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Title

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Permalink

<https://escholarship.org/uc/item/2qs6r14s>

Journal

Proceedings of the Vertebrate Pest Conference, 27(27)

ISSN

0507-6773

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Publication Date

2016

DOI

10.5070/V427110605

Orange County Vector Control and the County's Feral Cat TNR Program: Ne'er the Twain Shall Meet?

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ABSTRACT: In 2006, flea-borne rickettsiosis (flea-borne typhus), a zoonotic disease caused by either *Rickettsia typhi* or *R. felis* and transmitted primarily by two flea species, the Oriental rat flea and the cat flea, re-emerged as an important vector-borne disease in Orange County, California. The Orange County Mosquito and Vector Control District (OC Vector Control) has investigated 142 human cases of flea-borne rickettsiosis. Results of these investigations have established a link with *Rickettsia*-infected cat fleas, opossums, feral cats, and disease transmission to humans; no cases have been associated with rats and their fleas. Since initiation of a Trap-Neuter-Return (TNR) Program by Orange County (OC) Animal Care in 2009, OC Vector Control has been working with OC Animal Care to minimize the potential public health risks associated with the TNR Program. Interagency discussions have led OC Animal Care to prohibit the release of TNR cats at locations with a high risk for zoonotic disease transmission to humans, such as schools, parks, and health care facilities, and also to disclose the release sites to OC Vector Control. OC Animal Care has not agreed to OC Vector Control's request for a zoonotic disease review of its TNR Program, nor has it provided a procedural manual to verify the verbal agreements reached by the two agencies. In agreement with OC Vector Control's concerns, an investigation in 2015 by the Orange County Grand Jury of OC Animal Care's TNR Program recognized the Program's potential to increase zoonotic disease transmission to the public and other wildlife. We discuss the conflicting views arising from two governmental agencies, which perceive the zoonotic diseases risk associated with a TNR program at significantly different thresholds of concern.

KEY WORDS: animal control policy, disease, *Felis catus*, feral cat, flea-borne rickettsiosis, flea-borne typhus, grand jury, Orange County CA, public health, *Rickettsia*, TNR, vector-borne disease

Proc. 27th Vertebr. Pest Conf. (R. M. Timm and R. A. Baldwin, Eds.)
Published at Univ. of Calif., Davis. 2016. Pp. 280-287.

INTRODUCTION

Some notable zoonotic diseases have been held in check in the U.S. not only as the result of modern day living conditions, but also by the adoption of mandated animal control programs. Such programs, along with mandatory rabies vaccination of dogs, have included the use of open-admission impoundment centers to hold and euthanize abandoned and dangerous animals, especially stray dogs. Open admission centers accept all animals regardless of their age, breed, health, behavior, or aggressive tendencies, CNHS 2017). For most of their existence, the primary role of these facilities has been to protect public safety and private property rights in response to the problem of unwanted, abandoned, and free-roaming pets in communities (Miller 2007). Since the 1990s, however, most animal impoundment centers in the U.S. have re-defined their roles and evolved into shelters aimed at providing humane care and treatment of animals, and they no longer serve exclusively for the disposal of uninjured backyard wildlife (e.g., opossums, raccoons, and skunks), stray cats and dogs, nor unwanted pets. Shelters increasingly define themselves as agencies designed to save lives, not to end them (Kortis 2014).

In large part, this evolution of shelters reflects a transformation in the nation's perception about the care of animals, where the public safety threat that formerly justified the immediate destruction of impounded animals is no longer considered paramount. In California, passage of the Vincent and Hayden Laws in 1998 (California Statutes of 1998: AB 1856, Ch. 747; SB 1785, Ch. 752, respectively)

codified this belief into requirements that animal shelters play a leadership role in reducing pet overpopulation through spay/neuter practices and implement programs to reduce their euthanasia rate (Bryant 2004). Under these laws within the California Food & Agricultural Code, California shelters must release requested animals scheduled for death to approved rescue groups (CA FAC Secs. 31108, 31752-31753) and sterilize all healthy cats and dogs before adoption by the public or rescue groups (CA FAC Sec. 30503).

