supplementary submission from TNR Fund HK for Panel on Food Safety and Environmental Hygiene: Meeting on 14 January 2014

From: TNR Fund <tnrfundhk@gmail.com>
To: pyyoong@legco.gov.hk

History: This message has been forwarded.

3 attachments


Dear Ms. Yoong,

I wish to submit this as a supplement to my prior written submission. I hope this can be passed to the chairman. These articles contain large scale studies done in the recent years that proved the efficacy of TNR in dogs.

Regards,
Dr. Tinny Ho
Control of rabies in Jaipur, India, by the sterilisation and vaccination of neighbourhood dogs

J. F. Reece, S. K. Chawla

A programme to sterilise and vaccinate neighbourhood dogs against rabies was established in Jaipur, India. Neighbourhood dogs were captured humanely, sterilised surgically, vaccinated against rabies and, when they had recovered, released where they had been caught. Between November 1994 and December 2002, 24,986 dogs were treated in this way. Direct observational surveys of the local dog population indicated that 65 per cent of the females were sterilised and vaccinated, and that the population declined by 28 per cent. The records of human cases of rabies seen in the main government hospital of the city between January 1992 and December 2002 showed that the number of cases had declined to zero in the programme area but increased in other areas.

Rabies is a viral neurological disease affecting all mammals, including human beings, which is invariably fatal once the clinical signs have developed. It can be prevented by vaccination but people continue to die from this distressing disease. Official figures may underestimate the true number of human cases by up to 100 times (Fekadu 1991, Cleaveland and others 2002). Rabies accounts for approximately 20,000 human deaths annually in India alone (Anon 2004a). The main vector of the disease is the domestic dog, and 94 per cent of human cases in Asia are due to dog bites (Blancou 1988). About 45 per cent of human rabies cases are children under 15 years old, and many more males than females are affected (Fekadu 1991, Dutta 2002).

The World Health Organization (WHO) has classified dogs according to their degree of dependence and the restrictions imposed on them by people (Anon 1988). In India, over 60 per cent of dogs are considered to be ‘neighbourhood dogs’, being either semidependent or independent of people for food and shelter and unrestricted in their movements. These neighbourhood dogs account for about 60 per cent of reported dog-bite injuries (Sudarshan and others 2001).

The treatment of human dog-bite victims in India is poor, only 47·9 per cent received any postexposure rabies vaccination, and nearly half of these received only nerve tissue vaccine (Anon 2004a), which is not recommended by the WHO (Anon 2004b). Immunoglobulins were received by only 2·1 per cent of the patients, and compliance in completing the course of postexposure vaccination was only 40·5 per cent (Anon 2004a). Thus, the most cost-effective, long-term approach to the control of rabies would be to remove the disease from the animal reservoir (Perry and Wandeler 1993).

It is difficult to control neighbourhood dogs, but several methods have been tried. The physical removal of dogs has proved to be ineffective, and it is often carried out inhumanely (Anon 1988, Anon 2004b). In Ecuador, major removal campaigns were followed by increases in the fecundity of bitches and the survival of pups, and an overall increase in the number of rabid animals (Beran 1991). Any actions that cause instability in the dog population encourage an increase in the transmission of rabies (Blancou 1988, Beran 1991). However, the removal of dogs by culling remains a popular method in countries with large populations of neighbourhood dogs, vaccination programmes must be conducted on a heroic scale to control rabies. Largi and others (1988) cite one South American programme that vaccinated over a million animals annually for five to six years to eliminate rabies.

A threshold level of 70 per cent immune animals must be maintained if the transmission of rabies is to be controlled (Anon 2004b). Coleman and Dye (1996) calculated that the proportion of vaccinated dogs needed to control outbreaks would be between 39 and 57 per cent, and Fekadu (1991) cited a figure of 80 per cent if no dogs were to be removed concurrently with vaccination. Rabies reappeared in a previously controlled area when the percentage of vaccinated dogs dropped to 21 per cent (Beran 1991). In South America, Largi and others (1988) claimed that vaccination of 70 to 80 per cent of neighbourhood dogs controlled rabies. Anderson and others (1981) predicted that a policy of vaccination combined with population reduction would mean that a smaller proportion of animals would need to be vaccinated or removed than if only one of these control measures was applied.

The stability of the dog population is important in controlling rabies. In Ecuador, dogs under 11 months of age constitute 18 per cent of the population but account for 52 per cent of cases of rabies, whereas adult dogs constitute 67·6 per cent of the population but only 39·8 per cent of the cases of rabies (Beran 1991). In Tunisia, an annual turnover of 37 per cent of a dog population was reported by Seghaier and others (1999), and in West Bengal, Pal (2001) reported 82 per cent mortality in dogs of less than one year of age. Studies on populations of cats suggest that sterilising group members leads to a lower population turnover, increased social bonds and a decrease in aggressive behaviour (Neville and Remfry 1984, Zaunbrecher and Smith 1993).

This paper describes the effects of an eight-year rabies control programme in a northern Indian city. The programme combined the sterilisation and vaccination of neighbourhood dogs and was conducted along WHO and World Society for the Protection of Animals (WSPA) guidelines (Anon 1990). During the study the number of human rabies deaths in the programme’s area was reduced to zero and the population of neighbourhood dogs was reduced by 28 per cent.

MATERIALS AND METHODS

The study was conducted in Jaipur, the rapidly expanding capital city of Rajasthan, India, which has a population of approximately 2·5 million people. The city has a semidesert climate with an annual temperature range from 3°C to 46°C, and 90 per cent of the annual rainfall occurs during a monsoon period lasting two months.

VETERINARY RECORD
159, 379-383

J. F. Reece, BSc, BVSc, MRCVS, S. K. Chawla, BVSc&AH, Help in Suffering, Maharani Farm, Durgapura, Jaipur 302018, Rajasthan, India

The Veterinary Record, September 16, 2006
Sterilisation and vaccination
The ABC programme focused on the sterilisation and vaccina-
tion of captured female and prepubescent male dogs. Neighbourhood dogs were captured humanely from a given area, and the exact location of each dog’s capture was recorded. The dogs were caught by using the minimum safe restraint necessary; some dogs were caught by hand, holding the scruff, but most were caught by using a hessian sack (1 m deep by 1·26 m wide) with a rope drawing around the opening. Catching efforts were concentrated on one distinct area at a time, and a new area was selected only when no further dogs could be caught from the initial area. The new catching area was usually adjacent to the previous area because this facilitated the release of the dogs efficiently and accurately back into their territories. All the captured dogs were transported to the ABC facility, where they were individually kennelled and examined by a veterinary surgeon. Details of the animals’ location, sex, description, and health status were recorded. After a rest period of between 15 and 30 hours the animals were prepared for surgery. The dogs were premedicated with triflupromazine administered intramuscularly, and general anaesthesia was then induced and maintained by the intravenous infusion of either 2·5 per cent thiopentone solution, or a mixed solution of ketamine and xylazine. Before the surgery the dogs were given long-acting antibiotics and non-steroidal anti-inflammatory drugs.

