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Urban domestic dog populations as a source of canine distemper virus for wild carnivores in the Coquimbo region of Chile

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ABSTRACT

Urban areas can support dog populations dense enough to maintain canine distemper virus (CDV) and can be a source of infection for rural dogs and free-ranging carnivores. The aim of this study was to investigate the relationships between urban and rural domestic dog and wild carnivore populations and their effects on the epidemiology of CDV to explain retrospectively a CD outbreak in wild foxes in 2003. From 2005 to 2007 a cross-sectional household questionnaire survey was conducted in Coquimbo and Ovalle cities, in three towns and in rural sites along two transects from these cities to the Fray Jorge National Park (FJNP) in the Coquimbo region, Chile. Blood samples were collected from unvaccinated dogs at surveyed households and from free-ranging foxes in rural areas along the transects. The seroprevalence of CDV in domestic dogs was higher in urban than in rural areas and in the later was highest in dogs born before 2001–2002. The seroprevalence of CDV in foxes was higher in areas closer to human settlements. A high seroprevalence in dogs born before 2001–2002 further supports a link between CDV patterns in rural dog and fox populations. In our study area, urban dogs are proposed to be the source of CDV infection to wild carnivores. The large dog population size and density detected in Coquimbo and Ovalle provides optimal conditions for maintaining a large and dense susceptible population of dogs, which can act as a reservoir for highly infectious diseases and could have been the source of infection in the CD outbreak in wild foxes.

1. Introduction

Canine distemper is one of the most common and globally significant infectious diseases of the domestic dog (*Canis familiaris*). In addition to causing disease in domestic dogs, canine distemper virus (CDV) can cause high mortality rates in wild carnivores and can threaten endangered carnivore populations (Funk et al., 2001). Key aspects for the control of CDV and for minimising its threat to wildlife conservation should include the identification of infection reservoirs, the mechanisms by which infections are sustained within reservoirs, and the sources and routes of transmission from reservoirs to species of concern (Woodroffe, 1999). Following Haydon et al. (2002), a reservoir is defined as one or more epidemiologically connected populations or environments in which the

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pathogen can be permanently maintained and from which infection is transmitted to the defined target species (e.g., wild carnivores). On the other hand, a source population is defined as any population that transmits infection directly to the target population, being by themselves maintenance populations or constitute all or part of a transmission link from a maintenance population to the target population (Haydon et al., 2002).

Theoretical studies and empirical data suggest that infectious pathogens should only persist in populations larger than a threshold or critical community size (CCS), where the pathogen is maintained by an input of susceptibles by birth and/or immigration (Swinton et al., 2002). On the other hand, in populations below the CCS, such pathogens cannot persist because of the low probability of contact between infectious and susceptible hosts (Anderson and May, 1991). However, even those populations that are under a CCS (non-maintenance populations) if they are epidemiologically and spatially connected with other non-maintenance or maintenance populations (e.g., through immigration), they can be part of larger complex meta-population which can be part of a reservoir in which the pathogen can persist in the long-term (Haydon et al., 2002; Almberg et al., 2010).

Domestic dogs are one of the most numerous carnivores in the world (Daniels and Bekoff, 1989), and they are particularly abundant in urban areas of some developing countries where they can be excellent reservoirs for pathogens, since they usually live in large populations, are not vaccinated and are regularly allowed to roam freely, facilitating contact between infected and susceptible hosts (WHO/WSPA, 1990). In contrast, in rural areas, where dog densities and population size are often low (see Acosta-Jamett et al., 2010), highly virulent pathogens cannot be maintained and the infection fades out in the absence of the introduction of new infections from neighbouring areas (Swinton et al., 2002). Furthermore, rural areas tend to be the habitat of wild carnivores that may be susceptible to CDV (Appel, 1987; Funk et al., 2001). Wild carnivores commonly have small populations and occur at low densities. Therefore, they are often not suitable to maintain infections for highly pathogenic generalist viruses like CDV (Cleaveland et al., 2002). Instead, these pathogens tend to spill over from domestic dogs to wild carnivores through occasional contact (e.g., Cleaveland et al., 2000).

At the end of the austral spring in November 2002, wild foxes of the genus *Pseudalopex* were seen with canine distemper-like signs by local people in the surrounding areas of Tongoy town and after five months in the Fray Jorge National Park (FJNP) in the semi arid Coquimbo region of north-central Chile, reporting a peak of cases in the austral summer (January–March) of the next year (Moreira and Stutzin, 2005; Acosta-Jamett, 2009) (see Fig. 1). In this region the size and density of domestic dogs is many orders of magnitude higher in urban (i.e., ~80,000 dogs and 2000 dogs km^{-2}) than in rural areas (i.e., ~2000 dogs and 6 dogs km^{-2}) and it has been hypothesised that urban dogs, due to their high population size and density and high population turnover, can act as reservoir of directly transmitted pathogens such as canine distemper virus (Acosta-Jamett et al., 2010). CDV has been reported to be present in domestic dogs and in wild carnivores in Chile (González-Acuña et al., 2003). Whether domestic dogs inhabiting towns or cities in the Coquimbo region can be reservoir populations for directly transmitted pathogens such as canine distemper virus to domestic and wild carnivores inhabiting rural areas is unknown.

We hypothesise that the population size of rural dogs and wild carnivores in the Coquimbo region is far below that required for maintaining CDV in the region and that urban dogs were the source of CDV infection for wild carnivores during the CD outbreak in 2003. We estimated the seroprevalence of CDV in domestic dogs inhabiting urban and rural areas and in wild foxes in the Coquimbo region in central Chile, determined age-specific seroprevalence, and identified and quantified risk factors for CDV seropositivity that could explain retrospectively the 2003 CD outbreak in foxes, by exploring whether CDV prevalence in wild carnivores relates to urban domestic dog populations.

2. Material and methods

2.1. Study area

The study site comprised an area of ~1600 km^2 of the Coquimbo region in North Central Chile (71°12′ to 71°40′W, 29°58′ to 30°39′S). This area included two cities, three towns and several small human settlements connected to the FJNP through land use gradients (Fig. 1). The cities are the capital of the region, Coquimbo city, with a human population of ~148,500 inhabitants and an average of 3.4 people/household, and Ovalle city, with a human population of ~66,500, and an average of 3.5 people/household (INE, 2005). The towns are Tongoy, Guanaqueros and La Torre with a human population of less than 5000 inhabitants (INE, 2005). Rural human settlements are dispersed areas existing between cities and towns in settlements with a low human density of 2.0 individual/km^2 (INE, 2005), and where households are typically placed both sides of a main road in very isolated places. Two fox species inhabit rural areas in this region, the chilla (*Pseudalopex griseus*) and the culpeo (*Pseudalopex culpaeus*).

2.2. Sampling design

The sampling design is described in detail elsewhere (Acosta-Jamett et al., 2010). Briefly, in order to assess CDV prevalence in an urban/rural complex, sampling was carried out along gradients of urbanization by two transects from Coquimbo and Ovalle cities to FJNP (Fig. 1). The first transect ran for 80 km north-south from Coquimbo to the FJNP and included Guanaqueros and Tongoy towns (sites B and C, respectively) and the rural sites Lagunillas (A), El Tangue (D), and Punilla (E). The second ran for 40 km east-west transect from Ovalle city to the FJNP. This transect included the rural site Barraza (F) and La Torre town (G). The centroids were evenly spaced out along the transects at intervals of 13 km and a circle of 6.5 km radius drawn at each to demarcate the sampling site.