One consequence of the Hayden Law is that animal care agencies have had to deal with extended holding times for stray cats (CA FAC Sec. 31752) that were routinely euthanized under the former requirements, adding costs for additional funding of staff and expanded kennel space. To address the issue of increased stray cats, many community shelters have adopted trap-neuter-return (TNR) programs to ostensibly control the estimated 70 million stray cats in the U.S. (ASPCA 2016), and ultimately reduce the euthanasia rate and the financial burden of caring for unwanted kittens. TNR is a program in which free-roaming, un-owned cats are humanely trapped, sterilized and medically treated, and returned to the outdoor locations where they were found. Orange County Animal Care (OC Animal Care) initiated its TNR Program in 2009 as a pilot program to humanely address the overpopulation of feral cats in Orange County, CA, as an alternative to euthanasia of unadoptable cats (OC Animal Care 2016).

For the purposes of this discussion, a "feral cat" is defined as a cat without owner identification of any kind

Figure 1. Human cases of flea-borne rickettsiosis in Los Angeles and Orange counties, 2001-2016.

whose usual and consistent temperament is extreme fear and resistance to contact with people; a feral cat is not socialized to people, unlike pets and strays (CA FAC Sec. 31752).

The impact of feral cat populations on wildlife (Loss et al. 2013), their threat to public health (Gerhold and Jessup 2012), and questionable efficacy of TNR programs in controlling feral cat numbers (Natoli et al. 2006, Longcore et al. 2009, Loyd and DeVore 2010) have evoked serious concern among wildlife biologists and public health officials about the role of publicly-funded animal shelters in feral cat management. The Orange County Mosquito and Vector Control District (OC Vector Control) has opposed OC Animal Care's TNR Program in light of the resurgence of human cases of flea-borne rickettsiosis (flea-borne typhus) in the county (CDPH 2016) (Figure 1).

Flea-borne rickettsiosis is a vector-borne disease caused by either of two related bacterial pathogens, *Rickettsia typhi* and *R. felis*, that are transmitted by fleas (Azad et al. 1997, Pérez-Osorio et al. 2008). Rickettsial transmission from flea to animal host is through infectious flea bites, or contact with rickettsia-containing feces and tissues during or after blood feeding (Azad et al. 1997). The cat flea (*Ctenocephalides felis*) is the most common flea species found on mammalian pets and wildlife in Southern California, readily bites humans, and is a competent vector of both rickettsial species (Azad and Beard 1998, Ereemeeva et al. 2012). Neither rickettsial species is known to cause illness in animals, and most human infections with either pathogen cause only mild symptoms. Among patients with severe clinical illness, symptoms include high fever, headache, myalgia, fatigue, confusion, and rash, with onset typically occurring 6-14 days after exposure (Bitam et al. 2010). Hospitalization has been required in approximately 85% of the diagnosed cases in Orange County (Cummings et al. 2014). Mortality is less than 2% when patients receive appropriate antibiotic treatment, typically doxycycline (Azad and Beard 1998).

Although flea-borne rickettsiosis is no longer a nationally notifiable disease, cases are reported in a few U.S. states, principally Hawaii, California, and Texas, where

most outbreaks occur (Reighter et al. 2013). Since 2006, cases of this disease in Orange County have constituted 21.8% (159/731) of flea-borne rickettsial disease victims within California (CDPH 2016); prior to 2006, the last reported case in Orange County was in 1993 (OC Health Care Agency 2016). All reported cases in the county have occurred in suburban neighborhoods and have been associated with the cat flea and its primary hosts: the Virginia opossum (*Didelphis virginiana*), domestic cats (*Felis catus*), and dogs (*Canis familiaris*) (Ereemeeva et al. 2012, Cummings et al. 2014).