Details of the animals’ location, sex, description, and health status were recorded. After a rest period of between 15 and 30 hours the animals were prepared for surgery. The dogs were premedicated with triflupromazine administered intramuscularly, and general anaesthesia was then induced and maintained by the intravenous infusion of either 2·5 per cent thiopentone solution, or a mixed solution of ketamine and xylazine. Before the surgery the dogs were given long-acting antibiotics and non-steroidal anti-inflammatory drugs. For identification purposes, each animal was given an individual alphanumeric, four-character tattoo in its right ear, and a small semicircular notch was removed by a thermocautery device from the leading edge of its left ear. The surgical site was shaved and prepared for surgery. A 1 ml dose of an inactivated, adjuvanted, cell-culture rabies vaccine (Rabigen Mono; Virbac) was administered either subcutaneously or intramuscularly with a one inch, 22 G needle into the biceps femoris muscle or the dorsal lumbar musculature. The intramuscular route was used from 2001, when Coyne and others (2001) suggested that using this route to give the vaccine would result in a more prolonged effect.

Bitches were sterilised by complete ovariohysterectomy (spay) through a right flank incision; males were castrated through a single prescrotal incision. All fit females were sterilised, including animals more than three to four months old (weighing approximately 7 kg or more), pregnant animals and animals in oestrus. Only prepubescent males more than three to four months old (weighing approximately 7 kg or more) were castrated. Any animal that was found to be suffering from an incurable condition, or whose welfare was severely compromised, or was deemed dangerously aggressive, was humanely euthanased. Any animal found to have been previously sterilised and vaccinated received only a booster rabies vaccination.

After surgery, the animals were returned to their kennels to regain consciousness; they were examined daily by a veterinary surgeon and the date of their release, usually three to five days after surgery, was determined by these examinations. The dogs were released at the exact location from which they had been captured. A register was maintained in which the details of all the captured dogs were recorded, so that the programme could be monitored in detail, and data on the behaviour of neighbourhoud dogs could be collected.

Population surveys
The area selected for the population surveys was the old, partially walled, city of Jaipur known as the ‘Pink City’. It was chosen because it had only limited potential for further development, contained a cross-section of residential, commercial and civic areas, and was considered to be representative of the larger modern city. Direct observational counts of the numbers and types of dogs were made every six months at climatically benign times of the year, in March/April and September/October. To minimise counting variables, each survey was performed between 06.30 and 09.00 by the same staff, following the same route through the area. The Pink City was subdivided into six subareas, each of which was monitored in detail, and data on the behaviour of neighbourhoud dogs could be collected.

TABLE 1: Numbers of dogs dealt with annually by the Animal Birth Control programme in Jaipur between November 1994 and December 2002, including all the dogs caught by the staff of Help in Suffering (HS) and the municipal authorities

<table>
<thead>
<tr>
<th>Year</th>
<th>Dogs received at HS</th>
<th>Dogs vaccinated against rabies</th>
<th>Bitches spayed</th>
<th>Male dogs sterilised (includes 10 vasectomies)</th>
<th>Total number of operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>250</td>
<td>1409</td>
<td>2828</td>
<td>323</td>
<td>223</td>
</tr>
<tr>
<td>1995</td>
<td>223</td>
<td>1202</td>
<td>2394</td>
<td>580</td>
<td>223</td>
</tr>
<tr>
<td>1996</td>
<td>255</td>
<td>1169</td>
<td>2183</td>
<td>220</td>
<td>223</td>
</tr>
<tr>
<td>1997</td>
<td>1559</td>
<td>1910</td>
<td>1559</td>
<td>160</td>
<td>223</td>
</tr>
<tr>
<td>1998</td>
<td>2441</td>
<td>2144</td>
<td>2441</td>
<td>10</td>
<td>223</td>
</tr>
<tr>
<td>1999</td>
<td>2592</td>
<td>2325</td>
<td>2592</td>
<td>885</td>
<td>223</td>
</tr>
<tr>
<td>2000</td>
<td>3299</td>
<td>3627</td>
<td>3299</td>
<td>794</td>
<td>223</td>
</tr>
<tr>
<td>2001</td>
<td>3198</td>
<td>3816</td>
<td>3198</td>
<td>2684</td>
<td>223</td>
</tr>
<tr>
<td>2002</td>
<td>3119</td>
<td>19,129</td>
<td>3119</td>
<td>19,129</td>
<td>223</td>
</tr>
</tbody>
</table>

The Animal Birth Control (ABC) programme was started as a pilot project in a small area of Jaipur in November 1994 by Help in Suffering, an animal welfare organisation. In 1996 the pilot project was expanded to cover a larger area of the city. The area covered by the ABC programme, and this study, is approximately 14 km by 8 km. For the purposes of the study, the city was divided into a number of distinct areas along major geographical features such as main roads, railway lines and waterways. These areas varied in size but were approximately 2·3 km by 1·7 km, approximately 4 km².
RESULTS

Sterilisation and vaccination

Between November 1994 and December 2002 inclusive, a total of 22,442 dogs were vaccinated against rabies and 19,129 sterilisation operations were performed, of which 86 per cent were ovariohysterectomies (Table 1). Of the animals captured, 10–15 per cent were humanely destroyed after veterinary examination as being unfit for sterilisation and vaccination because of illness, injury or temperament; this proportion remained constant throughout the study. The numbers of animals passing through the programme increased annually, from 1409 in 1995 to 3816 in 2002. During each of the last three years of the study, over 3100 dogs were vaccinated, sterilised and released, nearly nine animals per working day. The total cost of each sterilisation and vaccination was about £4.80 at 2004 rates.

Population surveys

During the eight-year study period a decline in the neighbourhood dog population of 28 per cent was recorded between the peak and the last surveys (Fig 1), an average annual decline of 3.5 per cent. The proportion of surveyed female dogs that had been sterilised and vaccinated increased from zero at the beginning of the study to 65.7 per cent in 2002 (Fig 1), and the proportion that had been sterilised exceeded 65 per cent during the last three years of the study. Because only prepubescent male dogs were sterilised and vaccinated, the proportion of sterilised male dogs surveyed in the population increased more slowly (Fig 1). The ratio of sexually entire males to sexually entire females increased from 1.21:1 at the beginning of the study to 2.68:1 in 2002, although the ratio of genotypically male to genotypically female dogs remained approximately 1 (Fig 2).

Human rabies mortality data

During the study period the number of human rabies cases from the ABC area of Jaipur declined from a maximum of 10, and from October 2000 to December 2002, no cases of human rabies originating from the ABC area were reported in the Infectious Disease Unit of the SMS Hospital (Fig 3). However, the number of human rabies cases reported annually in residents of the non-ABC area of Jaipur increased during the study, and the total numbers of human rabies cases recorded annually, including those coming from throughout Rajasthan, remained approximately constant (Fig 3).

DISCUSSION

The data collected during this eight-year study provide evidence that rabies can be controlled in an Indian city through a combined vaccination and sterilisation programme of the neighbourhood dog population.

The programme endeavoured to follow WHO guidelines with respect to the vaccination of neighbourhood dogs against rabies. Dogs were revaccinated whenever the opportunity presented itself. Coyne and others (2001) reported that vaccination provides protection against challenge for up to 41 months if the vaccine is administered intramuscularly; most neighbourhood dogs this period will exceed their lifetime (Butler and Bingham 2000, Pal 2001). The Jaipur ABC programme has been using the intramuscular route for vaccination since those studies were published.

The direct observational counts of the neighbourhood dog population, made along defined routes, are not ideal. Censuses by this method were initiated when the programme was in development, and alternative methods of counting the dogs have since been suggested. However, no means have been found of correlating the data from any revised method with the estimated weight of less than 7 kg; dogs of this size were not caught for the ABC programme.

