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Assessing demographic and epidemiologic parameters of rural dog populations in India during mass vaccination campaigns

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ABSTRACT

Mass vaccination of dogs is a mainstay for efforts to control rabies and other viral pathogens. The success of such programs is a function of the ability to vaccinate sufficient proportions of animals to develop herd immunity. However, fully assessing success in reaching target vaccination-levels and in understanding the outcome of mass vaccination efforts is hindered if insufficient information is available on the demographics of dog populations and the prevalence of the targeted pathogens. While such information can sometimes be gained from questionnaire surveys, greater precision requires direct assessment of the dog populations. Here we show how such information can be gained from surveys of dogs conducted in association with mass-vaccination programs. We conducted surveys of dogs in six villages in rural Maharashtra, India, between February and July 2011 as part of an effort to reduce the risk of human rabies and virus transmission from dogs to wildlife. Mass vaccination efforts were conducted in each village, and paired with blood sample collection and photographic mark-recapture approaches to gain epidemiologic and demographic data. This data in turn facilitated estimates of dog abundance, population density and structure, vaccination coverage, and seroprevalence of antibodies against canine adenovirus (CAV), canine parvovirus (CPV), and canine distemper virus (CDV). The median dog population size for the six villages was 134 (range 90–188), the median dog population density was 719 dogs per km^2 (range 526–969), and the median human:dog ratio for these six villages was 34 (range 30–47). The median household:dog ratio for the six villages was 6 (range 5–8). Following vaccination efforts, the median vaccination coverage achieved was 34% (range 24–42%). The dog populations consisted mostly of adult dogs (67–86%) and the median sex ratio for the study area was male biased (1.55 males per female; range 0.9–2.5). The seroprevalence of antibodies against CAV, CPV and CDV was 68, 88 and 73%, respectively. Mass vaccination campaigns provide an opportunity to obtain vital epidemiological and demographic data, and develop a clearer understanding of the threats and impacts of diseases and disease control measures.

1. Introduction

Dogs, as reservoirs and vectors of infectious pathogens, pose a serious threat to the health and well-being of humans and livestock (WHO, 1999; Cleaveland et al., 2002; Coleman et al., 2004; Knobel et al., 2005). In India, for instance, canine rabies is estimated to kill approximately 20,000 people annually (Sudarshan et al., 2007). Pathogens

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transmitted from dogs also are a significant threat to the conservation of many wild carnivore species (Funk et al., 2001; Woodroffe et al., 2004). Epizootics putatively caused by viral transmission from free-ranging dogs are hypothesized to have caused several well-documented and precipitous declines in wildlife (Roelke-Parker et al., 1996; Laurenson et al., 1998; Kennedy et al., 2000). Vaccination is a mechanism for reducing the prevalence and incidence of viral loads in dogs and has been applied to African free-ranging dog populations to reduce risks to people and wildlife (Randall et al., 2006; Kaare et al., 2009; Fitzpatrick et al., 2012). Such approaches protect the vaccinated individual against infectious diseases and also contribute to 'herd immunity' within the broader population by reducing the population density of susceptible individuals to a point for which the basic reproduction number (R_0) for a pathogen is <1.

Mass vaccination of dogs has been suggested as the main tool for disease control to prevent disease transmission to humans, livestock and wildlife populations (Dodet and Meslin, 2001; Cleaveland et al., 2006). Epidemiological models and field experiences from various countries indicate that outbreaks of rabies and canine distemper virus (CDV) can be prevented by mass vaccination (Cleaveland, 1996; Coleman and Dye, 1996). The World Health Organization (WHO, 1987) has proposed a target level of 70% for mass vaccination to eliminate or prevent outbreaks of rabies. Yet identifying the vaccination coverage of a mass vaccination program is dependent on precise assessment of the dog population size or density. Furthermore, addressing the population trajectories of dogs requires detailed information on dog demographics. While some of this information is sometimes gained from surveys of owners independent of vaccination programs (e.g. Acosta-Jamett et al., 2010), or during the mass vaccination program (e.g. Fiorello et al., 2006), such examples are the exception, as many vaccination programs collect limited information on the demographics of the dogs and few studies provide detailed information on the demographics of dog populations, and in particular, rural free-ranging dog populations.

