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THE DEMOGRAPHIC CHARACTERISTICS OF DOGS PRESENTED FOR THE CAPTURE-NEUTER-VACCINATE-RELEASE (CNVR) PROGRAM IN BHUTAN

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ABSTRACT: A Capture Neuter Vaccinate Release (CNVR) programme was started in 2009 in Bhutan with the aim to control the dog population and the number of cases of rabies in humans and other animals. As of 30 June 2013, a total of 48,051 dogs had been neutered and vaccinated in Bhutan. A clear understanding of the dynamics of the owned and un-owned dog population that were presented for the programme would enable better planning and targeting of resources to maximise the benefits of this programme. The aims of this study were to: describe the population demographics and health status of the dogs presented at the CNVR clinics. Analyses were performed on data of 22,399 dogs processed at the CNVR clinic from 01 July 2011 to 30 June 2013, which had individual records of their owner, sex, age, neuter and pregnancy status, and presence or absence of diseases such as transmissible venereal tumour (TVT), pyometra and mange. More than half (53.3%; 95% CI 52.8 – 53.7) of the dogs presented to the CNVR clinic were not owned (stray animals). The overall sex ratio in dogs was 1.2 males per female (1.06:1 for the stray dogs and 1.4:1 for the owned dogs). The age distribution was highly skewed towards the adult age groups in both the stray and owned dog populations. Approximately one quarter of the dogs brought to the clinic had been previously neutered. A higher proportion of owned dogs (32.7%) had previously been neutered than stray dogs (15.8%). Approximately 5% of the dogs presented to the CNVR clinic had one or more health problems (mange, TVT or pyometra). Stray dogs were at increased risk of acquiring a health problem (OR = 2.75; 95% CI 2.40 - 3.16) and this highlighted the need for a sustainable programme to look after both the health and welfare of the stray dog population. Of the 7,929 female dogs that were neutered at the clinic, 6.5% were pregnant. The number of foetuses ranged from 1 to 11 with a mean count of 4.9 ±1.6 (n = 518). The mean foetal count was lower in juvenile bitches (4.1 ±1.3) than in adult females (5.1 ±1.6). The mean foetal count in stray dogs (5.2 ±1.6) was higher than in owned dogs (4.4 ±1.5). Pregnant bitches were seen thorough-out the year; however more pregnancies were observed in September to December. To maximize the impact of the programme, future CNVR programmes should target females (owned and stray) with reinforcement of the programme at the time of the peak mating season.

Keywords: Bhutan; CNVR; demographic; dog population; free-roaming.

1. INTRODUCTION

In many developing countries, including Bhutan, there are large numbers of free-roaming or stray dogs (Childs et al. 1997; Kato et al. 2003; Kayali et al. 2003; Reece and Chawla 2006; Totton et al. 2010c). Although domestic dog plays an important role in human life, , they pose a significant public health threats through dog bites and transmission of diverse range of zoonotic diseases (Ashford et al. 1998; Robertson and Thompson 2002; Acha and Szyfres 2003c, a, b; Schlundt et al. 2004). It has been estimated that approximately 55,000 people die each year from rabies globally and infection is mainly acquired from street dogs (WHO 1996, 2004). In Bhutan from 1996 to 2009, a total of 814 cases of rabies were reported in domestic livestock species, of which cattle and dogs accounted for 55% and 39% of the cases, respectively (Tenzin et al. 2011c). From 2006 to 2011, a total of 18 human deaths due to rabies (3 in

2006, 2 in 2007, 3 in 2008, 4 in 2009, 1 in 2010 and 5 in 2011) were reported in Bhutan (BHMIS 2012).

Although domestication of dogs was initiated 14,000 years ago they retain some of their wild instincts, including behaviours that can lead to attacks on humans. Dog bites in humans are a serious public health problem and have been well documented worldwide (Bernardo et al. 2002; Feldman et al. 2004; Gilchrist et al. 2008; Brooks et al. 2010; Cornelissen and Hopster 2010; Hossain et al. 2013). A survey of dog bites conducted in three hospital catchment areas in Bhutan reported an annual dog bite incidence of 869.8, 293.8 and 284.8 per 100,000 population in Gelephu, Phuentsholing and Thimphu, respectively (Tenzin et al. 2011b). There has been considerable media coverage concerning the stray dog population, the risk of dog bites and the public nuisance caused by free-roaming dogs in Bhutan (Gyelmo 2011). The free-roaming dogs also pose a threat to endangered wildlife species through the transmission of diseases or predation (Butler et al. 2003; Manor and Saltz 2003; Cleaveland et al. 2007). Despite Bhutan being a popular tourist destination, the presence of large numbers of free-roaming dogs and incessant barking at night can have an adverse effect on tourism (TCB 2010a 2011). In addition, free-roaming dogs cause other problems including fouling public places with excreta, causing road accidents and putting pressure on the road users (Robinson 1974). In addition stray dogs in the developing countries suffer from poor welfare conditions such as skin diseases, starvation, malnutrition, high mortality and injury from road accidents and abuse by humans (Jackman and Rowan 2007). The Bhutan National News paper (Kuensel) issue on the 11th September 2011 reported the treatment at the National Animal Hospital, Chubachu, Thimphu of 64 dogs that were injured as a result of motor vehicle accidents between January and August 2011 (Pelden 2011). This is likely to be an underestimate of the real number of cases as many dog injuries would go unreported.

Several strategies were implemented in the past to control the population of free-roaming dogs and their associated problems (WHO 1987; WHO and WSPA 1990; ICAMC 2007; OIE 2010). These include population control through culling of unwanted dogs and reproductive control, habitat control and legislative measures including responsible dog ownership (registration of dogs, restriction on number of dogs that can be owned, providing food and shelter to the dogs, confining of the dogs). However population control through culling has been opposed by members of the public and has not been effective as dogs from adjacent areas moved in and replaced the culled dogs and population growth from the surviving dogs quickly repopulate the area where culling has been implemented (OIE 2010). It has been demonstrated that the combination of animal birth control (ABC) and vaccination programme was successful in reducing the size of dog population and elimination of rabies incidence and improving the welfare condition of stray dogs in the campaign programme area in India (Reece and Chawla 2006; Reece et al. 2008; Totton et al. 2010c; Totton et al. 2011a).