Human rabies mortality data

The records of the Infectious Diseases Unit of the Sawai Man Singh (SMS) Hospital (the main government hospital) in Jaipur were reviewed over six visits to the unit during 2002/03 to extract information on patients with rabies admitted to the hospital. The records from January 1, 1992 to December 31, 2002 inclusive were reviewed, and all the information on these patients was documented. The patients’ records were then arranged by area of residence, separating those patients who came from within the area of Jaipur included in the ABC programme (the ABC area) and those patients that originated from outside the ABC area but still within the administrative area of Jaipur (the non-ABC area). The total number of symptomatically rabid patients treated at the hospital was also recorded, regardless of their place of residence and including patients coming from throughout Rajasthan state. Attempts to verify the information recorded in the hospital records were made by visits to a number of the patients’ families. The diagnoses were not routinely confirmed postmortem owing to the lack of expertise and facilities in the hospital.

FIG 2: Effects of the programme of sterilisation on the sex ratio of the population of neighbourhood dogs in the Pink City area of Jaipur between February 1997 and August 2002

FIG 3: Numbers of human cases of rabies recorded in the Sawai Man Singh Hospital in Jaipur from all regions, from the area of Jaipur covered by the Animal Birth Control (ABC) programme and from the non-ABC areas of Jaipur

The Veterinary Record, September 16, 2006
the data from the original method, and the census data have therefore continued to be collected by the method adopted originally.

The most recent population surveys indicate that 65-7 per cent of the currently alive female dogs and 5-8 per cent of the males have been vaccinated and sterilised. Figures from the most recent population survey imply that the vaccination coverage of the whole population is 35-5 per cent; this ignores a few animals that were vaccinated only, and is thus a low estimate of the total vaccination coverage. This figure is only slightly lower than the percentage cited by Coleman and Dye (1996) required to control the disease. If it is assumed that rabies transmission has been controlled at these vaccination coverage levels, they are substantially lower than the levels reported from other areas where sterilisation methods were not employed, for example, 83 per cent vaccination coverage in the Philippines and 60 per cent in Ecuador (Beran 1991). The data presented here are therefore consistent with Anderson and others (1981), who predicted that the threshold proportion for rabies control would be lower if vaccination and population reduction were practised together.

The Help in Suffering ABC programme has targeted dogs included in the lowest WHO categories of dog: neighbourhood dogs, unrestricted/unsupervised dogs and truly feral dogs. Most reported rabies control programmes concentrate on family and pet dogs, yet even with these more biddable groups, 11 to 15 per cent of the dogs are reported to be uncatchable (Anon 1988, Seghier and others 1999). Despite intensive, skilful catching efforts, approximately 30 per cent of bitches in Jaipur are uncatchable by current techniques. The ABC programme’s catching efforts may exert a selection pressure on the dog population in favour of undesirable behavioural traits; solutions to this problem are being investigated.

Dogs less than one year old are over-represented in rabies cases (Beran 1991); the affinity between children and young dogs may explain the large numbers of cases of rabies in children. The importance for rabies control of timing vaccination efforts to ensure that animals are vaccinated as young as possible has been stressed by Anderson (1986), MacInnes (1988) and Brochi and others (1991). The Jaipur ABC programme sterilises and vaccinates puppies that are estimated to be over four months of age (7 kg bodyweight). Stubbs and Bloomberg (1995) have shown that there are no veterinary or developmental problems associated with the sterilisation of young dogs except hypothermia during general anaesthesia. Bloomberg (1995) have shown that there are no veterinary or developmental problems associated with the sterilisation of young dogs except hypothermia during general anaesthesia.

Increases in public awareness due to the programme’s daily activities in residential areas may be a further factor confusing the apparent reasons behind the findings. The hospital workers recording data on individual human cases were independent of the ABC programme, and were, for much of the time, unaware of the programme. The veracity of the finding that the Jaipur ABC programme has caused a decline in human rabies cases within the ABC area of Jaipur is supported by the increases in human rabies cases reported in the non-ABC areas of the city; these non-ABC areas are rapidly expanding residential developments on the periphery of the city.

The authors believe that the combined sterilisation and vaccination procedure of the ABC programme may be an effective and humane method for controlling rabies in endemic areas with large populations of neighbourhood dogs, and may also create a more stable, smaller population.

ACKNOWLEDGEMENTS

The assistance of Dr Devi Shankar Rajoria and Dr Kailesh Chandra, numerous volunteer veterinary surgeons, and Mr J. Townsend in record-keeping and data collection is gratefully acknowledged. J. F. R. is supported by grants from the Humane Society International. The ABC Programme at Help in Suffering is supported by Ms M. Vogler and Animaux Secours, France, and by grants from the Government of India and the Animal Welfare Board of India, all of whom are thanked for their continued support. The authors thank Professor D. Briggs for her great encouragement, and Professor J. E. Cooper for commenting on the manuscript.

References


Bengal, India. *Acta Theriologica* 46, 69-78


- Members who wish to view all the consultations with which the BVA is currently involved, or to submit a response, should visit the BVA’s policy web pages at www.bva.co.uk/members/consultations/index.asp

**DEATHS**

**Mr T. W. Heard**

ON September 9, Terrence William Heard, MA, VetMB, MRCVS(RE), of Bangkook, Thailand, Mr Heard qualified from Cambridge in 1959.

John Owen writes: Terry Heard was born and brought up on a farm in the Forest of Dean, where he learned the animal husbandry and manual skills necessary to survive on a small marginal farm. He attended Monmouth School, where he played rugby for the school with future Welsh internationals, before going on to Jesus College, Cambridge, to read veterinary medicine.

After qualifying, he joined the old established and large dairy farming practice of Hale and Brown in Chippenham, Wiltshire, which later became the Hale Veterinary Group – the first practice in Britain to adopt such a style of title. In the 1960s, he and his partners were among the first to realise that species specialisation was essential within the profession in order to be of value to both farmers and all other animal owners; he therefore followed up his particular interest, which was pigs, other animal owners; he therefore followed up his particular interest, which was pigs, although he was also an accomplished surgeon on both small and large animals.

His work on the transmission of salmonella infections through feedstuffs in intensively housed pigs brought him international recognition. While working in tandem with the George Veterinary Group in Malmsbury, Wiltshire, he built up an advisory pig practice, first in the Philippines and then in Thailand. He also served on several RCVS and BVA committees.

Able to turn his hands to almost anything, he was an excellent mechanic, who was happy to get his hands dirty sorting out the problems with and mending old cars. He was also a first-class sailor, his last boat being a Rival ‘38’, which he fitted out himself and subsequently sailed for many years in waters throughout Europe, from the Bay of Biscay to the Baltic, until finally to a berth in St Katharine’s Dock, London.

In recent years, living in Thailand, he was involved in animal rescue work, and enjoyed tennis and motorcycling.

He enjoyed listening to music. He was also a good trumpet player, and wonderful company in whatever situation he found himself. Terry leaves many friends and colleagues whose lives are the richer for having known him. My sincere condolences go out to all his family.

David Burch writes: Terry was an active and loyal member of the Pig Veterinary Society for many years, and was one of the first pig-only practitioners in the UK. He was a past-president of the society (1979–81). In 1982, he took over the production of the Pig Veterinary Society Proceedings from Professor Richard Penny, who had originally started it, and later changed it to its present form, The Pig Journal. He took it from volume 9 to volume 41 over the next 16 years, after which he handed over the reins to the current publications chairman (D. B.). He was ably assisted by his delightful wife, Judith, who is still the journal’s efficient and indispensable secretary.

Terry went to Asia to develop his idea of pig practice in an emerging industry, similar to that of the 1960s in the UK. He co-owned a pig breeding farm in the Philippines, and a consultancy, where he established a close link with the Chulalongkorn University in Bangkok and Professor Annop, who became an overseas co-editor and contributor to The Pig Journal and is currently dean of the veterinary school.