RICKETTSIAL DISEASES ASSOCIATED WITH FERAL CATS

Feral cats can enhance transmission of zoonotic diseases to humans, other domestic animals, and wildlife (Barrows 2004). These diseases include toxoplasmosis, rabies, toxocarriasis, bartonellosis, bubonic plague, and flea-borne rickettsiosis (Gerhold and Jessup 2012). Results of 66 detailed human flea-borne rickettsial case investigations by OC Vector Control from 2012-2013 showed a relationship between rickettsial disease in humans and their association with stray/feral cats in 18 (27%) of the disease victims; they reported primary exposure to a rescued cat, cared for a cat colony, adopted strays, or had a cat colony at their worksite (Cummings et al. 2014). The remaining cases (41/66) had varied exposures to companion animals, opossums, or other wildlife; or, in 7 of 66 cases had exposure to fleas in the environment with no reported animal associations (Cummings et al. 2014).

Because opossums, feral cats, and domestic mammalian pets serve as hosts for cat fleas and share the same niche in the urban and suburban environment, the most likely route of flea-borne rickettsial transmission involves infected cat fleas moving from opossums and feral cats to household pets that frequently contact people (Ereemeeva et al. 2012). Feral cat feeding stations, which also provide food for opossums and other backyard wildlife, have been implicated in the flea-borne rickettsial disease transmission to an employee whose workplace allowed feeding stations (OC Grand Jury 2015a). High densities of feral

cat populations can support large populations of cat fleas (Akucewich et al. 2002).

ROLE OF GOVERNMENTAL AGENCIES

Orange County Mosquito and Vector Control District

The Orange County Mosquito and Vector District is one of over 100 independent special districts in California specifically dedicated to protecting public health in regard to vectors and vector-borne diseases. It was formed under the Mosquito Abatement and Vector Control District Law (CA Health and Safety Code Secs. 2000-2093) and operated on an annual budget of approximately \$11.8 million with 55 full-time employees and approximately 65 seasonal workers during fiscal year 2014 -15 (OC Vector Control 2015).

Orange County Animal Care

The OC Animal Care is an open-admission public shelter that serves a large portion of the county with an estimated population of 2.1 million people residing in 18 contract cities and unincorporated areas. The pet population within the area of coverage is estimated at 350,000 or more based on the size of the human population (AVMA 2012, OC Grand Jury 2015b). During fiscal year 2014-2015, OC Animal Care operated on a \$17.86 million annual budget and employed 139 full-time staff members and about 400 volunteers; it averaged over 26,000 live animal intakes per calendar year (2013–2015), of which nearly one-third were cats, and of these, most were stray kittens (OC Animal Care Shelter Statistics 2013-2015).

Although not mandated by California law, OC Animal Care implemented its version of TNR in 2013 after several years of a pilot study (OC Animal Care 2016) and frequent complaints about its euthanization rate of cats (Voice of OC 2016). The TNR Program has been supported by Orange County funds and annual recurring grant monies from several animal charities, principally PetSmart Charities (\$50,000 - \$100,000) and the American Society for the Prevention of Cruelty to Animals (ASPCA) (\$50,000) (OC Community Resources Annual Grants Tables FY 2013-14, FY 2014-15, FY 2015-16). OC Animal Care and volunteers from Feral Alley Cats and Friends of the Society for the Protection of Animals (FSPCA) provide staff for the Program (OC Animal Care 2016). In their version of TNR, healthy feral cats are treated with a topical flea medication, sterilized, vaccinated for rabies and feline viruses (rhinotracheitis, calicivirus, and panleukopenia); micro-chipped and ear-tipped for identification; and returned to the areas from which they were captured.

The goals of OC Animal Care's TNR Program are to reduce free-roaming cat populations, reduce the intake of feral cats and neonatal kittens, increase the live release rate for cats, save taxpayer money, and provide more shelter space for adoptable cats.

ORANGE COUNTY GRAND JURY'S REVIEW OF THE ORANGE COUNTY ANIMAL CARE TNR PROGRAM

In California, each county is required by law to impanel a grand jury of 19 to 23 members, depending on county population, to serve for a term of one year. The responsibilities of the grand jury include the examination of all

aspects of county government to ensure the county is being governed honestly and efficiently and that county monies are being handled appropriately (OC Grand Jury 2016). The 2014-2015 OC Grand Jury investigated a number of written and verbal complaints from current and former staff of OC Animal Care about the TNR program's ineffectiveness, potential public health hazard, and diversion of resources from emergency treatment of domestic cats and dogs awaiting adoption, among other topics (OC Grand Jury 2015a).