Since the 1970s Bhutan has attempted several measures to control the free roaming dog population (NCAH 2006; UNDP 2008; Wangmo 2010). As a part of the national rabies control programme, mass culling of dogs was undertaken in the 1970s and 1980s. This was discontinued as it was not effective in controlling the dog population or the number of rabies cases, as well as being heavily criticized by the Bhutanese community. Impounding of stray dogs was implemented in 2008, but was also discontinued due to its associated costs and on animal welfare ground. *Ad hoc* vaccination and sterilization of both owned and stray dogs were initiated in the 1990s, however this was not successful in controlling rabies or the dog population due to the low coverage (below 20%) compared with the recommended target of 75% (WHO 2004).

To address the chronic dog population and rabies problem in Bhutan, the Humane Society International and the Royal Government of Bhutan jointly embarked on the National Dog Population Management and Rabies Control Project in 2009. Through this project dogs are caught, neutered, vaccinated and released back to their place of origin. As of 30 June 2013, a total of 48,051 dogs had been neutered and vaccinated. A clearer understanding of the dynamics of the owned and un-owned dog population that were processed at the Capture Neuter Vaccinate Release (CNVR) clinics would enable better planning and targeting of resources to maximise the benefits of the ongoing CNVR programme in Bhutan. The aims of this study was to describe the population demographics and health status of the dogs presented at the CNVR clinics from July 2011 to June 2013.

2. MATERIALS AND METHODS

2.1 National Dog Population Management and Rabies Control Programme

The Department of Livestock of the Royal Government of Bhutan and the Humane Society International (HSI), USA initiated a pilot spay/neuter/vaccination program or CNVR programme between February and June 2009 in Thimphu, the capital city of Bhutan. After the success of this pilot project, the two entities signed a memorandum of understanding in September 2009 and formed a partnership to implement a long term project titled the "National Dog Population Management and Rabies Control Project" (NDPM & RCP) to undertake a three to five year CNVR campaign.

The CNVR programme focused on sterilization and vaccination of stray and owned dogs. All procedures performed on dogs were approved by the Murdoch University Animal Ethics Committee. All the animal handling and surgical procedures were done by veterinarians and para-veterinarians trained on the

standard HSI protocol for the CNVR programme. Sexually intact dogs older than 4 months of age were humanely captured by trained dog catchers using nets. The owned dogs were either brought to the clinics by their owners or collected from a designated place. The dogs brought to the CNVR clinics were administered xylazine (1mg/kg) and atropine sulphate (0.05 to 1mg/kg) as pre-anaesthetic medications and anaesthetised using intramuscular ketamine at 15mg/kg body weight. All dogs were given ivermectin (1% w/v) injectable for parasite control. Benzathine penicillin (11,000 to 22,000 IU/kg) and meloxicam (0.2 mg/kg) were administered to prevent secondary bacterial infection and to relieve pain, respectively. Male dogs were castrated through a single prescrotal incision. Bitches were sterilized by complete ovariohysterectomy through a mid-ventral abdominal incision. To identify the neutered dogs, they were ear notched while anaesthetized using a cautery device. After surgery the dogs were observed until they were fully recovered from their anaesthesia and were then either returned to their owners or to the place where they had been captured.

A brief physical examination of the dogs was done to assess their health condition as well as to check for the presence of skin and other health problems. During the surgery female dogs were examined for the presence of pyometra and pregnancy.

2.2 CNVR data

As of June 2013 a total of 48,051 dogs and 2,636 cats had been neutered and vaccinated in Bhutan (Figure 1). Data were compiled separately for two different periods i.e. from Feb 2009 to June 2011 (first phase) and July 2011 to June 2013 (second phase). There are no electronic records of individual animals processed at the CNVR clinic during the first phase. The data were compiled and aggregated by district on a monthly basis. During the first phase period 25,594 dogs were neutered and vaccinated, of which 54.2% were strays.

