Preventive Veterinary Medicine 118 (2015) 436–448

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Comparison of mark-resight methods to estimate abundance and rabies vaccination coverage of free-roaming dogs in two urban areas of south Bhutan

Tenzin Tenzin[a,*], Joanna S. McKenzie[b], Raphaël Vanderstichel[c], Bir Doj Rai[d], Karma Rinzin[a,e], Yeshey Tshering[a], Rinzin Pem[d], Chenga Tshering[f], Narapati Dahal[a], Kinzang Dukpa[a], Sithar Dorjee[c,g], Sonam Wangchuk[h], Peter D. Jolly[b], Roger Morris[i], Michael P. Ward[j]

[a] National Centre for Animal Health, Department of Livestock, Thimphu, Bhutan
[b] Institute of Veterinary, Animal and Biomedical Sciences, Massey University, New Zealand
[c] Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PEI, Canada
[d] Regional Livestock Development Centre, Department of Livestock, Wangdue, Bhutan
[e] College of Veterinary Medicine, School of Veterinary and Life Sciences, Murdoch University, Perth, Australia
[f] Regional Livestock Development Centre, Department of Livestock, Zhemgang, Bhutan
[g] Bhutan Agriculture and Food Regulatory Authority, Thimphu, Bhutan
[h] Department of Public Health, Ministry of Health, Thimphu, Bhutan
[i] MorVet Limited, Masterton, New Zealand
[j] Faculty of Veterinary Science, University of Sydney, Camden, Australia

ARTICLE INFO

Article history:
Received 2 September 2014
Received in revised form
12 December 2014
Accepted 8 January 2015

Keywords:
Population survey
Free-roaming dogs
Mark-resight methods
CNVR coverage
Rabies
Bhutan

ABSTRACT

In Bhutan, Capture-Neuter-Vaccinate-Release (CNVR) programs have been implemented to manage the dog population and control rabies, but no detailed evaluation has been done to assess their coverage and impact. We compared estimates of the dog population using three analytical methods: Lincoln-Petersen index, the Chapman estimate, and the logit-normal mixed effects model, and a varying number of count periods at different times of the day to recommend a protocol for applying the mark-resight framework to estimate free-roaming dog population abundance. We assessed the coverage of the CNVR program by estimating the proportion of dogs that were ear-notched and visually scored the health and skin condition of free-roaming dogs in Gelephu and Phuentsholing towns in south Bhutan, bordering India, in September–October 2012.

The estimated free-roaming dog population in Gelephu using the Lincoln-Petersen index and Chapman estimates ranged from 612 to 672 and 614 to 671, respectively, while the logit-normal mixed effects model estimate based on the combined two count events was 641 (95% CI: 603–682). In Phuentsholing the Lincoln-Petersen index and Chapman estimates ranged from 525 to 583 and 524 to 582, respectively, while the logit-normal mixed effects model estimate based on the combined four count events was 555 (95% CI: 526-587). The total number of dogs counted was significantly associated with the time of day (AM versus PM; $P = 0.007$), with a 17% improvement in dog sightings during the morning counting events. We recommend to conduct a morning marking followed by one count event the next morning and estimate population size by applying the Lincoln-Peterson corrected Chapman method or conduct two morning count events and apply the logit-normal mixed model to estimate population size.

* Corresponding author at: Present address: District Livestock Office, Paro Bhutan. Tel.: +975 02 351083; fax: +975 02 351095.
E-mail addresses: tenzinvp@gmail.com, tenzin.tenzin@yahoo.co.uk (T. Tenzin).

http://dx.doi.org/10.1016/j.prevetmed.2015.01.008
0167-5877/

The estimated proportion of vaccinated free-roaming dogs was 56% (95% CI: 52–61%) and 58% (95% CI: 53–62%) in Gelephu and Phuentsholing, respectively. Given coverage in many neighbourhoods was below the recommended threshold of 70%, we recommend conducting an annual "mass dog vaccination only" campaign in southern Bhutan to create an immune buffer in this high rabies-risk area. The male-to-female dog ratio was 1.34:1 in Gelephu and 1.27:1 in Pheuntsholing.

Population size estimates using mark-resight surveys has provided useful baseline data for understanding the population dynamics of dogs at the study sites. Mark–resight surveys provide useful information for designing and managing the logistics of dog vaccination or CNVR programs, assessing vaccination coverage, and for evaluating the impact of neutering programs on the size and structure of dog populations over time.

