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

TNR Fund to: pyyoong 15/01/2014 17:43

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

History: This message has been forwarded.

3 attachments

Jaipur Reece-2006.pdf Jaipur dog bites Reece 2013.pdf Jodpur Totton 2010.pdf

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

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

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.

Veterinary Record (2006) **159,** 379-383

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

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 of supposed dog and disease control in India. 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.

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

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 (HIS) and the municipal authorities

	1994	1995	1996	1997	1998	1999	2000	2001	2002	Totals
Dogs received at HIS	250	1409	2828	2558	3070	3319	4109	3627	3816	24,986
Dogs vaccinated against rabies	223	1202	2394	2280	2723	2941	3780	3377	3522	22,442
Bitches spayed	223	1169	2183	1559	1910	2441	2414	2221	2325	16,445
Male dogs sterilised (includes 10 vasectomies)	0	0	2	0	16	10	885	977	794	2684
Total number of operations	223	1169	2185	1559	1926	2451	3299	3198	3119	19,129

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 km^2.

Sterilisation and vaccination

The ABC programme focused on the sterilisation and vaccination 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 drawstring 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. 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 induced longer lasting immunity.

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 neighbourhood 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 counted on consecutive days, mainly on foot, in the two-and-a-half-hour period by two teams, each consisting of a recorder, usually a veterinary surgeon, and an experienced animal technician. The dogs were recorded as males, females, and puppies, and further subdivided into those with ear notches (which had been through the ABC programme) and those without. A puppy was defined as a young dog with an

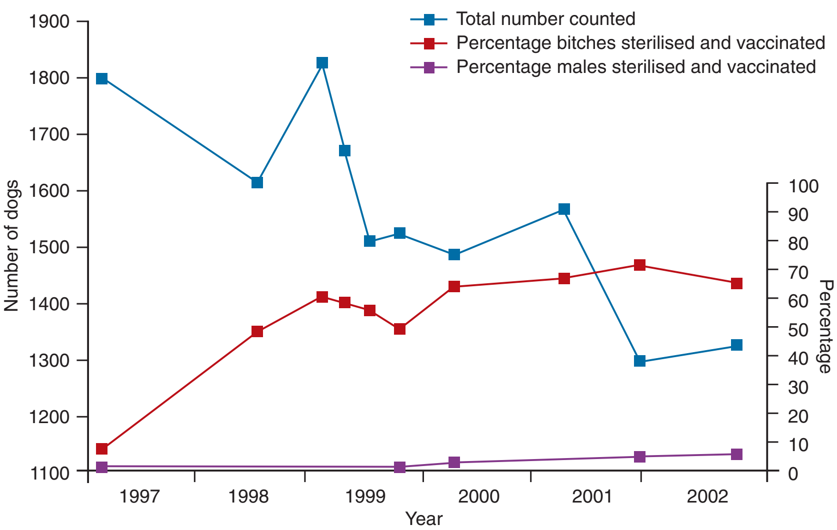

FIG 1: Total numbers of dogs counted in the Pink City area of Jaipur, and the percentages of the males and females that were sterilised and vaccinated against rabies

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

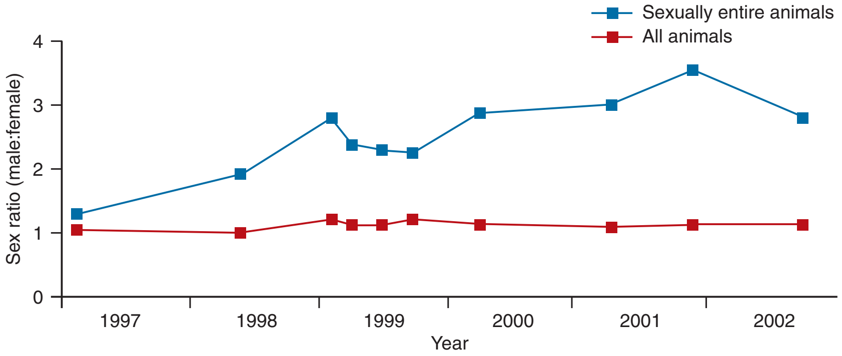

FIG 2: Effects of the programme of sterilisation on the sex ratio of the population of neighbourhood dogs in the Pink City area of Jaipur between February 1997 and August 2002

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.