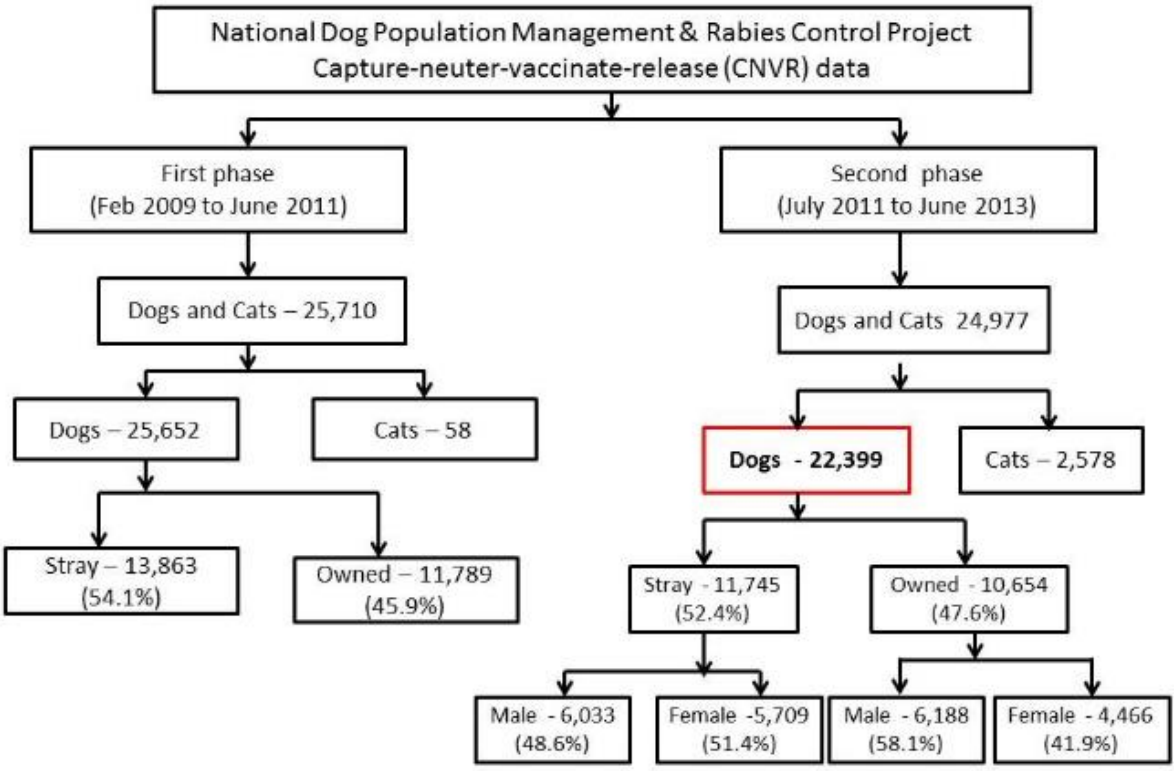

Figure 1: Number of dogs and cats nutered and vaccinated in two phase

From July 2011 onwards the CNVR team recorded all cases in a database. The field data were entered in an excel spreadsheet which were later uploaded to the main database maintained at the project's headquarters. The short comings of the previous recording system were addressed in this second phase. Separate records for dogs and cats, as well as records of animals that were only vaccinated or those that were vaccinated and neutered were kept. During this period a total of 22,399 dogs and 2,578 cats were either neutered and vaccinated or vaccinated only.

2.3 Data Analysis

Analyses were performed on data of 22,399 dogs processed at the CNVR clinic from 01 July 2011 to 30 June 2013, which had individual records of their owner, sex, age, neuter and pregnancy status, and presence or absence of diseases such as TVT, pyometra and mange. Analyses were done using Microsoft Excel (Microsoft Excel 2010, Redmond, USA) and Statistical software R

(R Development Core Team 2013). Descriptive statistics were performed and 95% CI for proportions were calculated using the exact binomial method (Ross 2003). Chi-square tests were used to compare the proportions of dogs presented between groups categorised by gender, age, neuter status, owner status, pregnancy status and presence or absence of disease conditions. Reproductive parameters, including proportion of pregnant females, foetal counts and monthly pattern of pregnancy, were evaluated and compared by age class and owner status. An independent two sample student's t-test was used to compare the mean foetal counts of the pregnant bitches between owned and stray dogs as well as adult and juvenile bitches. The χ^2 Goodness-of-Fit test was used to investigate the influence of season on the monthly pattern of pregnancies. Risk factors associated with the occurrence of various health problems such as mange, transmissible venereal tumour (TVT) and pyometra were assessed in different groups by odds ratios and their 95% confidence intervals.

3. RESULTS

3.1 CNVR Programme in Bhutan

From February 2009 to June 2013 a total of 48,964 dogs and 2,636 cats were presented to the CNVR Clinic including 913 dogs that were brought from Indian border towns. Of the total of 48,051 dogs neutered and vaccinated in Bhutan, 22,443 were owned and 25,608 were stray. The details of the dogs presented to the CNVR clinic are shown in Figure 1. The CNVR programme was undertaken in all 20 districts of Bhutan with the highest number of dogs neutered and vaccinated in Thimphu followed by Samtse, Sarpang, Paro, Chukha and Samdrup Jongkhar (Figure 2). The lowest number of dogs (less than 1,000 dogs) were vaccinated and neutered in Gasa, Lhuentse, Trongsa and Haa.

3.2 Demographic characteristics of the dog population.

The analysis reported in this paper was from a total dataset of 22,399 dogs that were presented to the CNVR clinic between July 2011 and June 2013, that had individual data on their owner, sex, age, neuter and pregnancy status, and presence or absence of disease conditions. The demographic characteristics of the dogs presented at the CNVR clinic during this two year period are summarised in Table 1.

3.2.1 Sex ratios

Overall there were slightly more males (54.6%; 95% CI 53.9 - 55.2) than female dogs (46.1%; 95% CI 44.8 - 46.1) presented to the CNVR clinic (sex ratio of male: female of 1.2:1 - Table 1). There was a similar distribution of males (51.4%; 95% CI 50.5 - 52.3) and females (48.6; 95% CI 47.7 - 49.5) with a sex ratio of 1.06:1 for the stray dogs. There was a greater proportion of males (58.1%; 95% CI 57.1 to 59.0) compared with females (41.9%; 95% CI 41.0 - 42.9) with a sex ratio of 1.4:1 for the owned dogs. Sex ratios of the stray dogs were significantly different to that of the owned dogs ($\chi^2 = 101.20$, df = 1, $p < 0.001$).

3.2.2 Age structure

The age distribution was highly skewed towards the adult age groups (73.4%; 95% CI 72.8 - 74.0) followed by juveniles (13.4%; 95% CI 13.0 - 13.7) and puppies (13.1%; 95%CI 12.7 - 13.6). There was no significant difference in the age distribution of owned and stray dogs ($\chi^2 = 0.00$, df = 1, $p = 0.98$).