He finally settled and retired in Bangkook, and lived on the banks of a klong (canal). He was involved with the university, helping with English translation and the production of the Thai Journal of Veterinary Medicine.

Our deepest sympathies go to his extended family in Europe and Asia; as a colleague and mentor on The Pig Journal for nearly 25 years, he will be sadly missed.

**Dr J. H. Marston**

ON May 26, John Hailey Marston, BVetMed, BS, PhD, MRCVS, of Burlington, Lansdowne Road, Malvern, Worcestershire. Dr Marston qualified from London in 1962.

Neal Farr writes: John Marston was a popular student of the veterinary profession, and met his wife, Barbara, while competing in the university debating society.

Following graduation, he became part of the ‘brain drain’, going to the USA, where he worked on the intra-uterine contraceptive device at the Worcester Foundation with Dr M. C. Clic. He returned to Birmingham, where he worked with Dr Zolly Zuckerman on the University Debating Society.

**Correction**

An item in The Veterinary Record of September 9 (vol 159, p 366) listed candidates who had recently been successful in final examinations at the Royal Veterinary College, University of London. It stated that they had been awarded the degree of BVS.

This was incorrect. The correct degree title is BVetMed. The error is regretted.

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**Election of BVA board members**

Members are invited to consider and propose suitable candidates for the membership for two Council-elected director posts on the BVA Board. Two Council-elected directors will be retiring by rotation at the Council meeting on December 6. Information packs and nomination forms will be sent out by the Company Secretary, Henrietta Alderman, on request. The closing date for returns is November 3.

**Headquarters activities**

**President’s diary**

The BVA President’s activities in the week ending September 16 included:

- A meeting with the Chief Veterinary Officer to discuss bluetongue.
- Meetings to discuss bovine tuberculosis and RCVS proposals for a new Veterinary Surgeons Act.
- Attending and speaking at the Universities Federation for Animal Welfare/BVA Ethics Committee ‘Quality of life’ symposium at the Royal Society of Medicine.
- Attending the British Equine Veterinary Association’s annual congress.
- Attending this year’s final-year students’ seminar at the University of Lancaster.

**Current consultations**

**Annual review of DEFRA’s exotic animal disease generic contingency plan**

The Animal Health Act 1981 requires DEFRA to produce a number of contingency plans, including those for foot-and-mouth disease (FMD), avian influenza (AI) and Newcastle disease (ND), to be reviewed and revised annually.

DEFRA is seeking comments on its generic exotic animal disease contingency plan for 2006, which includes volumes relating to FMD, AI and ND. Details are available at www.defra.gov.uk/corporate/consultation/animaldisease-plan2006/index.htm. The deadline for comments to the BVA is September 29.
reproductive physiology and was a pioneer in embryo transfer. Following the escape of the smallpox virus at the Queen Elizabeth Hospital in Birmingham, the monkey unit was disbanded and John took redundancy.

He was never one to conform; his independent spirit and left-wing views made him stand out from many of his colleagues.

For some years he ran a small animal practice in Shirley, West Midlands, after which he retired to Malvern to participate in his off-road activities in his beloved Land Rover.

He leaves his wife, Barbara, children, Nick, Jeffrey, Amy, Mary and Ann, and five grandchildren.

Hatch On September 8, Charles Hatch, MA, MS, PhD, MRCVS, of 8 Carolhill Park, Bangor, County Down. Dr Hatch qualified from Dublin in 1953.

Control of rabies in Jaipur, India, by the sterilisation and vaccination of neighbourhood dogs

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Stray dog population demographics in Jodhpur, India following a population control/rabies vaccination program

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ABSTRACT

Animal Birth Control (ABC) is a program by which stray dogs are sterilized and vaccinated against rabies with the aim of controlling both dog population size and rabies. Population size and demographics of stray dogs were measured before and after implementation of an ABC program in Jodhpur, India. Dog population size declined (p < 0.05) in three of five areas surveyed, showed a decreasing trend (p > 0.05) in 1 area, and remained stable in 1 area between 2005 and 2007. By 2007, 61.8–86.5% of the free-roaming dog population was surgically sterilized and vaccinated for rabies in the areas surveyed.

In March–May, 2007, adults comprised 80–96% of the free-roaming dog population, while subadults and puppies comprised 0–18 and 0–4%, respectively. The male:female ratio among dogs > 3 months old was 1.4:1. A population demographic model predicted that at the current level of sterilization/rabies vaccination, vaccination coverage would remain above 70%, and the dog population would decrease by 69% reaching stability after 13–18 years. A surgical sterilization coverage under 40% would maintain the dog population at current levels.

1. Introduction

More than 20,000 people die of rabies every year in India, and the majority of victims acquire the disease from the bite of a rabid stray dog (Sudarshan et al., 2007). Animal Birth Control (ABC) is a dog population control strategy by which stray dogs are captured, sterilized, vaccinated against rabies, and released at their point of capture (Reece et al., 2008). ABC has been adopted in many countries including India (Reece et al., 2008; Bogel and Hooye, 1990). However, little peer-reviewed data exist in the literature assessing the impact of ABC programs on stray dog population size and demographics.

Information on human rabies in the city of Jodhpur, India is scant and incomplete (Dr. Suresh Maheshwari, Professor and Head of the Sampurnanand Medical College in Jodhpur, pers. comm.,). The Sampurnanand Medical College in Jodhpur diagnoses an estimated ten human rabies cases annually (Dr. Suresh Maheshwari, pers. comm., February 2010).
24th, 2005). This figure may well underestimate the true incidence of human rabies in Jodhpur as most people who contract the disease in India do not go to hospital for treatment or formal diagnosis, preferring to die at home since there is no treatment (Roy, 1962).

Although the incidence of dog rabies in Jodhpur is unknown it is likely higher than the rabies incidence in humans (Dr. M.S. Rathore, Deputy Director of Government Veterinary Hospital, Jodhpur, pers. comm., 2006). Because there is no requirement or agency for reporting the disease, the majority of dogs with rabies in Jodhpur are not brought to the local government veterinary hospital but are killed by community members without being reported (Dr. M.S. Rathore, pers. comm., February 2006).

The objectives of this study were: (1) to estimate the age and gender demographics of the stray dog population in the city of Jodhpur, India, (2) to estimate the proportion of stray dogs sterilized and vaccinated for rabies through Jodhpur’s ABC program, (3) to estimate the current impact of the ABC program on stray dog population size in Jodhpur, and (4) to predict the long-term impact of ABC on dog population demographics in Jodhpur.

2. Materials and methods

The experimental unit was the stray dog, defined as a dog that is allowed to roam on public property in a completely unrestricted or semi-restricted manner, including those dogs which have a reference household or person(s) from whom they obtain food and/or shelter. All dogs used in this study were obtained from the streets of Jodhpur. All dogs in Jodhpur were eligible for this study, with the following exceptions: chained, leashed, confined, and/or collared dogs and puppies (dogs ≤ 3 months old) were not used in this study in deference to community sentiment.

2.1. Study area

This study took place in the city of Jodhpur (26.29° N, 73.03° E; altitude 230 m), in the state of Rajasthan, northwestern India. Pal (2001) divided the year in India into four seasons: summer (March–May), monsoon (June–August), late monsoon (September–November) and winter (December–February).