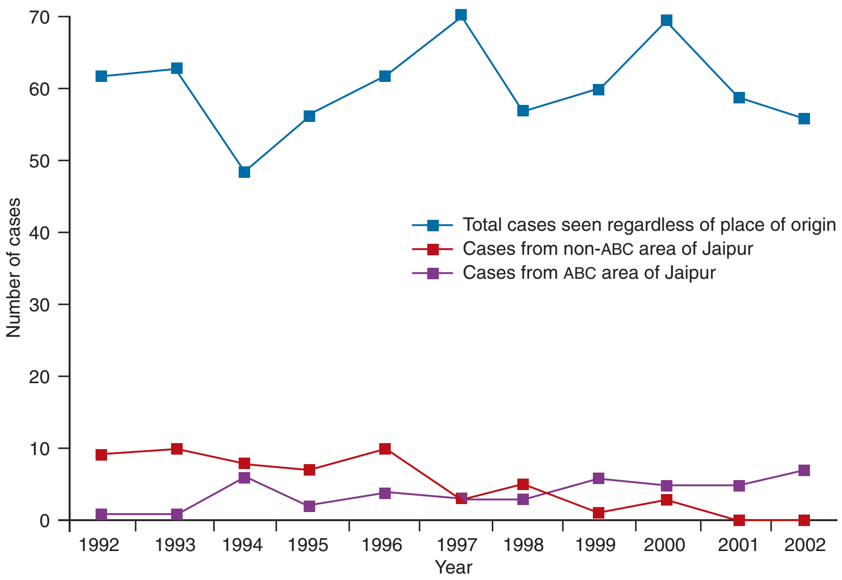

FIG 3: Numbers of human cases of rabies recorded in the Sawai Man Singh Hospital in Jaipur from all regions, from the area of Jaipur covered by the Animal Birth Control (ABC) programme and from the non-ABC areas of Jaipur

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, 10·3 per cent were humanely destroyed after veterinary examination as being unfit for sterilisation and vaccination by reason 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; for 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

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

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, Seghaier 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 Brochier 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. In Jaipur and elsewhere on the Indian subcontinent, breeding in neighbourhood dogs is highly seasonal, with the peak whelping season in Jaipur being October and November (Pal 2001, Chawla and Reece 2002); as a result, many puppies could be caught for the ABC programme during the winter. The risk of hypothermia in young animals has been found to be real, and the programme has had to balance the desire to vaccinate and sterilise as many young animals as possible against the welfare problem of hypothermia.

The unreliability of human rabies data collected in many countries where the disease is endemic, including India, is recognised. The decline in human rabies cases within the ABC area of Jaipur may be an artefact; however, the disease reporting procedures and records would have been expected to become more accurate over the period of the study. The population of the city has doubled during the study period. 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 Kailash Chandra, numerous volunteer veterinary surgeons, and Mr J. Townend 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 Mme J. 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

ANON (1988) Report of WHO consultation on dog ecology studies related to rabies control, WHO/Rab Res/88.25. Geneva, WHO

ANON (1990) Guidelines for dog population management WHO/WSPA, WHO/Zoon/90.165. Geneva, WHO

ANON (2004a) Assessing the burden of rabies in India. WHO sponsored national multicentric rabies survey 2003. Bangalore, Association for Prevention and Control of Rabies in India

ANON (2004b) WHO expert consultation on rabies: first report WHO Technical Report Series 931. Geneva, WHO

ANDERSON, R. M. (1986) Vaccination of wildlife reservoirs. *Nature* **322,** 304-305

ANDERSON, R.M., JACKSON, H. C. M., MAY, R. M. & SMITH, A. M. (1981) Population dynamics of fox rabies in Europe. *Nature* **289,** 765-771

BERAN, G. W. (1991) Urban rabies. In the Natural History of Rabies. 2nd edn. Ed G. M. Baer. Boca Raton, CRC Press. pp 427-443

BLANCOU, J. (1988) Epizootiology of rabies: Eurasia and Africa. In Rabies. Eds J. B. Campbell, K. M. Charlton. Boston, Kluwer Academic Publishers. pp 242-265

BROCHIER, B., KIENY, M. P., COSTY, F., COPPENS, P., BAUDUIN, B. & LECOCQ, J. P. (1991) Large-scale eradication of rabies using recombinant vaccinia rabies vaccine. *Nature* **354,** 520-522

BUTLER, J. R. A. & BINGHAM, J. (2000) Demography and dog-human relationships of the dog population in Zimbabwean communal lands. *Veterinary Record* **147,** 442-446

CHAWLA, S. K. & REECE, J. F. (2002) Timing of oestrus and reproductive behaviour in Indian street dogs. *Veterinary Record* **150,** 450-451

CLEAVELAND, S., FEVRE, E. M., KAARE, M. & COLEMAN, P. G. (2002) Estimating human rabies mortality in the United Republic of Tanzania from dog bite injuries. *Bulletin of the World Health Organization* **80,** 304-310

COLEMAN, P. G. & DYE, C. (1996) Immunisation coverage required to prevent outbreaks of dog rabies. *Vaccine* **14,** 185-186

COYNE, M. J., BARR, J. H. H., YALE, T. D., HARDING, M. J., TRESNAN, D. B. & MCGAVIN, D. (2001) Duration of immunity in dogs after vaccination or naturally acquired infection. *Veterinary Record* **149,** 509-515

DUTTA, J. K. (2002) Evaluation of Verovax for prophylaxis against rabies. *Journal of the Association for Prevention and Control of Rabies in India* **4,** 30-31

FEKADU, M. (1991) Canine rabies. In The Natural History of Rabies. 2nd edn. Ed G. M. Baer. Boca Raton, CRC Press. pp 367-387

LARGI, O. P., ARROSI, J. C., NAKAJATAA, J. & VILLA-NOVA, A. (1988) Control of urban rabies. In Rabies. Eds J. B. Campbell, K. M. Charlton. Boston, Kluwer Academic Publishers. pp 407-422