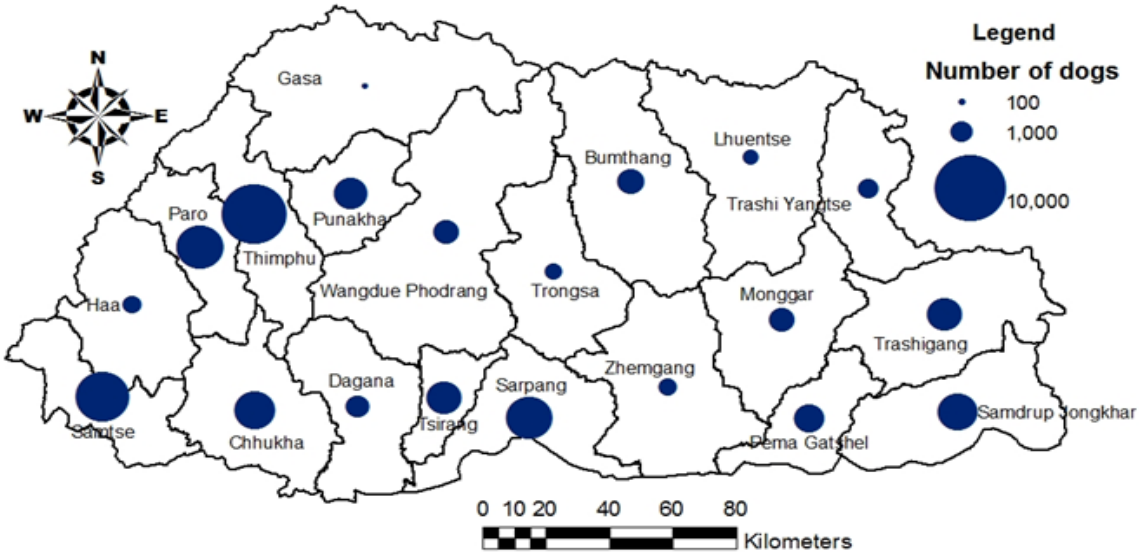

Figure 2: A district map of Bhutan showing the total number of dogs vaccinated and neutered (shown as proportional symbols) from February 2009 to June 2013 (n = 48051)**.**

3.2.3 Neuter status

Approximately one quarter (23.8%; 95% CI 23.3 - 24.4) of the dogs brought to the clinic had been neutered previously. Not surprisingly a significantly higher proportion of owned dogs (32.7%; 95% CI 31.8 - 33.6) had previously been neutered than stray dogs (15.8%; 95% CI 15.1 - 16.4) (χ^2 = 886.38, df = 1, p <0.001).

3.2.4 Health condition

Most dogs presented to the CNVR clinics were categorised as being in good health condition (84.9%; 95% CI 84.4 - 85.4). Significantly more un-owned dogs (87.1%; 95% CI 86.5 - 87.7) were in good health condition than owned dogs (82.5%; 95% CI 81.7 - 83.2) (χ^2 = 136.06, df = 2, p <0.001).

3.2.5 Health problems

Of the dogs presented to the CNVR clinics, 4.8% (95% CI 4.6 - 5.1) had one or more health problems (mange, TVT or pyometra). Significantly more stray dogs (6.9%; 95% CI 6.4 - 7.3) had a health problem than owned dogs (2.6%; 95% CI 2.3% to 2.9%). The risk of a stray dog having a health problem was 2.75 greater than that of owned dogs (95% CI 2.40 - 3.16; χ^2 = 220.12, df = 1, p <0.001). The various risk factors associated with occurrence of different health problems are presented in Table 2. There was no difference in the risk of mange in male and female dogs (OR = 1.02; 95% CI 0.88 – 1.19), while male dogs were less likely to have TVT (OR = 0.65; 95% CI 0.48 – 0.88). Intact dogs were at increased risk of mange (OR = 4.02; 95% CI 3.03 – 5.34) and TVT (OR = 4.19; 95% CI 2.33 – 7.54). Adult dogs were at increased risk of acquiring pyometra (OR = 2.47; 95% CI 1.75 – 3.47) and TVT (OR = 2.61; 95% CI 1.65 – 4.12), while they were less likely to have mange (OR = 0.70; 95% CI 0.61 – 0.84) than young dogs.

3.2.4 Reproductive parameters

Of the 7,929 females that were neutered at the clinic, 6.5% (95% CI 6.0% to 7.1%) were pregnant (Figure 3). The pregnancy levels of owned (7.0%, 95% CI 6.1 to 8.0%) and stray dogs (6.2%, 95% CI 5.6% to 6.9%) were similar (χ^2 = 1.80, df = 1, p =0.18). The foetal count in pregnant bitches ranged from 1 to 11 with a mean foetal count of 4.9 ±1.6 (n = 518). The mean foetal count was significantly lower in juvenile bitches (4.1 ±1.3, n = 90) than in adult females (5.1 ±1.6, n =

Table 1: Characteristics of dogs presented at the capture-neuter-vaccinate-release (CNVR) clinic from 01 July 2011 to 30 June 2013

Characteristics	Total n (%)	Stray n (%)	Owned n (%)	χ^2	P-Value
Sex					
Male	12221 (54.6)	6033 (51.4)	6188 (58.1)	101.20	<0.001
Female	10175 (45.4)	5709 (48.6)	4466 (41.9)		
Unknown	3 (0.01)	3 (0.03)	0 (0)		
Age					
Adult	16451 (73.4)	8627 (73.5)	7824 (73.4)	0.00	0.98
Juvenile	5948 (26.6)	1397 (26.5)	1607 (26.6)		
Neuter status					
Neutered	5336 (23.8)	1850 (15.7)	3486 (32.7)	886.38	<0.001
Intact	17063 (76.2)	9895 (84.3)	7168 (67.3)		
Health condition					
Poor	381 (1.7)	230 (2.0)	150 (1.4)	136.06	<0.001
Okay	3003 (13.4)	1285 (10.9)	1718 (16.1)		
Good	19015 (84.9)	10229 (87.1)	8786 (82.5)		
Presence of health problems					
Yes	1085 (4.8)	807 (6.9)	278 (2.6)	220.12	<0.001
No	21314 (95.2)	10938 (93.1)	10376 (97.4)		
Pregnancy status					
Yes	518 (6.5)	304 (6.2)	214 (7.0)	1.80	0.18
No	7411 (93.5)	4569 (93.8)	2842 (93.0)		

428) (t = 5.115, df = 516, p <0.001). The mean foetal count in stray dogs (5.2 ±1.6, n = 304) was significantly higher than in owned dogs (4.4 ±1.5, n = 214) (t=-5.401, df = 516, p<.001). The monthly distribution of pregnant bitches observed at the CNVR clinics during the two year period is presented in Figure 3. Both owned and stray dogs were found to be pregnant throughout the year, although more pregnancies were found in the period from September to December (Figure 3). The pregnancy rates differed significantly between months (χ^2 = 189.37, df = 11, p <0.001).