In India, for example, field data on dog demographics and measures of the prevalence of important pathogens are virtually lacking. The actual incidence of rabies in dog populations is not known, and data are also lacking for the prevalence of other canine pathogens, such as CDV, canine parvovirus (CPV), and canine adenovirus virus (CAV; the causative agent of canine hepatitis), each of which may play a role in limiting dog populations in the region and may represent risks to wild canids. This lack of epidemiological data as well as demographic data on the free-ranging dog populations in India and elsewhere is a major impediment in understanding the real threat of such pathogens, in achieving effective disease control, and in managing dog population growth.

Mass vaccination campaigns, if paired with surveys and sampling sessions, provide an opportunity to obtain high quality epidemiologic and demographic data for dog populations. Here we provide epidemiologic and demographic data collected from dog populations surveyed in six villages in rural Maharashtra, India. This work was spurred in part by an effort to reduce the risk of pathogen transmission from dogs to wild canids around the Great Indian Bustard Wildlife Sanctuary (GIB WLS), Nannaj, Maharashtra as well as to reduce the risk to humans in the focal villages where cases of human rabies occasionally occur. This region is of interest because CDV-related mortalities were documented in Indian foxes (*Vulpes bengalensis*) in 2006, and this mortality was putatively linked to spill-over of CDV from dogs (Vanak et al., 2007). Subsequently, mass dog vaccination campaigns were initiated by the Maharashtra Forest Department in villages around the GIB WLS, providing an opportunity to collect detailed information about dog pathogen exposure and demographics. Thus, this study was planned around the mass vaccination campaigns, using the opportunity to: (1) estimate dog abundance and density at each site, and then to estimate the vaccination coverage achieved during the mass vaccination campaigns; (2) document the dog population demographic characteristics at each site; (3) investigate the baseline seroprevalence of three viruses (CDV, CPV, and CAV). While our findings are specific to one region of India, we believe they also provide insights for those attempting to formulate disease control strategies in rural regions elsewhere across the globe.

2. Materials and methods

2.1. Study location

The study was conducted in six villages (Wadala, Mardi, Nannaj, Akolekati, Karamba and Gawdi Darfal) bordering the GIB WLS at Nannaj, Maharashtra in central India between February and July 2011. The GIB WLS is a series of six protected grassland patches (6 km^2), which are remnants of the grassland ecosystem in a human-dominated landscape. The population finder feature on the Census of India website was used to obtain the human population of the study villages in 2001 (http://www.censusindia.gov.in/PopulationFinder/Population_Finder.aspx), and the decadal growth rate for rural Solapur district (2001–2011) (http://www.censusindia.gov.in/2011-prov-results/paper2/data_files/mah/8-POP-11-26.pdf). The later was used to calculate the projected population of the study villages in 2011. The projected human population sizes of these villages in 2011 ranged between 2973 and 7448, and the number of households ranged between 490 and 1300.

Dogs are ubiquitous in this region and have the phenotype typical of the village dogs of India. The local economy is based on agro-pastoralism, and thus the landscapes used by dogs consist of a matrix of sugarcane fields, vineyards, seasonal crops, communal grazing lands, protected grasslands and forestry plantations. Other carnivores that are found in the study area include Indian fox, gray wolf (*Canis lupus*), golden jackal (*C. aureus*), jungle cat (*Felis chaus*) and gray mongoose (*Herpestes edwardsi*). The movements and interactions of dogs and wildlife in this region have been the subject of detailed study (Vanak et al., 2007, 2009; Vanak and Gompper, 2010, 2009).