MACINNES, C. D. (1988) Control of wildlife rabies: the Americas. In Rabies. Eds J. B. Campbell, K. M. Charlton. Boston, Kluwer Academic Publishers. pp 381-405

NEVILLE, P. F. & REMFRY, J. (1984) Effects of neutering on two groups of feral cats. *Veterinary Record* **114,** 447-450

PAL, S. K. (2001) Population ecology of free-ranging urban dogs in West

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

Bengal, India. *Acta Theriologica* **46,** 69-78
PERRY, B. D. & WANDELER, A. I. (1993) The delivery of oral rabies vaccine to dogs; an African perspective. *Onderstepoort Journal of Veterinary Research* **60,** 451-457
SEGHAIER, C., CLIQUET, F., HAMMAMI, S., AOUINA, T., TLATLI, A. & AUBERT, M. (1999) Rabies mass vaccination campaign in Tunisia: are vaccinated dogs correctly immunised? *American Journal of Tropical Medicine and Hygiene* **61,** 879-884
STUBBS, W. P. & BLOOMBERG, M. S. (1995) Implications of early neutering in the dog and cat. *Seminars in Veterinary Medicine and Surgery (Small Animal)* **10,** 8-12
SUDARSHAN, M. K., MAHENDRA, B. J. & NARAYAN, D. H. A. (2001) A community survey of dog bites, anti-rabies treatment, rabies and dog population management in Bangalore city. *Journal of Communicable Disease* **33,** 245-251
ZAUNBRECHER, K. I. & SMITH, R. E. (1993) Neutering of feral cats as an alternative to eradication programmes. *Journal of the American Veterinary Medical Association* **203,** 449-452

British Veterinary Association

Officers of the BVA
President Dr F. M. Scott-Park
Past-President Dr R. M. McCracken
President-Elect Mr D. F. Catlow

Address
7 Mansfield Street, London W1G 9NQ
Telephone 020 7636 6541
Fax 020 7436 2970
e-mail: bvahq@bva.co.uk
www.bva.co.uk

Election of BVA board members

Members are invited to consider and propose suitable candidates from 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 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/consult/animaldisease-plan2006/index.htm. The deadline for comments to the BVA is September 29.

Implementation of the Zoonoses (Monitoring) Regulations 2006 (EU Directive 2003/99/EC) DEFRA is seeking stakeholders' views on a draft Statutory Instrument that proposes a means by which the EU Directive on monitoring of zoonoses and zoonotic agents would be implemented in England. The deadline for comments to the BVA is October 1.

- 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(Ret), of Bangkok, 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, 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 Malmesbury, 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 cycling.

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 Bangkok, 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, BSc, PhD, MRCVS, of Burlington, Lansdowne Road, Malvern, Worcestershire. Dr Marston qualified from London in 1962.

Neal Farr writes: John Marston qualified from the Royal Veterinary College (RVC) in 1962. He had also completed a degree in physiology, one of the few to do so at the RVC.

As a student he was a popular president of the student union, 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 intrauterine contraceptive device at the Worcester Founda-tion with Dr M. C. Clic. He returned to Birmingham, where he worked with Sir Zolly Zuckerman on

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

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.

Stephens On August 3, David Eirwyn Stephens, BVSc, MRCVS, of Dolhywel, Llandovery, Dyfed. Mr Stephens qualified from Bristol in 1963.

Downloaded from veterinaryrecord.bmj.com on December 30, 2013 - Published by group.bmj.com

Veterinary Record

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

J. F Reece and S. K. Chawla

Veterinary Record 2006 159: 379-383
doi: 10.1136/vr.159.12.379

Updated information and services can be found at:
http://veterinaryrecord.bmj.com/content/159/12/379

These include:

References Article cited in:
http://veterinaryrecord.bmj.com/content/159/12/379#related-urls

Email alerting service Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/

Preventive Veterinary Medicine 97 (2010) 51–57

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

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

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

Sarah C. Totton[a,*], Alex I. Wandeler[b], Jakob Zinsstag[c,d], Chris T. Bauch[e], Carl S. Ribble[f], Rick C. Rosatte[g], Scott A. McEwen[a]

[a] *Department of Population Medicine, Ontario Veterinary College, University of Guelph, Guelph, ON N1G 2W1, Canada*
[b] *Canadian Food Inspection Agency, 3851 Fallowfield Road, P.O. Box 11300, Ottawa, ON K2H 8P9, Canada*
[c] *Department of Epidemiology and Public Health Swiss Tropical and Public Health Institute, P.O. Box 4002 Basel, Switzerland*
[d] *Associated Institute of the University of Basel, Switzerland*
[e] *Department of Mathematics and Statistics, University of Guelph, 50 Stone Road East, Guelph, ON N1G 2W1, Canada*
[f] *Department of Ecosystem and Public Health, Faculty of Veterinary Medicine, University of Calgary, HRIC 2AC66, 3280 Hospital Drive NW, Calgary, AB T2N 2Z6, Canada*
[g] *Ontario Ministry of Natural Resources, Wildlife Research and Development Section, Trent University, DNA Building, 2140 East Bank Drive, Peterborough, ON K9J 7B8, Canada*

A R T I C L E   I N F O

Article history:
Received 9 January 2010
Received in revised form 28 June 2010
Accepted 18 July 2010

Keywords:
Animal Birth Control
Demographic model
India
Mark-recapture
Population
Stray dog

A B S T R A C T

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.