Table 2: Risk factors associated with occurrence of various diseases of those dogs brought to the CNVR Clinic (a) Mange in dogs, (b) TVT in dogs and (c) Pyometra in female dogs that were neutered at the clinic

Risk Factor	Disease	No Disease	Odds Ratio	95% CI	P-Value
(a) Mange					
Owner status					
Stray	528	11216	2.84	2.38 - 3.37	<0.001
Owned	174	10480			
Gender					
Male	387	11834	1.02	0.88 - 1.19	0.760
Female	315	9859			
Neuter status					
Intact	650	16412	4.02	3.03 - 5.35	<0.001
Neutered	52	5284			
Age					
Adult	468	15983	0.71	0.61 - 0.84	<0.001
Young	234	5713			
(b) Traumatic-Veneral-Tumour (TVT)					
Owner status					
Stray	139	11479	4.00	2.72 - 5.88	<0.001
Owned	32	10579			
Gender					
Male	75	12060	0.65	0.48 - 0.88)	<0.001
Female	96	9995			
Neuter status					
Intact	159	16761	4.19	2.33 - 7.54	<0.001
Neutered	12	5297			
Age					
Adult	150	16160	2.61	1.65 - 4.12	<0.001
Young	21	5898			
(c) Pyometra					
Owner status					
Stray	155	4718	1.49	1.11 - 1.99	0.010
Owner	66	2990			
Age					
Adult	180	4935	2.47	1.75 - 3.47	<0.001
Juvenile	41	2773			

4. DISCUSSIONS

This study provides insights into Bhutan's owned and stray dog population that were presented to CNVR clinics from July 2011 to June 2013. A total of 22,399 dogs had been neutered and vaccinated in Bhutan during the study period of which 52.4% were strays. Although similar CNVR programmes have been undertaken in other countries, this is the only programme covering a whole country with all 20 districts in Bhutan being included. This is a major achievement given the high volume of CNVR coverage and the logistical challenges in implementing such a programme in scattered settlements across a rugged geographical terrain.

It has long been recognized that understanding the population dynamics of owned and stray dog populations is required for successful rabies and dog population control (Immink and Charbon 1988; OIE 2010). The availability of electronic records of individual dogs during the two year period enabled description of the population characteristics of both owned and stray dogs. As the stray dogs are captured by trained dog catchers and processed at the CNVR

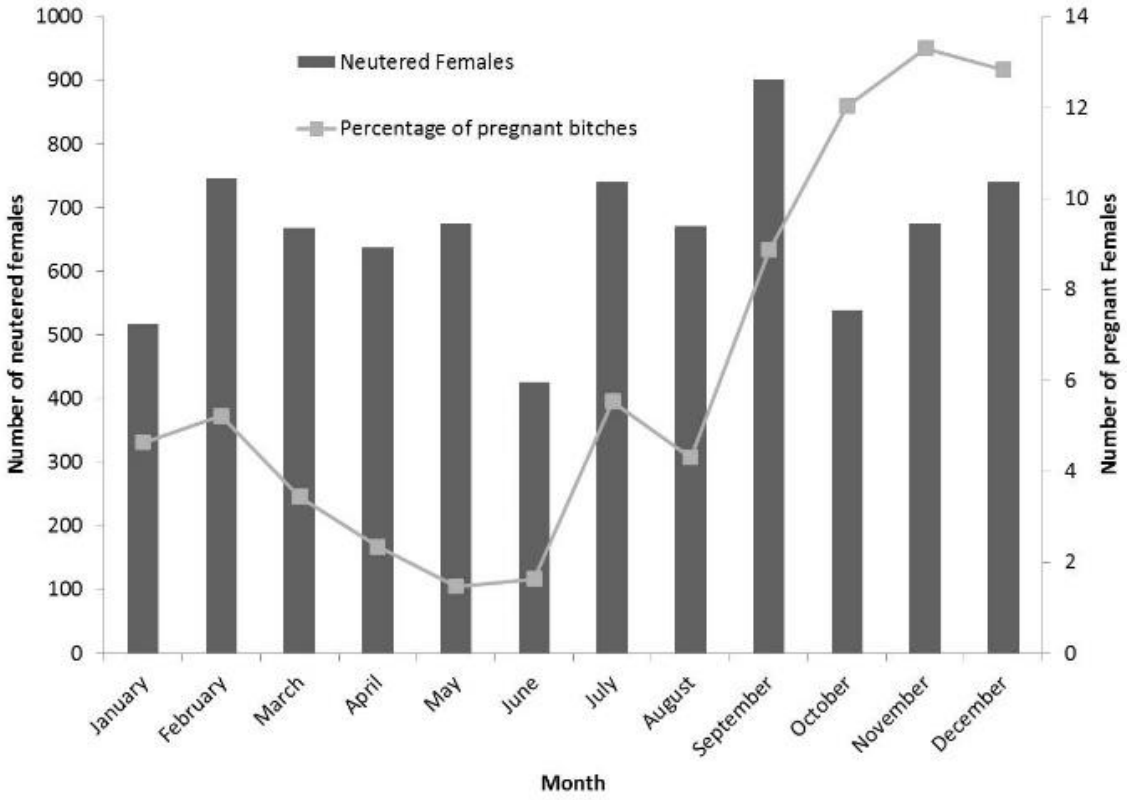

Figure 3: Monthly pattern of female dogs neutered and proportion of pregnant bitches observed when spayed during the CNVR programme in Bhutan from July 2012 to June 2013.

clinic while owned dogs are presented on a voluntary basis by their owners, there are potential sampling biases and as such the demographic characteristics reported in this study must be interpreted with caution. Some studies in other developing countries have reported the demographic characteristics of the owned dog population (Brooks 1990; De Balogh et al. 1993; Butler and Bingham 2000; Matter et al. 2000; Kitala et al. 2001a; Kongkaew et al. 2004; Knobel et al. 2008; Suzuki et al. 2008; Acosta-Jamett et al. 2010). However, there are very limited studies that have examined the demographical characteristics of stray or un-owned dogs (Childs et al. 1997; Kato et al. 2003; Reece and Chawla 2006; Reece et al. 2008; Totton et al. 2010b; Totton et al. 2011b).