Mark-recapture studies were performed in 2005 and 2007 in six different areas within the city of Jodhpur, chosen to reflect different habitat types found in the city (e.g. residential, market, tourist, under construction, etc.). Area 1 was located within the walls of the Old City (oldest part of Jodhpur), contained narrow, winding streets and alleys and comprised Hindu commercial, Muslim commercial and some residential components. ABC was initiated in this area after March 2005. Area 2 was also located within the walls of the Old City. This area is predominantly market and middle-class to lower-class residential. ABC was launched here in December 2004. Area 3 was an upper-class residential area with wide avenues. The ABC program was launched here in March 2005. Area 4 was a middle-class residential area with large green spaces (vacant lots) and extensive areas of construction. When ABC was launched here after October 2005. Area 5 consisted of middle-class residential, some market areas and a few, small parks. This area was covered by the ABC program in February 2005. Area 6 was lower-, middle- and upper-class residential with stray cows, pigs and tethered goats. This was one of the first areas to undergo ABC (April 2004).

2.2. Dog population size and demographics assessment

The 2005 mark-recapture studies were carried out in the late monsoon season (September–November) (except in Area 1 where the 2005 mark-recapture study took place in March) while the 2007 mark-recapture studies were carried out in the summer season (March–April). Each mark-recapture study ran for 5 days because, based on preliminary observations, this was the length of time the marks persisted on the dogs. From day 1 to day 4 the marking team proceeded through the designated area, marking every unmarked dog observed (i.e. no dog was marked more than once). Mark-recapture was conducted between 8:00 a.m. and 10:00 a.m., when stray dogs were most active and visible. Marks were applied from a distance with an Aspee Eden 5-l spray canister. Black dogs were marked with a tumeric solution; all other dogs were marked with beet-root juice. The marking team recorded the total number of dogs they marked, the gender of each dog they marked and whether each dog had a notch in its left ear. All dogs processed through Jodhpur’s ABC program received a notch in the left ear at the same time as they were surgically sterilized.

On days 2–5, about 15 min after the marking team had begun marking the dogs and were out of sight of the counting team, the counting team proceeded through the area using the same route, recording the gender, age, notch status and mark status (marked versus not marked) of every dog observed. Dogs were never handled, thus “recapture” refers to visual recapture. In both 2005 and 2007, the marking and counting teams used the same route through a given area when marking and counting dogs, respectively.

Dogs were classified as adults if they had developed teats (females) or descended testes (males). Sexually immature dogs were classified as subadults or puppies using Daniels’s (1983) visual criteria of body size and allometry, head size and leg length relative to body size. The number of puppies observed was used solely for population age demographic calculations.

The dog population size was estimated using the Schumacher Method (Schumacher and Eschmeyer, 1943) with 95% confidence limits calculated using the equations of Caughley (1977). Decimal places were rounded up to the nearest whole number. The assumptions of the Schumacher population estimation method were tested using the method outlined by Caughley (1977, p. 140) by plotting on the y-axis the number of marked dogs seen on a given day divided by the total number of dogs seen on a given day, and plotting on the x-axis the cumulative number of dogs marked on that day. If the resulting plot does not form a straight line (assessed by eye) passing through the origin, one or more of the assumptions of the Schumacher Method have been violated. To estimate the prevalence of males in the stray dog population, data from the marking team were pooled across all areas for 2005, and all areas for 2007.
The prevalence of vaccinated dogs was calculated as the number of notched dogs observed by the marking team in each area, divided by the total number of dogs observed by the marking team in that area. Because the marking team did not record age of the dogs marked, nor did they mark puppies, the counting team’s data alone were used to estimate the proportion of adults, subadults and puppies in the population. To avoid counting any particular litter of puppies more than once, data from only one randomly selected mark-recapture counting day (using the Random Integer Generator at http://www.random.org/integers/) were used for each of the mark-recapture areas in 2005 and 2007. All dogs observed on the randomly selected days, whether marked or not, were used in our calculations.

2.3. Dog population demographic model

We used the mark-recapture data to develop a demographic model of the stray dog population in VenSim DSS32 Version 5.1A (Ventana Systems, Inc., Harvard, USA) to predict the long-term impact of the current sterilization rates on the dynamics of the dog population over time. The total number of females and males with respect to neuter status and age composition were not estimated therefore the model could not be gender- or age-stratified. The model utilized the following equations:

\[
\frac{dD}{dt} = bD - nD - cD(D + N) \\
\frac{dN}{dt} = nD - cN(D + N)
\]

Jacobian Matrix and Eigen values

\[
\begin{bmatrix}
  b - n - 2cD - cN - E & -cD \\
  n - cN & -cD - 2cN - E
\end{bmatrix}
\]

where \( D \) is the total number of dogs not yet sterilized, \( N \) is the number of sterilized dogs, \( b \) is the birth rate, \( n \) is the overall rate of sterilization and \( c \) is the resource competition constant. The term \( bD \) represents births; the term \( nD \) represents neutering; and the terms \( cD(D + N) \) and \( cN(D + N) \) represent competition effects: as the total population \( D + N \) increases, the terms \( cD(D + N) \) and \( cN(D + N) \) become larger in magnitude and hence depress population growth more. A Jacobian matrix was used to estimate Eigen values \( E1 \) and \( E2 \) which provide stable equilibrium conditions of the dog population (Keeling and Rohani, 2007).

The characteristic polynomial can be written as:

\[
(b - n - c(D + N) - E1)(-c(D + N) - E2)
\]

\[
E1 = b - n - c(D + N)
\]

For the model, the total number of dogs in 2005 and 2007 was the combined total of the number of dogs in each area for 2005 and 2007, as estimated by the Schumacher equation. The total number of notched dogs was calculated as the percentage of notched dogs (obtained directly from the marker’s data) multiplied by the total number of dogs in 2005 and 2007. We considered the transition between 2005 and 2007 as one time step with 2-year duration, interpolating values for the year 2006 and refitting the model with an annual time step over 3 years. Parameters \( n \) and \( c \) were fitted for all study areas separately and for all data pooled together.

Per capita birth rates \( (b) \) were estimated by multiplying the annual pregnancy rate \( (0.475) \) reported for Jaipur, a neighbouring city to Jodhpur (Reece et al., 2008) with the median litter size obtained from the analysis of uterine contents of bitches during sterilization in a separate study in Jodhpur (median = 5) (unpublished data), which provided an annual reproduction rate of females in reproductive age of 2.375. The proportion of reproductive females in the whole population was 0.427 \((n = 549)\) and a median litter size of 5 (minimum 1; maximum 9), which yielded, using a Monte Carlo simulation (@Risk software V.3.5.2, Palisade Corporation, normal approximation of the binomial estimate), an annual per capita birth rate of 1.014 (95% confidence limits: 0.354–1.674). We assumed that mortality rate was dependent on competition over available resources. To avoid over-parameterizing our model, we used a single mortality rate for all dogs (sexually intact and sterilized) in our final model. Mortality rates can be obtained by multiplying the resource competition constant \( (c) \) with the population size at a given time.

Parameters were fitted simultaneously using a Powell algorithm.

For the long-term simulations we used the parameter values in Table 1. For the equilibrium analysis we used the first Eigen value \( E1 = -0.4773796 \) from Eq. (4) which, summed with the sterilization rate, provided a stable dog population \((D)\) for the duration of the simulation (Figs. 1 and 2, line with crosses).