© 2010 Elsevier B.V. All rights reserved.

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 Hoyte, 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

* Corresponding author at: 340 Second Avenue West, Owen Sound, ON N4K 4L7, Canada. Tel.: +1 519 371 1032; fax: +1 519 371 0045.
E-mail address: sarah.totton@gmail.com (S.C. Totton).

0167-5877/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.prevetmed.2010.07.009

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 beetroot 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:

$$\frac{dD}{dt} = bD - nD - cD(D + N) \quad (1)$$

$$\frac{dN}{dt} = nD - cN(D + N) \quad (2)$$

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:

$$(b - n - c(D + N) - E1)(-c(D + N) - E2) \quad (3)$$

$$E1 = b - n - c(D + N) \quad (4)$$

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 1
Variation of the birth rate, resource competition constant (death rate) and sterilization rate found in a population demographic model of stray dogs in Jodhpur, India in the wake of an Animal Birth Control program.

Parameter	Mean	SD	Min	Max	Method
Birth rate (b)	1.01412	0.3368	0.2066	1.979067	Monte Carlo
Resource competition constant (c)	0.00099584				Demographic model
Sterilization rate (n)	0.80437				Demographic model
			Lower 95% credibility interval	Upper 95% credibility interval	
Mortality (c*690)	0.7789	0.02038	0.7378	0.8173	Bayesian
c	0.00112	0.000029	0.00106	0.00118	
Sterilization rate (n)	0.7048	0.02255	0.6601	0.7479	Bayesian

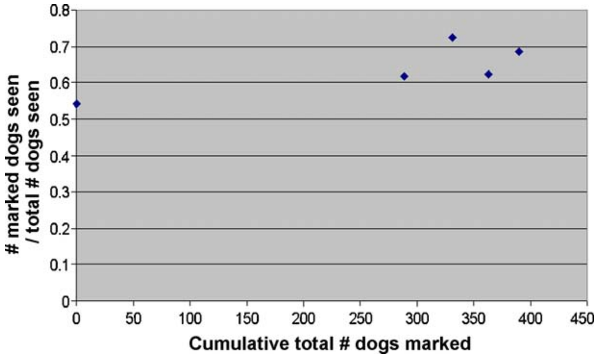

Fig. 1. Graphical test of the assumptions of the Schumacher population estimation method for Area 1 in 2005.

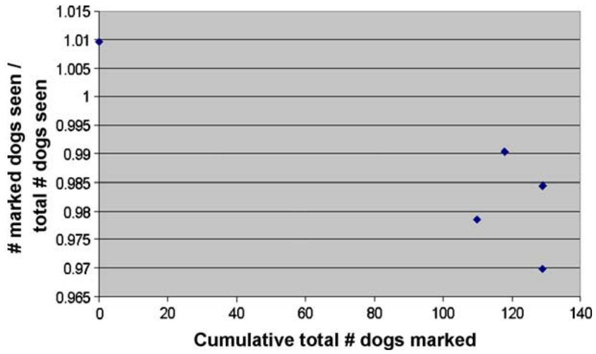

Fig. 2. Graphical test of the assumptions of the Schumacher population estimation method for Area 1 in 2007.

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 2. Dog population size declined significantly ($p < 0.05$) between 2005 and 2007 in Areas 3, 4 and 6. Area 2 showed a non-significant ($p > 0.05$) decreasing trend. The dog population size did not change significantly in Area 5 between 2005 and 2007.

There was an increase ($p < 0.05$) in the percentage of dogs notched in Areas 2, 3 and 4 between 2005 and 2007. In Area 5 the prevalence of notched dogs did not change. The percentage of dogs notched increased non-significantly in Area 6 between 2005 and 2007.

The prevalence of males in the stray dog population > 3 months old was 56.5% (95%CI = 52.3–60.6%; n = 549) in 2005 and 58.4% (53.7–62.9%; n = 435) in 2007, yielding a male-biased sex ratio of 1.3:1 in 2005 and 1.4:1 in 2007. The prevalence of adults, subadults and puppies in the Jodhpur stray dog population is shown in Table 3.

Table 3
Age structure of populations of free-roaming dogs in five areas within the city of Jodhpur, India.

Area	Age structure 2005[a,b]	Age structure 2007
2	A 96% (90–99%) S 2% (0–7%) P 2% (0–7%)	A 89% (81–94%) S 6% (3–13%) P 5% (2–12%)
3	A 87% (76–93%) S 3% (1–10%) P 10% (5–20%)	A 80% (69–87%) S 18% (11–28%) P 2% (1–10%)
4	A 90% (81–95%) S 1% (0–7%) P 9% (5–18%)	A 93% (81–98%) S 7% (2–19%) P 0% (0–8%)
5	A 95% (87–98%) S 3% (1–9%) P 2% (1–9%)	A 96% (90–99%) S 0% (0–5%) P 4% (1–11%)
6	A 88% (77–94%) S 4% (1–12%) P 8% (4–19%)	A 96% (88–99%) S 4% (2–12%) P 0% (0–5%)

[a] Proportion of the free-roaming dog population which are: A = adult (sexually mature), S = subadult (sexually immature but independent from mother), P = puppy (≤3 months old).
[b] Numbers in brackets are 95% confidence intervals.

