

# Temporal occurrence and environmental risk factors associated with cytauxzoonosis in domestic cats

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## Abstract

*Cytauxzoon felis* is a tick-transmitted protozoan parasite of domestic and wild felids in the south-central and southeastern United States. Infection of domestic cats (*Felis domesticus*) with *C. felis* is typically acute and characterized by fever, anorexia, listlessness, anemia, icterus and usually death within 19–21 days. To determine the temporal occurrence and environmental risk factors associated with infection of *C. felis* in domestic cats from Oklahoma, information in the electronic medical records from the Oklahoma Animal Disease Diagnostic Laboratory (OADDL) and Boren Veterinary Medical Teaching Hospital (BVMTH) was retrospectively searched. A total of 232 cytauxzoonosis cases from 1995 to 2006 from OADDL ( $n = 180$ ) and 1998 to 2006 from BVMTH ( $n = 52$ ) were combined and analyzed. The number of cytauxzoonosis cases remained relatively consistent from year to year. Diagnosis of *C. felis* infection in domestic cats followed a bimodal pattern with a peak in the number of cases in April, May, and June followed by a second smaller peak in August and September. The majority ( $n = 72$ ; 31.0%) of cytauxzoonosis cases were diagnosed in May. No cases of *C. felis* infection were diagnosed in December and only a few ( $n = 10$ ; 4.3%) cases were observed from November through March during the 12-year period. In cases for which the client's address was available, geographic coordinates were assigned and landscape characteristics were quantified within a 100-m radius of each cytauxzoonosis case location. Of cytauxzoonosis cases ( $n = 41$ ) with a known client address, a majority ( $n = 28$ ; 68.3%) occurred in low density residential areas and more cases ( $n = 8$ ; 19.5%) were found in urban edge habitat than expected at random. Locations of diagnosed cytauxzoonosis cases were significantly associated with more wooded ( $31.8 \pm 4.03\%$ ) cover and closer ( $55.5 \pm 18.45$  m) proximity to natural or unmanaged areas than randomly selected control sites. Practicing and diagnostic veterinarians can expect to see a distinct temporal pattern in cases of cytauxzoonosis and more cases can be expected in domestic cats living in close proximity to environments that support tick vectors and bobcats.

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## 1. Introduction

*Cytauxzoon felis* is a tick-borne protozoan parasite of domestic and wild felids. Originally reported in 1976 from domestic cats in southwestern Missouri (Wagner, 1976), *C. felis* is considered as an emerging infectious disease agent found throughout the south-central and

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southeastern United States (Birkenheuer et al., 2006; Hauck et al., 1982; Jackson and Fisher, 2006; Meinkoth and Kocan, 2005). Infection of domestic cats (*Felis domesticus*) with *C. felis* is acute and characterized by fever, anorexia, listlessness, anemia, icterus and usually death within 19–21 days (Wagner, 1976; Wagner et al., 1980). Historically, the mortality rate of cytauxzoonosis has approached 100%; however, clinical cases have been described in which cats survived infection both with and without treatment (Motzel and Wagner, 1990; Walker and Cowell, 1995). A focus of *C. felis*-survivor cats has been identified in a discrete geographic area ranging from western Arkansas to eastern Oklahoma (Meinkoth et al., 2000). Free-ranging and apparently healthy cats that survived infection of *C. felis* also have also been identified in Florida and Tennessee (Haber et al., 2007).

Cats become infected with *C. felis* sporozoites from tick bites. Within infected cats, *C. felis* first replicates asexually by schizogony in endothelium and macrophages lining organs (Kocan et al., 1992). Lungs, spleen, liver, and lymph nodes (Kier et al., 1987) are most noticeably infected although almost any organ is susceptible. The end products of schizogony are merozoites, which rupture the host macrophage and enter either a new host macrophage or erythrocyte. Within erythrocytes, the parasites, called piroplasms, have a characteristic signet-ring appearance and reproduce asexually through binary fission. The piroplasm can rupture erythrocytes; however, schizogonous replication of *C. felis* within macrophages is more pathogenic and results in the occlusion of vessels producing systemic disease (Kier et al., 1987).

Since infection of domestic cats is presumably dependent upon transmission of *C. felis* from ticks, the occurrence of disease seems to be limited to activity periods of tick vectors in enzootic areas. To date, the only experimentally confirmed vector of *C. felis* is *Dermacentor variabilis*, the American dog tick (Blouin et al., 1984). Infection of *C. felis* has been reported in three partially engorged *Amblyomma americanum*, lone star tick, nymphs recovered from a cat that died of cytauxzoonosis (Bondy et al., 2005). It is unclear whether the *A. americanum* ticks were infected prior to engorgement or if they ingested blood containing piroplasms from the vertebrate host while feeding. It also has been speculated (Hoover et al., 1994; Wightman et al., 1977) that cases of cytauxzoonosis are most often observed in rural cats free to roam in wooded areas. The purpose of the present study was to determine the temporal occurrence of cytauxzoonosis and to identify environmental risk factors associated

with *C. felis* infection in domestic cats. Practicing and diagnostic veterinarians will benefit by knowing when to expect more cytauxzoonosis cases, what environmental factors are associated with infection, and how to effectively target parasite prevention efforts.

## 2. Materials and methods

### 2.1. Medical records

Electronic records from Boren Veterinary Medical Teaching Hospital (BVMTH) and Oklahoma Animal Disease Diagnostic Laboratory (OADDL), both in Stillwater, OK, were searched for cases of *C. felis* infection in domestic cats. Cases from 1998 to 2006 and 1995 to 2006 were reviewed from BVMTH and OADDL, respectively. Cytauxzoonosis cases were defined by either piroplasm detection on microscopic examination or by schizont detection through histopathology, with both detection methods predicated upon report of clinical signs characteristic of cytauxzoonosis. Data from BVMTH and OADDL were combined and analyzed according to the year and month of occurrence.

### 2.2. Geographical information system (GIS)

A street database based on 2000 TIGER/Line files from the Census Bureau for Oklahoma was obtained from geo information systems at the University of Oklahoma. Cases with client addresses were assigned geographic coordinates by linking street addresses for each case to the street database using ArcGIS® v.9.2 (Environmental Systems Research Institute, Redlands, CA). If a client address was unavailable or incomplete, then the record was excluded from the risk factor analysis. Once addresses were matched to geographical coordinates, each point was moved to the center of the home corresponding to the identified street location.

Landscape characteristics within a 100-m radius of each case location were quantified in order to represent the area of highest activity by domestic cats. Previous research suggested domestic cats typically remain close to their house of residence and move less than 100 m on a daily basis (Coleman and Temple, 1989; Kays and DeWan, 2004). Each case location was classified as occurring in low density residential or rural, high density residential, or urban edge areas using 2003 NAIP (National Agriculture Imagery Program) natural color positive images. Low density residential or rural areas included single family homes located on large (>50 m from another home) lots in urban or rural areas.

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