Rickettsial Infections in Fleas from Southern California

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Abstract: The objective of this 10-week project was to identify infection rates in fleas of the rickettsial pathogens, *Rickettsia felis* and *Rickettsia typhi*, in response to an increased number of reported cases of flea-borne rickettsioses in Los Angeles and Orange counties since 2001. This project involved organizing and analyzing data on a variety of flea and mammal species collected in southern California between 2014 and 2019. We found a significant upward trend in the prevalence of *R. felis*-infected fleas between 2016 and 2019. Cats and opossums had a significantly higher risk of being infested by *R. felis*-positive fleas. The results will help the Orange County Mosquito and Vector Control District (OCMVCD) to determine how to better allocate rickettsial disease prevention resources and minimize the risk of human exposure to fleas in Orange County.

Introduction/Background

- *Rickettsia typhi* and *Rickettsia felis* are flea-borne bacterial pathogens, which both cause acute undifferentiated febrile illness in people throughout the world. [1]
- Southern California has experienced a reemergence of human cases of flea-borne rickettsial disease since 2006; the majority of the cases were reported from Orange and Los Angeles counties. [2]
- The reasons for the apparent regional endemicity of rickettsial disease in the state are largely unknown. [3]
- This project will determine the distribution of flea species, their mammalian hosts, and the association between the flea species/host animals and infection rates of flea-borne rickettsiae.

Objectives

1. To identify changes in the *R. felis/R. typhi* infection rates in flea species between 2016-2019 in southern California.
2. To determine the association between *R. felis/R. typhi* infection rates and commonly found flea species in Southern California.
3. To determine the association between *R. felis/R. typhi* infection rates and commonly found host species in Southern California.
4. To identify the association between *R. felis/R. typhi* infection rates and sexes of flea in southern California.
5. To test the difference in the infection rate of *R. felis/R. typhi* between Orange and Los Angeles counties.

Method

- This was a retrospective study that analyzed flea and mammal host data collected by the OCMVCD from 2014 to 2019.
- The database was cleaned and organized with 12 flea species and 14 host species.
- The final dataset for assessing flea distribution and rickettsial infection had a total sample size (N) of 3,733; most of the samples were used in the statitical anylyses.
- RStudio [version 1.2.5033] was used to conduct Chi Square test, Fisher's exact test, Proportional trend test and Cochran Mantel Haenszel test to determine the associaton stated in the objectives

Results

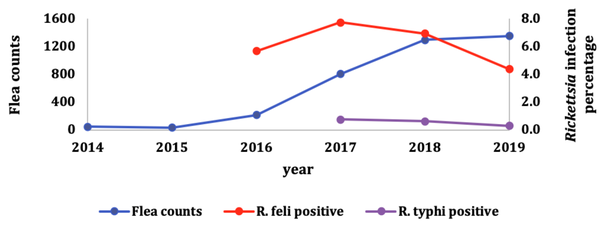

Figure 1. Flea counts collected from 2014 to 2019 and *R. felis/R. typhi* infection prevalence from 2016 to 2019. The blue line represents the number of fleas tested for the two types of bacteria by years. Red and purple lines represent the *R. felis* and *R. typhi* infection prevalence over the total samples of that year, respectively. For red and purple lines, only those years tested in statistical analyses were shown in the figure.

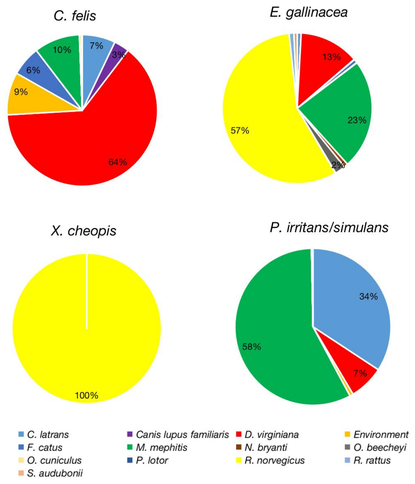

Figure 3. Charts of flea proportionality by host species across four most common flea species. *C. felis* and *E. gallinacea* were more commonly found on multiple host species, with *C. felis* more frequently found on *D. virginiana*, and *E. gallinacea* more frequently found on *R. norvegicus*. Interestingly, *X. cheopis* was only found on *R. norvegicus*.

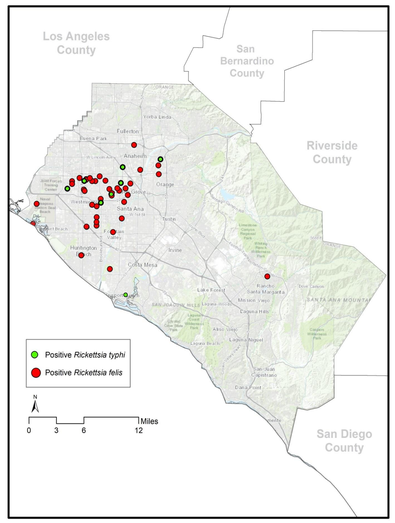

Figure 2. Map of *R. typhi* and *R. felis* positive fleas collected from 2015 to 2019 in Orange County.

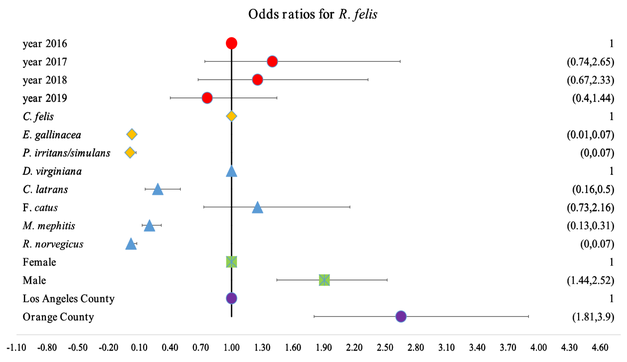

Figure 4. Forest plot for a summary of odds ratios of *R. felis* infections for five variables (collecting year, flea species, host species, flea sex, year, collecting county) tested in this study. Year 2016, *C. felis*, *D. virginiana*, female fleas, and Los Angeles County were the reference group for the respective variables. Odds ratios and confidence intervals were displayed for each level.

Discussion

- We found a statistically significant upward trend in *R. felis* infection rates from 2016 to 2019, reflecting a similar pattern of human cases of flea-borne rickettsioses reported in California ($p = 0.008$).
- We found cat fleas had a significantly higher rate of being infected with *R. felis*, while oriental rat fleas had a significantly higher rate of being infected with *R. typhi*.
- We found that cats and opossums had a significantly higher odds of being infested by *R. felis*-positive fleas ($p < 0.0001$), supporting the opossums-cats-cat fleas suburban transmission cycle.
- Norway rats had a significantly higher rate of being infested by *R. typhi*-positive fleas ($p = 0.024$), supporting the classic rat–flea cycle of *R. typhi.*
- While higher *R. felis* prevalence was found in fleas, diagnostic tests in humans do not distinguish between the two rickettsiae.

Conclusions

- The prevalence of *R. felis* infected fleas was significantly increasing from 2016 to 2019, while decreasing for *R. typhi*.
- Male fleas had a significant higher odds of being infected with *R. felis* compared with females.
- Orange County was found to have a significantly higher risk of detecting *R. felis* fleas than Los Angeles County.
- The etiologic agent causing human flea-borne rickettsioses in California should be considered for further investigation.
- To prevent the transmission of rickettsial infection from animals to human, OCMVCD should aim to minimize excessive proliferation of flea-infested feral cats and opossums.

Acknowledgments and Permissions

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