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

Area	2005 %Notched[b] (95%CI)	2005 Schumacher Estimate	2007 % Notched (95%CI)	2007 Schumacher Estimate
1	0% (0–1.0%)	463 (437–493)	76.7% (68.7–83.2%)	126 (113–143)
2	53.7% (45.3–62.0%)	189 (138–297)	73.5% (64.2–81.1%)	113 (93–145)
3	12.1% (7.3–19.2%)	164 (124–242)	61.8% (50.6–71.9%)	80 (78–83)
4	0% (0–3.7%)	111 (98–128)	65.7% (53.7–75.9%)	68 (67–70)
5	86.8% (79.0–92.0%)	114 (105–126)	86.5% (78.9–91.6%)	111 (105–118)
6	55.9% (45.8–65.6%)	112 (103–123)	67.1% (56.2–76.5%)	81 (74–90)

[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.

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.

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

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.

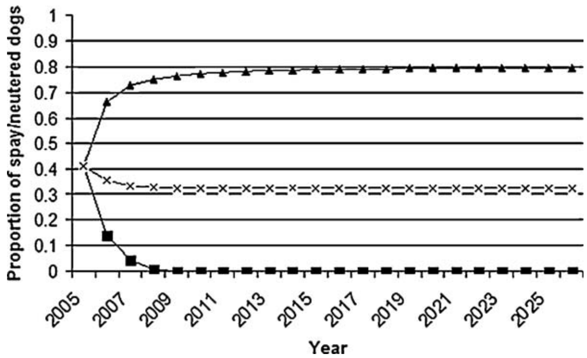

Fig. 3. Dog population demographic model showing proportion of sterilized dogs in the population if sterilization continued at the current rate (triangles), if the population remained stable (crosses) or if sterilization ceased in 2005 (squares).

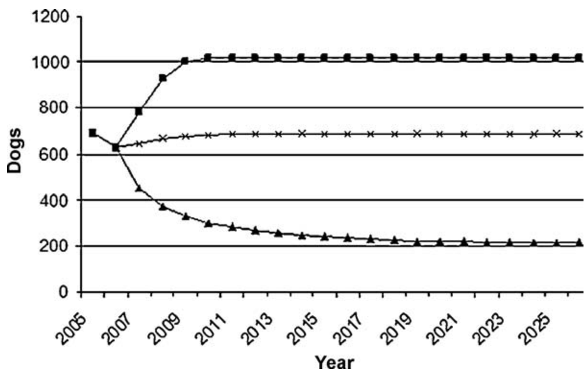

Fig. 4. Change in the total stray dog population size over time in Jodhpur, India, in the wake of an Animal Birth Control program if sterilization continued at the current rate (triangles), if the population remained stable (crosses) or if sterilization ceased in 2005 (squares).

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 (>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 unfortunately, since Jodhpur is a military town, we were unable to acquire a detailed street map of the city. This prevented us from calculating the degree of overlap between mark-recapture areas and other ABC-covered areas in the city.

In addition to ABC programs, habitat modification (decreasing the amount of food available in the habitat) should help maintain the population at the new reduced levels brought about by ABC programs (Beran and Frith, 1988). However, the most important determinant of dog population size is the attitude of humans (Matter and Daniels, 2000). Due to cultural tolerance, it is unlikely that stray dogs will ever be completely eliminated from India.

4.3. Gender and age ratios

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 estimate. 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

The Marwar Animal Protection Trust (http://www.marwartrust.org) funded this study with assistance from the World Society for the Protection of Animals (WSPA), and Humane Society International. Sarah Totton received stipend support through an Ontario Veterinary College Ph.D. Fellowship and a University Graduate Scholarship. We thank Gobind Ram, and Chandra Kant Mishra for technical support. We thank Anne Valliant, Dr. Zvonimir Poljak, and William Sears for statistical support. We thank Federico Spinola, Kim Doyle, Bishan Shukla, Rajan Jaisinghani, Drs. Subhash Kachhawaha, Mahesh Kumar, Leela Ram, Kalpana Shukla, and Baldev Singh, Dr. Pukhraj Rathore, Dr. Mahendra Singh Rathore, Dr. Suresh Chandra Maheshwari, Lex Hiby, Dr. Kate Blaszak, Dr. Elly Hiby (WSPA), Dr. Michelle Morters, Dr. François Meslin (World Health Organization), Andrew Rowan and Kelly O'Meara (Humane Society International), Dr. David Waltner-Toews, and Dr. James Valcour. Dr. Penelope Vounatsou is acknowledged for statistical review.

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

Beran, G.W., 1991. Urban rabies. In: Baer, G.M. (Ed.), The Natural History of Rabies, second edition. CRC Press, Boca Raton, Florida, pp. 427–443.

Beran, G.W., Frith, M., 1988. Domestic animal rabies control: an overview. Rev. Infect. Dis. 10, S672–S677.