To obtain information of parameter variability for the sensitivity analysis, we used Bayesian estimates of the neutering rate \((n)\) and the resource competition rate \((c)\) using

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth rate ((b))</td>
<td>1.01412</td>
<td>0.000959584</td>
<td>0.2066</td>
<td>1.979067</td>
<td>Monte Carlo</td>
</tr>
<tr>
<td>Resource competition constant ((c))</td>
<td>0.80437</td>
<td></td>
<td></td>
<td></td>
<td>Demographic model</td>
</tr>
<tr>
<td>Sterilization rate ((n))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Demographic model</td>
</tr>
<tr>
<td>Mortality ((-690))</td>
<td>0.7789</td>
<td>0.00112</td>
<td>0.000029</td>
<td>0.8173</td>
<td>Bayesian</td>
</tr>
<tr>
<td>(c)</td>
<td>0.7048</td>
<td>0.02255</td>
<td>0.6601</td>
<td>0.7479</td>
<td>Bayesian</td>
</tr>
<tr>
<td>Sterilization rate ((n))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1. Graphical test of the assumptions of the Schumacher population estimation method for Area 1 in 2005.

Fig. 2. Graphical test of the assumptions of the Schumacher population estimation method for Area 1 in 2007.

WinBUGS, (Version 1.4.3, Imperial College and MRC, UK) the probability distribution of the observed parameters of all areas assuming a binomial distribution of $c$ and $n$, and a normal distribution of $b$.

3. Results

3.1. Stray dog population demographics

According to the graphical test, the assumptions of the Schumacher Estimate were violated in Area 1, as the graphs of the mark-recapture data did not produce a line moving upward toward the right (Figs. 1 and 2) so the data from Area 1 were dropped. The number of stray dogs (>3 months old) and the percentage of dogs notched in each of the remaining 5 areas in 2005 and 2007 are shown in Table 3.

Table 2
Stray dog population size estimates and percentage of dogs sterilized (95% confidence intervals in brackets) in six areas in the city of Jodhpur, India.

<table>
<thead>
<tr>
<th>Area</th>
<th>2005 %Notched (95%CI)</th>
<th>2005 Schumacher Estimate</th>
<th>2007 % Notched (95%CI)</th>
<th>2007 Schumacher Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0% (0–1.0%)</td>
<td>463 (427–493)</td>
<td>76.7% (68.7–83.2%)</td>
<td>126 (113–143)</td>
</tr>
<tr>
<td>2</td>
<td>53.7% (45.3–62.0%)</td>
<td>189 (138–297)</td>
<td>73.5% (64.2–81.1%)</td>
<td>113 (93–145)</td>
</tr>
<tr>
<td>3</td>
<td>12.1% (7.3–19.2%)</td>
<td>164 (124–242)</td>
<td>61.8% (50.6–71.9%)</td>
<td>80 (78–83)</td>
</tr>
<tr>
<td>4</td>
<td>0% (0–3.7%)</td>
<td>111 (98–128)</td>
<td>65.7% (53.7–75.9%)</td>
<td>68 (67–70)</td>
</tr>
<tr>
<td>5</td>
<td>86.8% (79.0–92.0%)</td>
<td>114 (105–126)</td>
<td>86.5% (78.9–91.6%)</td>
<td>111 (105–118)</td>
</tr>
<tr>
<td>6</td>
<td>55.9% (45.8–65.6%)</td>
<td>112 (103–123)</td>
<td>67.1% (56.2–76.5%)</td>
<td>81 (74–90)</td>
</tr>
</tbody>
</table>

$^a$ These estimates are of the number of stray dogs > 3 months old (not including pet dogs). Decimals rounded up to the nearest whole number.

$^b$ Notched = spayed/neutered and vaccinated for rabies through an Animal Birth Control program.

3.2. Dog population demographic model

A summary of the parameters estimated by the model is given in Table 4. The dog population remains stable when 31% of the dogs are sterilized (Fig. 3). In contrast, the currently observed sterilization rate reaches a stable proportion of sterilized dogs of 80%. If sterilization were to cease in 2005, the percentage of neutered dogs...
Table 4
Summary of estimated parameters based on a dog population demographic model of stray dogs in Jodhpur, India undergoing an Animal Birth Control program.

<table>
<thead>
<tr>
<th>Area</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>All dogs</td>
<td>189</td>
<td>164</td>
<td>111</td>
<td>114</td>
<td>112</td>
</tr>
<tr>
<td>Dogs (intact)</td>
<td>88</td>
<td>144</td>
<td>111</td>
<td>15</td>
<td>49</td>
</tr>
<tr>
<td>Resource competition constant</td>
<td>0.00741275</td>
<td>0.0115608</td>
<td>0.0141232</td>
<td>0.002632</td>
<td>0.0107059</td>
</tr>
<tr>
<td>Annual resource competition constant</td>
<td>0.003706375</td>
<td>0.0057804</td>
<td>0.0070616</td>
<td>0.001316235</td>
<td>0.00535295</td>
</tr>
<tr>
<td>Number dead dogs</td>
<td>62</td>
<td>137</td>
<td>87</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Neutering rate</td>
<td>1.60721</td>
<td>1.27133</td>
<td>1.35176</td>
<td>1.73034</td>
<td>1.46082</td>
</tr>
<tr>
<td>Annual neutering rate</td>
<td>0.803605</td>
<td>0.635665</td>
<td>0.67588</td>
<td>0.86517</td>
<td>0.73041</td>
</tr>
<tr>
<td>Number spayed/neutered dogs</td>
<td>71</td>
<td>92</td>
<td>75</td>
<td>13</td>
<td>36</td>
</tr>
</tbody>
</table>

in the population is predicted to drop to 0% by 2009 (Fig. 3).

Long-term simulations revealed that at the current rate of sterilization, the dog population should continue to decrease until it stabilizes at a 69% decrease from the original population size, in about 13–18 years (Fig. 4).

Sensitivity analysis revealed that the most sensitive parameter is the birth rate, followed by the neutering rate and the resource competition constant $c$ (which indirectly includes the mortality rate). Variability of the three parameters is given in Table 1.

Fig. 3. Dog population demographic model showing proportion of sterilized dogs in the population if sterilization continued at the current rate (triangles), if the population remained stable (crosses) or if sterilization ceased in 2005 (squares).

Fig. 4. Change in the total stray dog population size over time in Jodhpur, India, in the wake of an Animal Birth Control program if sterilization continued at the current rate (triangles), if the population remained stable (crosses) or if sterilization ceased in 2005 (squares).

4. Discussion

4.1. Rabies vaccination coverage

Empirical data from a number of studies in the United States indicates that dog rabies will be eliminated if 80% of the dog population $\geq 4$ months of age are vaccinated (70% of the total dog population) (Beran, 1991) though the necessary level of coverage is likely to vary with disease transmission dynamics, population demographics, behavioral and spatial characteristics of the dog population (WHO, 2004). Coleman and Dye (1996) created a theoretical model that predicted that vaccinating at least 70% of the dog population was necessary to eliminate or prevent rabies on at least 96.5% of occasions.

Observed data from our Jodhpur study indicate that this threshold of vaccination coverage in the stray dog population is achievable; by 2007, the prevalence of sterilized/vaccinated dogs ($\geq 3$ months old) in each of our mark-recapture areas was between 61.8 and 86.5%. Total coverage of the dog population was not possible because the dog catchers in Jodhpur’s ABC program do not pick up lactating bitches or those in advanced pregnancy (i.e. later than 51 days post-conception) or puppies $\leq 3$ months old, since the rabies vaccine is not recommended for use in dogs so young.