Even though the main focus of the HSI/ RGOB CNVR programme was towards stray dogs, 47.6% of the dogs presented were owned dogs. This high percentage is likely due to effective dissemination of information about the programme and involvement and support provided by livestock officials in the districts and sub-districts to the project team. Approximately 92.3% of the owned dog population (based on 2012 census) (22443 of 24320) had been neutered and vaccinated from February 2009 until June 2013. This high proportion may be due to underestimation of the actual owned dog population from the census which is focused on livestock and rural communities rather than urban and pet animals. In order to come up with a reliable estimate of the owned dog population, a properly planned cross-sectional household survey in both rural and urban areas should be undertaken (De Balogh et al. 1993; Childs et al. 1997; Butler and Bingham 2000; Kitala et al. 2001b; Kayali et al. 2003; Flores-Ibarra and Estrella-Valenzuella 2004; Horisberger et al. 2004; Gsell et al. 2012; Hossain et al. 2013). It is likely this would be cheaper, as well as more accurate, than a census. Similarly population estimates of free-roaming and stray dogs should be undertaken in urban areas using wildlife techniques which are now commonly applied for estimating populations of free-roaming dogs (Caughley 1977; Bookhout 1994; Sutherland 2006). These methods have been used in several countries including Bangladesh, Bhutan, Cairo, India, Nepal and Sri Lanka to enumerate free-roaming dogs (WHO and WSPA 1990; WSPA 2009; Hiby et al. 2011).

In this study we found a similar distribution of males and females (sex ratio of 1.05:1) for stray dogs, although more males were owned than females (sex ratio of 1.39:1). The preference for owning male dogs is consistent with the findings of other studies and is likely associated with avoiding the issues of oestrus in female dogs or the likelihood of pregnancies (De Balogh et al. 1993; Suzuki et al. 2008; Ratsitorahina et al. 2009). The age distribution was more skewed towards the adult age group for both owned and stray dogs. There were fewer juveniles and puppies as a reasonable proportion of the adult females had already been neutered and the likely poor survival rates of the

puppies. High mortality rates of puppies has been reported in other studies undertaken in developing countries (Brooks 1990; De Balogh et al. 1993; Butler and Bingham 2000; Kitala et al. 2001b). Correct records of the number of puppies born and those that survived in both owned and stray dogs would be a useful adjunct to better understand the dog population dynamics.

In this study 15.8 and 32.7% of the stray and owned dogs, respectively presented to the clinics were already neutered. This demonstrates that some of the dogs which had been neutered prior to the initiation of the ongoing CNVR campaigns are still surviving. *Ad hoc* neutering and vaccination campaigns have been conducted in Bhutan since the early 1990s by the Department of Livestock as part of an anti-rabies campaign for both owned and stray dogs (NCAH 2006, 2007). As a result of these campaigns, in combination with the removal of in-contact animals during rabies outbreaks, outbreaks of rabies in animals are now reported only from the Southern border districts (Tenzin et al. 2010; Tenzin et al. 2011a; Tenzin et al. 2011c; Tenzin et al. 2011d). Recent outbreaks in the interior part of the country have been associated with the movement of domestic animals from the south where rabies is still endemic (Tenzin et al. 2010; Tenzin et al. 2011a; Tenzin et al. 2011c). The coverage of previous campaigns has been below the WHO/WSPA recommendations of 70%. These low coverages would not be sufficient to significantly reduce the dog population or to prevent an outbreak of rabies.

Most of the dogs observed at the CNVR clinics were found to be in good health (84.9%), with very few owned (1.4%) or stray (2.0%) dogs being in poor health condition. This highlights that even stray dogs have access to a reliable food source, most likely from the predominantly Buddhist community. Approximately 5% of the dogs presented to the clinic had a recognisable health problem. Not surprisingly a higher proportion of stray dogs (6.9%) had health problems than owned dogs (2.6%). Stray dogs were more likely to have mange, TVT and pyometra. These differences are likely to be associated with differences in behavioural, hormonal and immunological factors between the two populations (Reece and Chawla 2006; Totton et al. 2011a; Yoak et al. 2014).

Approximately 6.5% of the female dogs that were neutered at the clinic were found to be pregnant. The pregnancy rates in the owned and stray dogs were not significantly different which likely indicates that the owned dogs were not continuously confined but had access to males during oestrus. As expected lower foetal counts were observed in younger dogs than in adult females and similar findings have been reported by others (Brooks 1990; Butler and Bingham 2000; Kitala et al. 2001b). Stray dogs had a higher mean foetal count than owned dogs. Pregnancies in both owned and stray dogs were observed throughout the year, although more pregnancies were reported in the months of September to December (Figure 3). Higher pregnancies have been observed in these months in similar studies conducted in Jodhpur and Jaipur City in India (Reece et al. 2008; Totton et al. 2010a; Hiby et al. 2011). To maximize the impact of the programme, future CNVR programmes should target females (owned and stray) with reinforcement of the programme at the time of the peak mating season (August to October).

In conclusion, this study provided insight on the population demographics of the owned and stray dog population presented to CNVR clinics in Bhutan. This study will allow better planning and targeting of resources to maximise the benefits of the ongoing CNVR programme in Bhutan. As expected, stray dogs are more prone to acquiring health problems and this highlights the need for a sustainable programme to look after both the health and welfare of the stray dog population. The owned dog population are likely to be the main source of stray dogs due to poor responsible ownership (uncontrolled breeding and abandoning of puppies). Therefore the CNVR programme should focus on both owned and stray dogs by working closely with the communities and the relevant stakeholders through a one health approach in order to bring the free-roaming dog population down to a manageable level. In order to have a sustainable dog population control programme, the CNVR programme should be continued along with implementation of legislative measures to ensure responsible dog ownership, better habitat control through proper solid waste management in the urban areas, as well as aggressive awareness campaigns on the benefits of CNVR programme.

REFERENCES

Acha PN and Szyfres B (Eds.) (2003a). Zoonoses and Communicable Diseases Common to Man and Animals: Bacterioses and Mycoses. Pan American Health Organisation Washington D.C.

Acha PN and Szyfres B (Eds.) (2003b). Zoonoses and Communicable Diseases Common to Man and Animals: Chlamydioses, Rickettsioses and Viroses. Pan American Health Organisation Washington D.C.

Acha PN and Szyfres B (Eds.)(2003c). Zoonosis and communicable diseases common to man and animals: Parasitoses. Pan American Health Organization Washington D.C.