Bogel, K., Hoyte, J.A., 1990. Guidelines for Dog Population Management. World Health Organization and World Society for the Protection of Animals, Geneva.

Caughley, G., 1977. Analysis of Vertebrate Populations. John Wiley & Sons, London.

Coleman, P.G., Dye, C., 1996. Immunization coverage required to prevent outbreaks of dog rabies. Vaccine 14, 185–186.

Daniels, T.J., 1983. The social organization of free-ranging urban dogs. I. Non-estrus social behavior. Appl. Anim. Ethol. 10, 341–363.

Daniels, T.J., Bekoff, M., 1989. Population and social biology of free-ranging dogs, *Canis familiaris*. J. Mammal. 70, 754–762.

Ghosh, B., Choudhuri, D.K., Pal, B., 1984. Some aspects of the sexual behaviour of stray dogs, *Canis familiaris*. Appl. Anim. Behav. Sci. 13, 113–127.

Keeling, M., Rohani, P., 2007. Modeling Infectious Diseases in Animals and Humans. Princeton University Press, Princeton.

Leney, J., Remfry, J., 2000. Dog population management. In: Macpherson, C.N.L., Meslin, F.X., Wandeler, A.I. (Eds.), Dogs, Zoonoses and Public Health. CABI Publishing, New York, pp. 299–331.

Matter, H.C., Daniels, T.J., 2000. Dog ecology and population biology. In: Macpherson, C.N.L., Meslin, F.X., Wandeler, A.I. (Eds.), Dogs, Zoonoses and Public Health. CABI Publishing, New York, pp. 17–62.

Pal, S.K., 2001. Population ecology of free-ranging urban dogs in West Bengal, India. Acta Theriol. 46, 69–78.

Reece, J.F., Chawla, S.K., 2006. Control of rabies in Jaipur, India, by the sterilisation and vaccination of neighbourhood dogs. Vet. Rec. 159, 379–383.

Reece, J.F., Chawla, S.K., Hiby, E.F., Hiby, L.A., 2008. Fecundity and longevity of free-roaming dogs in Jaipur, India. BMC Vet. Res. 4, 6.

Roy, K.B., 1962. Problem of stray dogs in India. Indian J. Public Health 6, 141–142.

Schumacher, F.X., Eschmeyer, R.W., 1942. The estimate of fish population in lakes or ponds. J. Tenn. Acad. Sci. 17/18, 228–249.

Sudarshan, M.K., Madhusudana, S.N., Mahendra, B.J., Rao, N.S.N., Ashwath Nurayana, D.H., Abdul Raman, S., Meslin, F.X., Lobo, D., Ravikumar, K., Gangaboraiah, 2007. Assessing the burden of human rabies in India: results of a national multi-center epidemiological survey. Int. J. Infect. Dis. 11, 29–35.

Totton, S.C., Wandeler, A.I., Gartley, C.J., Kachhawaha, S., Suman, M., Ribble, C.S., Rosatte, R.C., McEwen, S.A., 2010. Assessing reproductive patterns and disorders in free-ranging dogs in Jodhpur, India to optimize a population control program. Theriogenology doi:10.1016/j.theriogenology.2010.05.008.

World Health Organization, 2004. Expert Consultation on Rabies (first report), WHO Technical Report Series 931. WHO, Geneva.

Downloaded from veterinaryrecord.bmj.com on December 31, 2013 - Published by group.bmj.com

附錄III
Appendix III

Paper

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 2006) 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 (2003) 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 reproductively 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.

Veterinary Record (2013) doi: 10.1136/vr.101079

J. F. Reece, BSc, BVSc, MRCVS, Help in Suffering, Maharani Farm, Durgapura, Jaipur, Rajasthan 302018, India
S. K. Chawla, BVSc & AH, Humane Society International, Giriraj Nagar, ISKCON Road, Opp. Vijay Path, Mansarovar, Jaipur, Rajasthan, India
A. R. Hiby, BSc, Dip Stat, Conservation Research Ltd., 110, Hinton Way, Great Shelford, Cambridge, Cambridgeshire CB22 5AL, UK;
E-mail for correspondence: jack@his-india.in

Provenance: Not commissioned; externally peer reviewed

Accepted February 15, 2013

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.

Downloaded from veterinaryrecord.bmj.com on December 31, 2013 - Published by group.bmj.com

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 km^2. The Pink City area surveyed is 7.8 km^2. 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.

Fig 5 shows the proportion of females that were found to be spayed during the Pink City index of abundance surveys, which started in 1997. Sterilising of female dogs started a year earlier in other areas of the city. It shows that ABC intervention can quickly result in a large reduction in the percentage of females capable of raising a litter.