1. Introduction

Free-roaming dogs are domestic dogs (*Canis familiaris*) that are on public areas and not currently under direct control of owners (Bogel and Hoyte, 1990; WSPA, 2009; Hiby et al., 2011). Many factors are associated with increasing free-roaming dog populations in developing countries including rapid urbanization, increased human population growth, poor waste management, absence of responsible dog ownership and poor management, and cultural tolerance (Bogel and Hoyte, 1990; Jackman and Rowan, 2007). Although domestic dogs play an important role in human life, they may also pose significant risks to human health and well-being. The most serious threat to public health is dog bites and as potential sources of infectious diseases including rabies (for a review see (Tenzin et al., 2011a)). Noise pollution, fighting, faecal contamination of the environment, uncontrolled breeding and spread of rubbish from the bins are some of the additional social problems associated with free-roaming dogs (Jackman and Rowan, 2007). In addition, many free-roaming dogs in developing countries suffer from extremely poor welfare as a result of skin diseases such as mange along with secondary bacterial infections, high mortality due to road accidents, malnutrition, starvation and abuse from humans (Jackman and Rowan, 2007). Several methods have been implemented in the past to control dog populations and rabies, including catch and kill, shooting and poisoning, but have been stopped in many countries due to negative public reaction (Windiyaningsih et al., 2004; Kumarapeli and Awerbuch-Friedlander, 2009; Clifton, 2010; Putra et al., 2013). Currently, animal birth control (ABC) programs based on surgical sterilization are being implemented to limit population growth and improve the welfare of free-roaming dogs in most developing countries (Reece and Chawla, 2006; WSPA, 2007). It has been demonstrated that ABC and vaccination have been successful in eliminating rabies and reducing the free-roaming dog population in the program areas (Cleaveland et al., 2003; Reece and Chawla, 2006; Totton et al., 2010).

In Bhutan, the large number of dogs roaming the streets is associated with major public health and social problems such as dog bites. Rabies is only reported in some areas of south Bhutan that border India (Tenzin et al., 2011a; Tenzin et al., 2011b; Tenzin et al., 2012a). The number of human deaths resulting from rabid dog bites is small; 16 deaths in total were recorded between 2006 and 2013, equating to a cumulative incidence of 0.23 per 10,000 population (Tenzin et al., 2011c; Tenzin et al., 2012b). However, dog bites are common and the cost of PEP treatment is escalating every year (Tenzin et al., 2011a; Tenzin et al., 2011c; Tenzin et al., 2012b). A capture-neuter-vaccinate and release (CNVR) program has been implemented in Bhutan by Humane Society International (HSI) and the Bhutan Department of Livestock since February 2009 to sustainably manage and vaccinate the free-roaming dog population. This intensive campaign will be continued until June 2015, and will then be continued as a community-based animal birth control program (CABC). Up to June 2013, approximately 48,051 dogs and 2636 cats had been neutered and vaccinated, covering all the major towns and villages of Bhutan. To date no detailed evaluation has been done to assess the impact of CNVR on the size and age structure of the free-roaming dog population, nor on the proportion of the free-roaming dog population that has been vaccinated. Evaluation of both these impacts of the CNVR program requires accurate estimation of the free-roaming dog population and of the neutered and vaccinated sub-population using methods that provide comparable results across different time periods and different geographic areas.

Methods used to estimate the size of free-roaming dog populations in urban areas include questionnaire surveys, distance methods exhaustive counts of randomly selected city blocks, and mark-resight surveys (Child et al., 1998; Matter et al., 2000; Hiby et al., 2011). The mark-resight method is an important tool that has been used in a number of more recent studies to estimate the population size of dogs (e.g. Matter et al., 2000; Totton et al., 2010; Hiby et al., 2011; Punjabi et al., 2012; Dias et al., 2013). An assumption underlying mark-resight methods is that the proportion of marked individuals resighted in the second sample(s) represents the proportion of marked individuals in the population as a whole. A number of analytical methods have been used to estimate population size using mark-resight data. The traditional Lincoln-Petersen index is easy to implement with fairly simple calculations (Seber, 1970). However, the disadvantage of the Lincoln-Petersen method is that it is sensitive to overestimating population size when the number of initially marked dogs is small relative to the total population size. The Chapman estimate uses a modified algorithm that is less sensitive to population size and remains relatively simple to calculate (Chapman,