Acosta-Jamett G, Cleaveland S, Cunningham AA and Bronsvoort BM (2010). Demography of domestic dogs in rural and urban areas of the Coquimbo region of Chile and implications for disaese transmissions. Preventive Veterinary Medicine 94: 272-281.

Ashford DA, David JR, Freire M, David R, Sherlock I, Eulalio MC, Sampaio DP and Badaro R (1998). Studies on control of visceral leishmaniasis: impact of dog control on canine and human visceral leishmaniasis in Jacobina, Bahia, Brazil. American Journal of Tropical Medicine and Hygiene 59:53-57.

Bernardo LM, Gardner MJ, Rosenfield RL, Cohen B and Pitetti R (2002). A comparison of dog bite injuries in younger and older children treated in a pediatric

emergency department. Pediatr Emerg Care, 18:247-249.

BHMIS (2012). Annual Health Bulletin 2013. Ministry of Health, Royal Government of Bhutan, Thimphu.

Bookhout TA (Ed.)(1994). Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Bethesda, Maryland.

Brooks A, Moxon R and England GC (2010). Incidence and impact of dog attacks on guide dogs in the UK. Veterinary Record, 166:778-781.

Brooks R (1990). Survey of the dog population of Zimbabwe and its level of rabies vaccination. Veterinary Record, 127:592-596.

Butler J and Bingham J (2000). Demography and dog-human relationships of dog population in Zimbabwean communal lands. The Veterinary Record, 147:442-446.

Butler J, du Toit J and Bingham J (2003). Free-ranging domestic dogs (Canis familiaris) as predators and prey in rural Zimbabwe; threats of competition and disease to large wild carnivores. Biological Conservation, 115:369-378.

Caughley G (1977). Analysis of Vertebrate Populations. John Wiley & Sons.

Childs J, Robinson L, Sadek R, Madden A and Miranda M (1997). Density estimates of rural dog populations and an assessment of marking methods during a rabies vaccination campaign in the Philippines. Preventive Veterinary Medicine, 33: 207-218.

Cleaveland S, Mlengeya T, Kaare M, Haydon D, Lembo T, Laurenson MK and Packer C (2007). The conservation relevance of epidemiological research into carnivore viral diseases in the Serengeti. Conservation Biology, 21:612-622.

Cornelissen JM and Hopster H (2010). Dog bites in The Netherlands: a study of victims, injuries, circumstances and aggressors to support evaluation of breed specific legislation. Veterinary Journal, 186:292-298.

De Balogh KK, Wandeler AI and Meslin FX (1993). A dog ecology study in an urban and a semi-rural area of Zambia. Onderstepoort Journal of Veterinary Research, 60, 437-443.

Feldman K, Trent R and Jay M (2004). Epidemiology of Hospitalizations resulting from dog bites in California, 1991-1998. American Journal of Public Health 94:1940-1941.

Flores-Ibarra, M and Estrella-Valenzuella G (2004). Canine ecology and socioeconomic factors associated with dogs unvaccinated against rabies in a Mexican city across the US-Mexico border Preventive Veterinary Medicine 62, 79-87.

Gilchrist J, Sacks JJ, White D and Kresnow MJ (2008). Dog bites: still a problem? Injury Prevention, 14:296-301.

Gsell AS, Knobel DL, Kazwala RR, Vounatsou P and Zinsstag J (2012). Domestic dog demographic structure and dynamics relevant to rabies control planning in urban areas in Africa: the case of Iringa, Tanzania. Bmc Veterinary Research, 8:1-10.

Gyelmo D (2011). Dog bite numbers go through the roof Kuensel. Kuensel Corporation Limited, Thimphu, 4.

Hiby LR, Reece JF, Wright R, Jaisinghan R, Wright R, Singh B and Hiby EF (2011). A mark-resight survey method to estimate the roaming dog population in three cities in Rajasthan, India. BMC Veterinary Research, 7/46.

Horisberger U, Stark KD, Rufenacht J, Pillonel C and Steiger A (2004). [Demographic characteristics of dog population in Switzerland]. Schweiz Arch Tierheilkd, 146:223-232.

Hossain M, Ahmed K, Marma ASP, Hossain S, Ali M., Shamsuzzaman AM and Nishizono A (2013). A survey of the dog population in rural Bangladesh. Preventive Veterinary Medicine, 111:134-138.

ICAMC (2007). Humane Dog Population Management Guidance. International Companion Animal Coalition.

Immink WF and Charbon GA (1988). Distinction between alpha-adrenergic receptors in eight vascular areas of the dog. Arch Int Pharmacodyn Ther 292:172-181.

Jackman J and Rowan A (2007). Free-Roaming Dogs in Developing Countries: The Benefits of Capture, Neuter, and Return Programs. The State of the Animals IV. 55-78.

Kato M., Yamamoto H, Inukai Y and Kira S (2003). Survey of the stray dog population and the health education program on the prevention of dog bites and dog-acquired infections: a comparative study in Nepal and Okayama Prefecture, Japan. Acta Med Okayama, 57:261-266.

Kayali U, Mindekem R, Yémadji N, Vounatsou P, Kaninga Y, Ndoutamia AG and Zinsstag J (2003). Coverage of pilot parenteral vaccination campaign against canine rabies in N'Djaména, Chad. Bulletin of World Health Organization 81, 7.

Kitala P, McDermott J, Kyule M, Gathuma J, Perry B and Wandeler A (2001a). Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya. Acta Tropica, 78:217-230.

Kitala P, McDermott J, Kyule M, Gathuma J, Perry B and Wandeler A (2001b). Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya. Acta Tropica, 78:217-230.

Knobel DL, Laurenson MK, Kazwala RR, Boden LA and Cleaveland S (2008). A cross-sectional study of factors associated with dog ownership in Tanzania. BMC Veterinary Research, 4(5).

Kongkaew W, Coleman P, Pfeiffer DU, Antarasena C and Thiptara A (2004). Vaccination coverage and epidemiological parameters of the owned-dog population in Thungsong District, Thailand. Preventive Veterinary Medicine, 65:105-115.