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 (Sriaroon 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

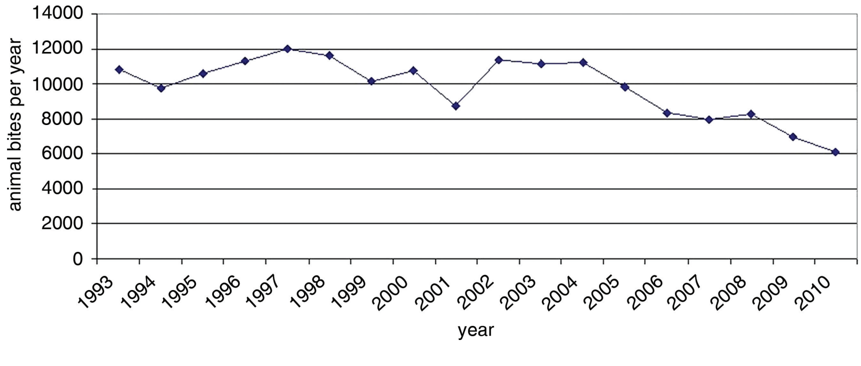

FIG 1: Human animal-bite cases treated at the Bite Unit of the SMS Hospital, Jaipur 1993 to 2010. Data from 1993 to 2002 from Sharma and others (2002)

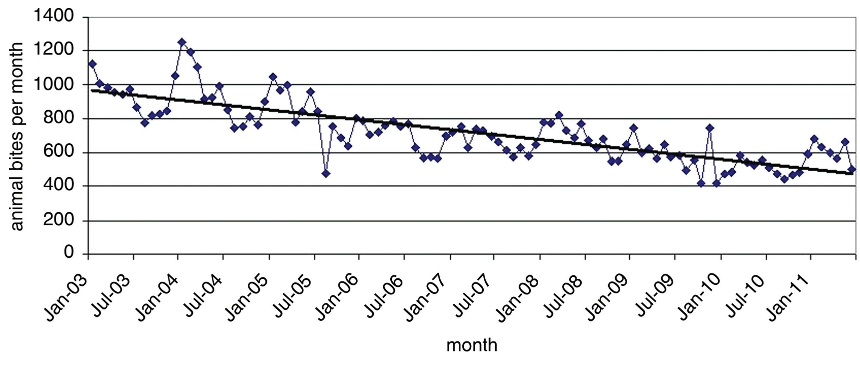

FIG 2: Number of animal bites per month treated at the Bite Unit of the SMS Hospital from January 2003 to June 2011

Downloaded from veterinaryrecord.bmj.com on December 31, 2013 - Published by group.bmj.com

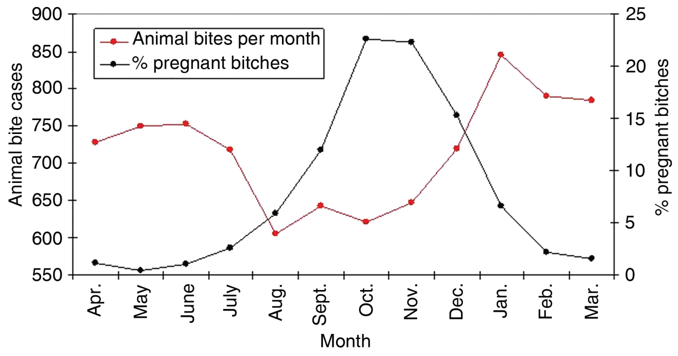

FIG 3: Monthly averages of human animal bites and canine pregnancies in Jaipur over the years 2003–2011

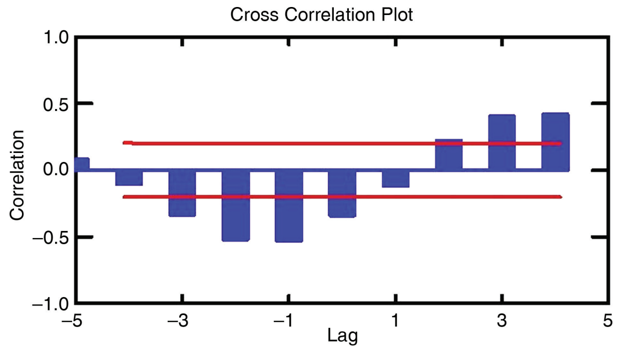

FIG 4: Cross-correlation between the percentage of females pregnant when sterilised in each month from January 2003 to June 2011, and the residuals from a least squares linear regression of the number of animal bites in each month over the same period. The plot shows a significant positive correlation between pregnancy and bite frequency three to four months later

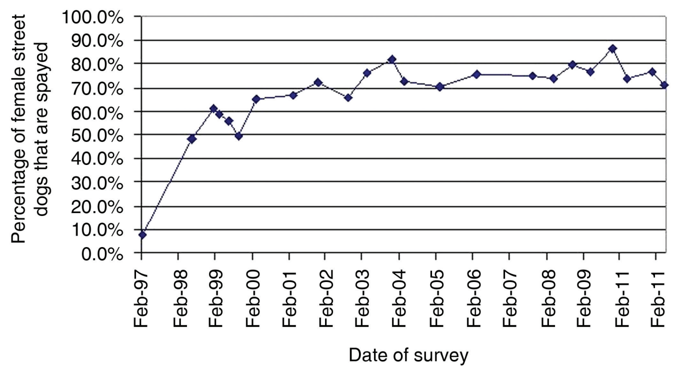

FIG 5: Proportion of female roaming dogs found to be spayed during index of abundance surveys in the Pink City area of Jaipur

be explained by increased outdoor activity, since January is a most inclement month in Jaipur with very low night temperatures, a rapid fall of temperature in late afternoon, mist and occasional rain. All these factors, combined with the fact there are no major school holidays, suggest the January peak cannot be explained by the increased outdoor activity of children.