Among 10 OC Grand Jury Findings and Recommendations for the OC Animal Control, one questioned the effectiveness of the TNR Program at reducing cat overpopulation and identified it as a possible contributor to the spread of zoonotic disease agents, including flea-borne rickettsiosis (OC Grand Jury 2015a). In response, OC Animal Care disagreed partially with the finding and maintained that their former 6-decade practice of "trap and kill" for feral cat control was ineffective and even promoted increased cat numbers; TNR was seen as a viable alternative, based on its use elsewhere in the U.S. (Johnson and Cicirelli 2014, Lazenby et al. 2015). While the OC Grand Jury recommended an immediate evaluation of the program, OC Animal Care maintains that they need approximately 7 to 10 years of data to draw meaningful conclusions on whether their TNR program is effective in reducing numbers of feral cats, cat intakes, and the euthanasia rate (OC Grand Jury 2015c). Overall, OC Animal Care views their TNR Program as a humane approach to cat population reduction, without undue risk to public health from zoonotic diseases associated with feral cats and damage to the environment.

DISCUSSION

Exposure to flea-borne rickettsial disease agents is highly variable and involves a complex matrix of ecologic and economic factors and changes in human behavior (Azad et al. 1997). Regardless of the relative importance of each element, the increased prevalence of flea-borne rickettsiosis in Los Angeles and Orange counties (CDPH 2016) (Figure 1) may be due partially to government-sanctioned programs that encourage the maintenance of feral cat colonies in highly populated areas (County of Los Angeles Departments of Public Health and Animal Care and Control 2009, LA Animal Services 2010, Cummings et al. 2014), which contradicts recommendations of public health veterinarians (NASPHV 1996). Free-roaming cat colony feeding stations also attract other cat flea hosts (e.g., opossums), potentially increasing human flea-borne rickettsiosis exposure incidents (Nelson et al. 2016, Wekesa et al. 2016).

While many members of the public, animal welfare advocates, and local elected officials strongly support OC Animal Care's TNR Program, the placement of feral cats in neighborhoods already faced with increased cat densities is contrary to the goals of OC Vector Control, whose mission is to protect the public from vector-borne diseases. In contrast, the primary purpose and goal of OC Animal Care's TNR Program is not to address zoonotic disease but to control increases in community (i.e., feral) cat populations and improved feral cat health (OC Animal Care 2016).

Local TNR policies typically do not receive the formal environmental review that projects with potential adverse environmental effects normally require; this probably results from the perception of TNR as an animal welfare, rather than environmental, measure (Longcore et al. 2009). OC Animal Care maintains that its TNR Program need not be subjected to an Environmental Impact Review, because TNR just returns cats to existing populations and is not an additive threat to the environment or public health. However, Eremeeva et al. (2012) found that untreated feral cats living in close contact with multiple cats in colonies can maintain flea populations year-round in temperate Southern California and can increase the flea-borne rickettsiosis disease risk to humans. In most TNR programs, ongoing flea treatment of feral cats is not feasible, resulting in feral cat colonies with flea infestation rates as high as 92.5% (Akucewich et al. 2002) threatening human health (Kliks 2003). In a disease outbreak, flea suppression is the first public health action often initiated, and failure to control free-roaming cat populations can lead to future outbreaks (Gerhold and Jessup 2012).

The proliferation of feral cat colonies in Los Angeles County has given rise to an increase of complaints to the county public health department from residents who are unable to eliminate fleas in their yards due to the repeated presence of free-roaming cats (Urban Wildlands Group 2012) and to warnings on their potential health effects (County of Los Angeles Departments of Public Health and Animal Care and Control 2009). In Los Angeles and Orange counties, annual flea-borne rickettsiosis cases prior to 2007 were relatively few ($< 21/\text{yr.}$, Los Angeles County), or non-existent (Orange County) (Figure 1). By 2010, cases began to increase in both counties (CDPH 2016), with several flea-borne rickettsiosis outbreaks occurring in clusters (Green et al. 2011, Wekesa et al. 2016), especially in mobile home communities with high feral cat densities (OC Register 2015, OC Vector Control 2016, Nelson et al. 2016).