Manor R and Saltz D (2003). The impact of free-roaming dogs on gazelle kid/ female ratio in a fragmented area. Biological Conservation 119:231-236.

Matter HC, Wandeler AI, Neuenschwander BE, Harischandra LP and Meslin FX (2000). Study of the dog population and the rabies control activities in the Mirigama area of Sri Lanka. Acta Trop 75: 95-108.

NCAH (2006). A policy and operational strategy: Guidelines for prevention and control of rabies in Bhutan and emergency preparedness plan, National

Centre for Animal Health, Department of Livestock, Thimphu.

NCAH (2007). WHO Project on Rabies Prevention and Control in Bhutan. National Centre for Animal Health, Department of Livestock, Mnistry of Agriculture, Royal Government of Bhutan, Thimphu.

OIE (2010). Terrestrial Animal Health Code In: OIE (Ed.), Chapter 7.7 : Stray dog population control.

Pelden S (2011). Collateral damage of increased traffic. Kuensel. Kuensel Corporation Limited Thimphu.

Ratsitorahina M, Rasambainarivo JH, Raharimanana, S, Rakotonandrasana H, Andriamiarisoa MP, Rakalomanana FA and Richard V (2009). Dog ecology and demography in Antananarivo, 2007. BMC Veterinary Research 5.

Reece JF and Chawla S (2006). Control of rabies in Jaipur, India, by the sterilisation and vaccination of neighbourhood dogs The Veterinary Record 159, 379-383.

Reece JF, Chawla SK, Hiby EF and Hiby LR (2008). Fecundity and Longevity of roaming dogs in Jaipur, India. BMC Veterinary Research 4:6.

Robertson I and Thompson R (2002). Enteric parasitic zoonoses of domesticated dogs and cats. Microbes and Infection 4:867-873.

Robinson D (1974). Dog Nuisance vs Dog Control. Journal of American Veterinary Medical Association 165.

Ross TD (2003). Accurate confidence intervals for binomial proportion and Poisson rate estimation Computers in Biology and Medicine 33, 509-531.

Schlundt J, Toyofuku H, Jansen J and Herbst SA (2004). Emerging foodborne zoonoses. Rev. Sci. tech Off. int. Epiz. 23:513-553.

Sutherland WJ (Ed.) (2006). Ecological Census Techniques - A Handbook. Cambridge University Press.

Suzuki K, Pereira JA, Frias LA, Lopez R, Mutinelli LE and Pons ER (2008). Rabies-vaccination coverage and profiles of the owned-dog population in Santa Cruz de la Sierra, Bolivia. Zoonoses Public Health 55:177-183.

TCB (2010). Bhutan tourism monitor: Annual report 2009. Tourism Council of Bhutan, Royal Government of Bhutan, Thimphu.

TCB (2011). Bhutan tourism monitor: Annual report 2010. Tourism Council of Bhutan, Royal Government of Bhutan, Thimphu.

Tenzin, Dhand NK, Dorjee J and Ward MP (2011a). Re-emergence of rabies in dogs and other domestic animals in eastern Bhutan, 2005-2007. Epidemiology and Infection 139:220-225.

Tenzin, Dhand NK, Gyeltshen T, Firestone S, Zangmo C, Dema C, Gyeltshen R and Ward MP (2011b). Dog bites in humans and estimating human rabies mortality in rabies endemic areas of Bhutan. PLoS neglected tropical diseases 5, e1391.

Tenzin, Dhand NK and Ward MP (2011c). Patterns of Rabies Occurrence in Bhutan between 1996 and 2009. Zoonoses and public health, 58:463-471.

Tenzin, Sharma B, Dhand NK, Timsina N and Ward MP (2010). Reemergence of Rabies in Chhukha District, Bhutan, 2008. Emerging Infectious Diseases, 16:1925-1930.

Tenzin, Wacharapluesadee S, Denduangboripant J, Dhand NK, Dorji R, Tshering D, Rinzin K, Raika V, Dahal N and Ward MP (2011d). Rabies virus strains circulating in Bhutan: implications for control. Epidemiology and Infection, 139:1457-1462.

Totton SC, Wandeler AI, Gartley CJ, Kachhawaha S, Suman M, Ribble CS, Rosatte RC and McEwen SA (2010a). Assessing reproductive patterns and disorders in free-ranging dogs in Jodhpur, India to optimize a population control program. Theriogenology, 74:1115 - 1120.

Totton SC, Wandeler AI, Ribble CS, Rosatte RC and McEwen SA (2011a). Stray dog population health in Jodhpur, India in the wake of an animal birth control (ABC) program. Prev Vet Med 98: 215-220.

Totton SC, Wandeler AI, Ribble CS, Rosatte RC and McEwen SA (2011b). Stray dog population health in Jodhpur, India in the wake of an animal birth control (ABC) program. Preventive Veterinary Medicine, 98:215-220.

Totton SC, Wandeler AI, Zinsstag J, Bauch CT, Ribble, CS, Rosatte RC and McEwen SA (2010b). Stray dog population demographics in Jodhpur, India following a population control/rabies vaccination program. Preventive Veterinary Medicine, 97, 51-57.

UNDP (2008). Grappling with Stray Dog Problem in Bhutan - Advice; Experiences. Thimphu, 15.

Wangmo S (2010). The Stray Dog Dillema of Bhutan. New York.

WHO (1987). Guidelines for dog rabies control. World Health Organization.

WHO (1996). Report on third international symposium of rabies in Asia. World Health Organization, WHO/EMC/ZOO/96.98.

WHO (2004). WHO Expert Consultation on Rabies World Health Organization, Geneva.

WHO & WSPA (1990). Guidelines for dog population management. In: Frucht, K., Drysdale, G., Remfry, J. (Eds.) World Health Organization and World Society for the Protection of Animals, WHO/ZOO/90.166.

WSPA (2009). Surveing roaming dog populations: guidelines on methodology. WSPA, London.

Yoak AJ, Reece JF, Gehrt SD, Hamilton IM (2014). Disease control through fertility control: Secondary benefits of animal birth control in Indian street dogs. Preventive Veterinary Medicine, 113:152-156.