Also, our demographic model indicates that at the current level of sterilization, the threshold of 80% of the population should be reached over the long-term, which is sufficient to interrupt rabies transmission in this population. This is assuming that all sterilized dogs are also vaccinated and that immunity following vaccination is lifelong given the short lifespan of stray dogs (as has been assumed by Reece and Chawla, 2006) in Jaipur’s ABC program. Stray dogs in India have been reported to live an average of only 2.6 years (Pal, 2001).

However, our model predicts that if the sterilization/vaccination program is stopped in Jodhpur, the percentage of vaccinated dogs in the population will rapidly fall below the threshold and will return to pre-ABC levels within 3–4 years.

4.2. Dog population size

In contrast to the rule of thumb for rabies control, there is no hard-and-fast rule regarding what proportion of the population needs to be sterilized in order to control the
dog population itself. It has been reported that Animal Birth Control programs, properly carried out, are expected to decrease the dog population, with stabilization occurring 5–7 years after implementation (Leney and Remfry, 2000). Our population demographic model indicated a longer time-to-stabilization (13–18 years). There is little information in the literature reporting actual dog population size changes in cities undergoing ABC programs. Reece and Chawla (2006) reported a 28% decrease (between 1997 and 2002) in the stray dog population in Jaipur, a city located 343 km from Jodhpur, with an ABC program that was launched in 1994. This is a smaller decrease than we reported. However, because ABC began in Jodhpur in 2004, we expected to see a decrease in the dog population in all areas covered by the program, but not stabilization. We observed a more dramatic decrease in our dog population size ranging from 27.7% (Area 6) to 51.2% (Area 3) between 2005 and 2007. Our population demographic model indicates the most dramatic drop in the dog population occurs in the first 3 years after implementation of the ABC program. The reason for Reece and Chawla’s (2006) smaller reported decrease may be because their dog population size estimates began 3 years after implementation of the ABC program in Jaipur had begun.

The reason for the lack of a decrease in our dog population size in Area 5 where > 80% of the free-roaming dog population was already sterilized in 2005, may have been because the effects of ABC on dog numbers in this area may already have become apparent by the time we began our study in 2005, although our demographic model does not predict such a rapid stabilization (see below). Coverage of dogs by the ABC program in areas bordering those in which we conducted mark-recapture studies might also have affected the population dynamics in each of our study areas, since there were no physical barriers to stray dog movement into and out of our study areas.

A possible contributing cause of differences in degree of decrease of the dog population between areas may be that our mark-recapture areas were chosen to reflect different habitat types. They were not chosen with regard to whether or not surrounding areas were undergoing ABC. The dog-catchers selectively implemented ABC in Jodhpur beginning in areas of the city where community acceptance was highest. In some cases, there may well have been “spillover” from an adjacent ABC area into our mark-recapture areas. We were unable to quantify this, because the dog-catchers recorded their progress via street names and only 4 were observed in 2005 so this bias is probably minimal. We found a significant male-biased gender ratio among the population of adults and subadults in Jodhpur. In West Bengal, India, a male:female ratio of 1.37:1 was reported for free-ranging dogs (Pal, 2001). However, the ratio of males:females was approximately 1:1 in Jaipur after an ABC program had been implemented (Reece and Chawla, 2006). The male sex ratio bias has been attributed to the selection of males as pets, perhaps because of the perception that males make better guard dogs than females and to avoid the nuisance of owning a bitch in estrus or having to deal with unwanted puppies (Daniels and Bekoff, 1989; Daniels, 1983). Estrus females tend to cause neighbourhood complaints because they attract groups of intact male dogs. The male-biased sex ratio was not significantly different between 2005 and 2007 in our study. It could be that the full impact of ABC on dog gender ratio in this population has yet to be observed.

In theory, ABC programs should increase the adult fraction of the population by increasing longevity and decreasing reproduction. In one study of urban dogs (30% of which were allowed to roam free) in Ecuador, 18% of the dog population was 3–11 months old (Beran and Frith, 1988). Given that stray bitches in India have been reported to have their first estrus at 7–13 months of age (Ghosh et al., 1984) the 3–11 month old dogs are roughly equivalent to the subadult fraction of our population. In the same study, 14% of urban dogs were <3 months of age (puppies) and 67.6% were 1 year of age or older (adults) (Beran and Frith, 1988). As in our study, adults comprised the majority of the population. We did not see a clear pattern regarding whether there was a higher prevalence of puppies than subadults.

4.4. Study limitations/future outlook

Potential bias arises in our dog population size estimates because the marking team did not mark collared free-roaming dogs, in deference to community attitudes. These dogs were not represented in our population estimates. However, collared free-roaming dogs were rare in the dog population; no collared dogs were observed in 2007, and only 4 were observed in 2005 so this bias is probably minimal.

Ideally, the 2005 and 2007 mark-recapture surveys in our study should have been carried out at the same time of year, however, our 2005 mark-recapture studies were carried out in the late monsoon season (September–November) while our 2007 mark-recapture studies were carried out in the summer season (March–April). This may be important if whelping is seasonal, because the population would be expected to fluctuate as new dogs are born and enter the population. A study of stray dogs in Jaipur, a city 331 km from Jodhpur, found a mean whelping date of November 23rd (Reece et al., 2008). If whelping is seasonal in Jodhpur, as is likely since estrus and pregnancy are seasonal in the Jodhpur stray dog population (Totton et al., 2010), our mark-recapture studies in March–April should have shown an increase in the dog population in the form of
new subadults entering the population at this time of year. The consistency of the observed population decline in areas from 2005 to 2007 is suggestive of a real decline as opposed to normal fluctuation in population size. Admittedly, the higher ambient temperature typical of the summer season in Jodhpur may have caused more dogs to seek shelter from the sun during the counting period compared to the late monsoon season when temperatures were more moderate. However, both the counting team and the marking team took care to search for dogs under parked vehicles and porches and community members were often helpful in pointing out dogs that were hiding from the counting team. We therefore feel confident that though a slight difference may have existed in our ability to detect dogs in the summer season that this difference would not have been great.

Our demographic model is parsimonious, but was fitted to a very limited number of time points. For the estimation of the variability of resource competition constant \( c \) we used a Bayesian binomial model using observed mortality data. Average values of \( c \) were close between the demographic and Bayesian estimate (Table 1). Longer time series and possibly gender- and age-differentiated numbers of sterilized and total numbers of dogs would allow us to fit a gender- and age-structured model possibly as a stochastic process. It is important to continue annual monitoring of the stray dog population size in Jodhpur over time as this will help refine model estimates.

5. Conclusion

Because the Jodhpur ABC program was launched in 2004, its full impact on the dog population is likely still to be realized. The results of this study showed a promising decline in the dog population after implementation of an ABC program. In addition, the observed data indicate that the target 70% vaccination coverage required for the elimination of rabies from this population is achievable.

Acknowledgements

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The study sponsors had no role in the study design, data analysis, interpretation or in the writing of the manuscript or in the decision to submit for publication. The Marwar Animal Protection Trust did employ the members of the marking team who collected some of the data.

References

Decline in human dog-bite cases during a street dog sterilisation programme in Jaipur, India

J. F. Reece, S. K. Chawla, A. R. Hiby

Human dog-bite injuries are a major public health problem, particularly where there are large populations of free-roaming or street dogs. Dog bites are also the major source of human rabies infections. There is little information on the means to reduce these injuries. Monthly human animal-bite injury records from January 2003 to June 2011 were obtained from the main government hospital in Jaipur, India. The data were analysed and compared with records of pregnancy in street dogs in Jaipur obtained from a street dog sterilisation programme. Human animal-bite injuries showed a seasonal pattern which followed by approximately 10 weeks the seasonal peak of street dog breeding. The number of human animal bites has declined significantly since 2003. It is concluded that a street dog sterilisation programme can reduce human dog-bite injuries by reducing the maternal protective behaviour of the street dogs, as well as reducing the total size of the roaming dog population.