Hotspot analysis (ESRI, ArcMap 10.2, Hot Spot Analysis) of the locations of 138 human flea-borne rickettsial disease cases showed significant clustering among 99 cases in the county [$p < 0.05$, Getis-Ord GI, range 0.7 - 1.5 cases/ km^2 (1.8 - 3.9 cases/ mi^2)] (Figure 2). (For epidemiological purposes, it is assumed that rickettsial transmission occurred predominately at the case household or within the immediate vicinity of a reported case address). A review of TNR cat locations ($N=3,247$) provided by OC Animal Care for 2013-2015 showed that 268 TNR cats were placed within 400 meters (0.25 mi.) of the locations of 69 flea-borne rickettsial disease cases. This is in contrast to OC Animal Care's assurances not to return cats to areas where rickettsial disease transmission had occurred previously (OC Vector Control 2014). Furthermore, the proximity of TNR cats to each other suggests that many were placed in cat colonies, which is also contrary to the interagency agreement (OC Vector Control 2014). While this hotspot analysis demonstrates clustering of human rickettsial disease cases, it does not suggest a causative relationship between rickettsial disease transmission and placement of TNR cats. However, it does identify areas of high flea-borne rickettsial disease occurrence and greater relative risk for rickettsial transmission compared to other

areas of Orange County. The factors underlying higher rickettsial disease prevalence and transmission in these affected areas suggest several possible causes, including an abundance of host animals (opossums, feral cats) with *Rickettsia*-infected cat fleas (Boostrom et al. 2002, Eremeeva et al. 2012).

OC Animal Care maintains that TNR cats represent only 1.3% of a larger feral cat population of more than 300,000 animals and do not pose an inordinate zoonotic disease risk for the public (OC Grand Jury 2015c). Because of its dedicated volunteer groups, OC Animal Care reports that it is cheaper to process cats through TNR than to euthanize them, costing \$451.24 vs. \$455/cat, respectively (OC Register 2015). Since inception, OC Animal Care's TNR Program has returned 13.5% (4,730/34,995) of the received cats to their sites of capture (OC Animal Care Shelter Statistics 2013-2015). None of these returned cats have received follow-up flea treatments or rabies vaccination after release to the field.

Following implementation of the OC Animal Care's TNR Program, average annual cat intake decreased about 19.8% (13,141 vs. 10,542) from 2014 to 2015 (OC Animal Care Shelter Statistics 2013-2015), but this decline may not be the result of the TNR Program. Overall, the cat euthanization rate declined from approximately 75% to 50% in two years compared to the previous 4-year average (2010-2013). Coincidentally, average annual dog intake declined as well, falling approximately 30.8% (14,199 vs. 9,846) during the same time period, 2014-2015 (OC Animal Care Shelter Statistics 2013-2015). Hence, the decline in both dog and cat intake may be the result of better behavior by the public towards pet ownership, higher sterilization rates, or a statistical artifact of an improved economy, where pets are less likely to be abandoned or turned in for euthanization because of the lack of finances on the part of owners (ASPCA 2009, LA Animal Services 2010). Intake into an open admission shelter can fluctuate — as the cat population drops, intake typically goes down, too; however, the relationship is not absolute and changes in intake can reflect other confounding variables, such as changes in shelter policy (Kortis 2014).

