⁰F) in August. There were ten chickens per flock.

During 2005, there were 11 human and 10 equine cases of WNV in our county. A map of these cases, superimposed on a map showing average daily high temperatures in August 2005, revealed that virtually all cases occurred in areas of the county where the average daily high temperature was 85° F or above (Fig. 3). There was a single human case in Richmond, the westernmost city in the county, but according to information received from the Contra Costa County Department of Health Services this patient had a history of recent travel to another part of the state where virus incidence was much higher, and was presumed to have been infected outside the area. Seroconversions in sentinel chickens followed a similar pattern, with the majority of chickens (seven out of 10) seroconverting in flocks located in Knightsen and Oakley, three out of 10 in the Walnut Creek, a single chicken in Martinez and none in Hercules (Fig. 4). The concentration of human and equine cases and seropositive chickens in the eastern part of the county suggests that dead bird report incidence, rather than the raw distribution of reports, was giving us a more accurate indication of the risk of virus transmission.

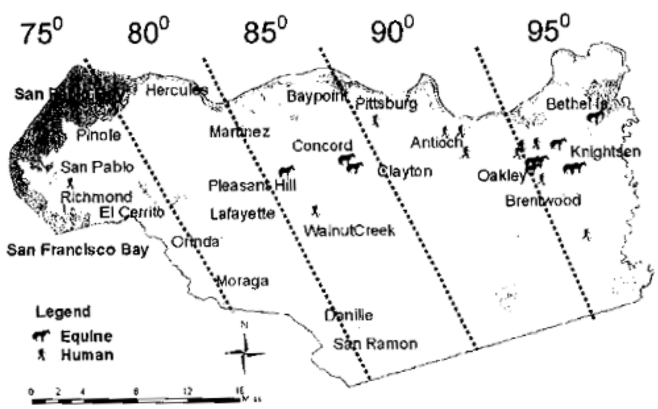

Figure 3. Locations of human and equine WNV cases in Contra Costa County, 2005 in relation to average daily high temperatures (⁰F) in August.

Existing WNV risk assessment models like DYCAST (Theophilides et al. 2002) analyze the spatial and temporal variation in the distribution of dead bird reports, but do not take human population density into account. Our data suggest that this may result in an overestimate of risk in more densely populated communities and an underestimate in less populated areas, resulting in less than optimal allocation of often limited field resources. In addition, in areas with large variations in microclimate differences in ambient temperature may have a significant influence on the local risk of virus transmission. These factors may be important in the development and refinement of future risk assessment tools.

Acknowledgements

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