Introduction

Human dog bites are a major public health problem throughout the world. The main victims are children, especially boys, and the poor (Ozanne-Smith and others 2001). In countries with endemic rabies, the bites of animals are the main means of transmission of this disease, and dogs make up the majority of the biting animals causing 90.7 per cent of all animal-bite wounds in Dhaka, Bangladesh (Hossain and others 2011), 91.5 per cent of all bite wounds in India (Sudarshan and others 2008) and 86 per cent in Thailand (Sriaroon and others 2006). In South Africa, dog bites accounted for 1.5 per cent of all patients presented to a paediatric trauma unit (Dwyer and others 2007). Bites by dogs were responsible for 96.2 per cent of human rabies cases in India (Sudarshan and others 2007). Despite the public health importance of dog bites, there has been little research into the causes or means of prevention (Overall 2001). Recommendations to limit this problem are vague and general: for example, a large study in India (Sudarshan and others 2006) concluded that ‘appropriate community awareness and dog vaccination campaigns and effective stray dog control measures’ be taken.

Control of stray dogs is recommended by WHO as part of rabies control measures (Anon 2004). In India control of free-roaming dog populations has been attempted using animal birth control (ABC) programmes. Reece and Chawla (2006) report that the ABC approach has been successful in controlling both the street dog population and rabies. Cleaveland and others (2005) report a reduction in dog bites following a dog vaccination campaign in Tanzania. Pratap and others (2011) found a seasonal trend in human animal bites in India, and suggest that a possible cause is canine reproductive behaviour.

Unpublished observations of street dog litters in Jaipur found that dispersal of pups from the dam occurred between 90 and 120 days after whelping (Help in Suffering (HIS) unpublished data). Anecdotal evidence from animal control personnel in the city indicates that bitches will often try to protect their two/three-month-old pups by biting the threatening personnel. Given that canine reproduction is markedly seasonal in parts of India (Chawla and Reece 2002), the objective of the current study was to determine if a relationship exists between canine reproductive behaviour and human dog bites. In that case, an ABC programme may reduce dog-bite frequency by reducing the proportion of reproducitively active dogs before it achieves any reduction in the total size of the population. This hypothesis was investigated using data from the main government hospital in Jaipur, the SMS Hospital, and from the long-term ABC project at HIS, Jaipur.

Methods

Human animal-bite data

The publicly displayed human animal-bite data from the Bite Unit of the SMS Hospital in Jaipur (city population c. 3 million) was plotted by year from 1993 to 2010, and by month from January 2003 to June 2011. The historical data from 1993 to 2002 was extracted from a previous study on human animal-bite cases in Jaipur (Sharma and others 2002). The presence of any long-term trend in bite frequency was investigated using linear least squares regression.

Canine reproduction data

The proportion of bitches pregnant when sterilised by the HIS ABC programme was determined from the records of 20,359 bitches sterilised by the programme from January 2003 to June 2011. Details of the overall HIS ABC programme methods can be found in Reece and Chawla (2006), and of the programme’s surgical approach in Reece and others (2012). Pregnancy was determined by a veterinary surgeon by gross visual examination of the removed female genitalia. The presence of any long-term trend in pregnancy was investigated using linear least squares regression.
Change in percentage of roaming dogs spayed

Canine demographic data was obtained from the index of abundance surveys undertaken from 1997 to 2010 in a large but well defined area of Jaipur city known as the Pink City, Jaipur is the state capital city of Rajasthan with a population of c. 3 million people. It currently covers an area of about 100 km². The Pink City area surveyed is 7.8 km². The surveys were undertaken at the same time of day and year, and as far as possible with the same personnel throughout the study. Surveys involved each of two teams walking set routes through the area for approximately 12 hours in total for each survey. Sterilised bitches were identified by a notch cut in the leading edge of the left pinna at the time of sterilisation surgery.

To investigate seasonality in bite frequency and pregnancy, both sets of data were presented as monthly averages and compared. The cross-correlation between the original pregnancy series and the detrended bite frequency series was also calculated at lags of up to ±5 months.

Results

Fig 1 shows the annual number of animal-bite cases reported by the SMS hospital in Jaipur from 1993 to 2010. In Fig 2 the numbers are shown by month from January 2003 to June 2011. A linear least squares regression shows a significant reduction of 4.91 bites per month over the latter period (F test, 1 and 100 DF, P < 0.001). The reduction in bite frequency has occurred despite an annual increase in human population of 4.95 per cent.

Fig 3 compares the monthly average human animal-bite cases with the monthly average percentage of bitches pregnant when sterilised. The figure shows that the bite frequency is at a maximum in January, about three months after the peak in the percentage of females pregnant. This is plotted from April to March, since both datasets peak around the change of the calendar year and would be split if plotted by calendar year. Fig 4 plots the cross-correlation between the original pregnancy series from January 2003 to June 2011, and the residuals from the linear regression fit to the original bite frequency series over the same period. No long-term trend was evident in the percentage of females pregnant when sterilised (F test, 1 and 100 DF; p = 0.663). The plot shows a significant positive correlation between pregnancy and bite frequency three to four months later.

Discussion

Reported human dog-bite cases were found to be seasonal in Jaipur with the main peak in January and a secondary peak in June. Canine reproduction was found to be seasonal with peak whelping activity in November. Following the start of the intervention in 1996, the percentage of the total female dog population that had been spayed rose quickly, and has remained between 70 per cent and 80 per cent since 2003. The number of human animal-bite cases has declined since then despite a rapidly expanding human population.

Human animal bites, as reported at the main government hospital in Jaipur, show a seasonal trend with peaks in January and in June. This is in agreement with the findings of Pratap and others (2011) working in government hospitals in the Indian state of Orissa. The proportion of animal bites that are caused by dogs is reported to be 91.54 per cent (Sharma and others 2002). The publicly available hospital data used in this study does not detail which species of animal was involved, but unless the 8.5 per cent of bites by animals other than dogs are very markedly seasonal it is likely that the seasonality illustrated here is a result of seasonality in dog bites.

Who the victims of dog bites are, and the timings of the bites has been studied in a number of different locations. Children represent the greatest single proportion of bite patients in India, with 47.5 per cent of bite patients being aged 2–18 years (Sudarshan and others 2006). In Pune, India, 52.8 per cent of animal-bite cases were in children aged 0–14 years (Shetty and others 2005). In the USA, most dog-bite cases occur in the summer and at weekends because both children and dogs are more active at these times (Overall 2001). In Thailand, dog-bite cases in children peak during school holidays (Staroon and others 2006), but there is no seasonal trend for adult bite cases. The school holidays in Jaipur occur from mid-May to mid-July, and this could correlate with the minor peak seen in the numbers of human animal-bite cases in this city. It is unlikely that the January peak can...
The breeding of street dogs in Jaipur was found to be markedly higher than during index of abundance surveys in the Pink City area of Jaipur where ABC programmes operate.

The evidence presented here suggests that in addition to benefits in rabies control (Reece and Chawla 2006) programmes of mass sterilisation of street dogs may have an effect on the numbers of human animal-bite cases that far exceed the effects of reducing the dog population to the same level by indiscriminate culling. Sterilisation may therefore be recommended to reduce this major public health problem. Further research is required into these effects in Jaipur and other cities where ABC programmes operate.

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