For TNR programs to be effective and achieve long-term declines in feral cat populations, designers should select a targeted area, emphasize colony-level targeting, accurately estimate the number of cats, and sterilize most (75-95%) of the free-roaming cats in the colony in order for attrition to outpace feline reproduction (Kortis 2014). TNR, as currently practiced by most municipalities, is rarely optimized for population control (Boone et al. 2014). Instead, shelters measure the success of their TNR programs based on reduced euthanasia rates rather than determining if feral cat numbers actually decline in the field (Jessup 2004). Studies in several large urban areas (Foley et al. 2005, Natoli et al. 2006) failed to show any meaningful TNR-induced population-level effects after years of processing a combined total of more than 34,000 cats (range 7,890- 14,452/yr.). At less than 2% of the estimated feral cat population, the OC Animal Care TNR Program's feral cat sterilization rate is too small to achieve effective reduction (Andersen et al. 2004) and protection of public health. In contrast, removal is predicted to reduce feral cat populations quickly for local populations greater

Figure 2. Locations of human flea-borne rickettsiosis cases, endemic flea-borne rickettsiosis hotspot areas, and feral cat releases, 2013- 2015, Orange County, CA. (OC Health Care Agency 2012). Human case addresses were randomly offset spatially by 0.5 km (0.3 mi) for display on the map to comply with OC Health Care Agency privacy regulations under the Health Insurance Portability and Accountability Act (HIPAA 1996). Some cases are obscured by overlapping circles because of clustering.

than 50 cats if the effort is sustained and enough of the population is captured (Lloyd and DeVore 2010).

Effectiveness of TNR programs in achieving reductions of feral cat colonies in urban areas is inconsistent. Good results can occur when comprehensive programs are used on small populations (Levy et al. 2003, Winter 2004). However, at times reductions have been disappointingly small (Natoli et al. 2006). In other attempts, feral cat numbers remain unchanged (Hughes et al. 2002) or have shown increases (Castillo and Clarke 2003, Winter 2004). Maintenance of outdoor cat populations through TNR often creates an attractive nuisance that only encourages immigration of unsterilized cats into colonies, illegal cat dumping by the public, and ultimately, increases in the feral cat population (Castillo and Clarke 2003, Natoli et al. 2006). For these reasons, TNR programs as practiced by municipal shelters are not effective methods for reducing public health concerns or for controlling feral cats. Instead, they merely transfer cats destined for shelter death to living outdoors and lower the euthanization rate of the agency. Responsible pet ownership, universal rabies vaccination of

pets, and removal of strays remain integral components to control rabies and other zoonotic diseases (Roebeling et al. 2014). When feral cat colonies are stable or increasing and they pose active public health risks, the American Veterinary Medical Association (AVMA) does not oppose euthanasia, when conducted by qualified personnel using appropriate humane methods as described in their guidelines (AVMA 2016). The AVMA's Committee on Environmental Issues also stated its support for prohibitions on local ordinances that allow for managed cat colonies (Barrows 2004).

Preventing Flea-borne Disease Transmission to Humans

Both OC Vector Control and OC Animal Care acknowledge their responsibility in preventing zoonotic diseases. The public health hazards that feral cats represent, including maintenance of flea populations and continuous production of feces, are not diminished by neutering through a TNR program. Once the topical flea treatment applied at a shelter wears off within 30 days, TNR cats will support

flea infestations throughout their lifetimes. TNR programs typically have a goal of slow attrition and maintenance of cat populations, so that releasing neutered cats into the environment may actually increase cat survivorship in well-maintained colonies due to decreased fighting and absence of reproductive stress (Loyd and DeVore 2010).

The OC Vector Control has requested several measures be undertaken by OC Animal Control to mitigate the zoonotic disease risk associated with feral cat colonies. The first step would be the establishment of a joint agency TNR procedural manual that would incorporate harm-reduction practices into the TNR release program, to minimize the zoonotic disease risk to the public. This document would also codify the requests of OC Vector Control as outlined earlier in this discussion. Some other recommendations aimed at reducing zoonotic disease risk are:

- Incorporate feeding stations that also administer a topical residual flea control product to cat pelage or use feed-through flea treatments;
- Use community targeting in its TNR Program, rather than opportunistic sterilization. Focus on densely-populated communities, such as mobile home parks, where community cats roam freely in close proximity to human living quarters;
- Educate TNR advocates of the adverse effects of cats on the environment and potential disease risks;
- Explore the use of contraceptive vaccines for feral cat control (Levy 2011).

ACKNOWLEDGEMENTS

We thank Joe Ramirez with the County of Los Angeles Environmental Vector Management Program for his insight in working with feral cat advocacy groups.

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