The breeding of street dogs in Jaipur was found to be markedly seasonal. This finding is in agreement with earlier published findings from this city (Chawla and Reece 2002) and Jodhpur (Totton and others 2010). The mean whelping date for street dogs of Jaipur is 23 November (Reece and others 2008). The larger peak seen in human animal-bite cases in Jaipur is in January. This is about 10 weeks after the peak whelping date of street dogs in that city. Unpublished observations on the early family life of 17 street dog litters in Jaipur over two breeding seasons found that dispersal of pups from the dam occurred between 90 and 120 days after whelping (HIS unpublished data). The peak in animal-bite cases occurs when many bitches will be nursing litters of puppies of an age that are most attractive and most visible to children, yet still firmly bonded to their dam. 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. Ichhpujani and others (2008) report that 64.3 per cent of 1357 human animal-bite cases studied as part of a multicentric study in India were unprovoked bites by stray dogs. However, given the large number of young children involved in these cases, whether an attack by a dog was unprovoked or not, must be open to some doubt since it is the bitch's perception of an interaction that is important rather than the child's intention.

If the peaks seen in street dog reproduction and human animal-bite cases are related as suggested above, it should follow that reducing the number of bitches raising young in an area should reduce the number of animal-bite cases in that area. The proportion of fertile (unspayed) bitches in the city has dropped from 100 per cent before 1997 to between 20 and 30 per cent in 2010.

Synchrony between the major peak in bite frequency and the number of puppies on the street does not prove that dog bites are primarily the result of bitches trying to protect their puppies, but further evidence is provided by the pattern of bite frequencies over time.

Fig 2 shows a significant decline in bite frequency since 2003, whereas prior to 2003, Fig 1 shows an increase up to 1997, the year after the start of the ABC intervention, followed by fluctuating levels up to 2003 and the subsequent reduction. It is highly likely that at the start of the intervention the roaming dog population was increasing in line with the growth of the human population and the expansion of the city. Whereas sterilisation could not have led to an immediate halt in the growth of the dog population, the rapid increase in the percentage of spayed females, as illustrated by Fig 5, could have prevented further increase in bite frequency if dog bites are indeed primarily due to bitches trying to protect their puppies.

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.

Acknowledgements

JR is supported by grants from Humane Society International and by HIS (UK). The ABC programme at HIS is supported by the Animal Welfare Board of India and Animaux Secours. The authors thank these groups and the many colleagues and supporters who help the ABC work of Help in Suffering.

Funding Humane Society International.

References

ANON (2004) WHO Technical Report Series 931 WHO Expert Consultation on Rabies. Geneva, Switzerland: WHO

CHAWLA, S. C. & REECE, J. F. (2002) Timing of oestrus and reproductive behaviour in Indian street dogs. *Veterinary Record* **150**, 450–451

CLEAVELAND, S., KAARE, M., TIRINGA, P., MLENGEYA, T. & BARRAT, J. (2003) A dog rabies vaccination campaign in rural Africa: impact on the incidence of dog rabies and human dog-bite injuries. *Vaccine* **21**, 1965–1973

DWYER, J. P., DOUGLAS, T. S., VAN AS, A. B. (2007) Dog bite injuries in children- a review of data from a South African paediatric trauma unit. *South African Medical Journal* **97**, 597–600

HOSSAIN, M., BULBUL, T., AHMED, K., AHMED, Z., SALIMUZZAMAN, M., HAQUE, M.S., ALI, A., HOSSAIN, S., YAMADA, K., MOJI, K. & NISHIZONO, A. (2011) Five-year (January 2004-December 2008) surveillance on animal-bite and rabies vaccine utilization in the Infectious Disease Hospital, Dhaka, Bangladesh. *Vaccine* **29**, 1036–40

ICHHPUJANI, R. L., MALA, C., VEENA, M., SINGH, J., BHARDWAJ, M., BHATTACHARYA, D., PATTANAIK, S. K., BALAKRISHNAN, N., REDDY, A. K., SAMNPATH, G., GANDHI, N., NAGAR, S. S. & SHIV, L. J. (2008) Epidemiology of animal-bites and rabies cases in India; a multicentric study. *Journal of Communicable Diseases* **40**, 27–36

OVERALL, K. L. (2001) Dog bites to humans-demography, epidemiology, injury and risk. *Journal of the American Veterinary Medical Association* **218**, 1923–1934

Downloaded from veterinaryrecord.bmj.com on December 31, 2013 - Published by group.bmj.com

OZANNE-SMITH, J., ASHNY, K. & STATHAKIS, V. Z. (2001) Dog bite injury prevention- analysis, clinical review and research agenda. *Injury Prevention* 7, 321–326
PRATAP, A. K., BEHERA, T. R., SATAPATHY, D. M., SETHI, S. & TRIPATHY, R. M. (2011) Seasonal trend of animal-bite cases at ARC of MKCG Medical College Berhampur, Orissa. *Journal of the Association for the Prevention and Control of Rabies in India* 13, 24–29
REECE, J. F. & CHAWLA, S. K. (2006) Control of reproduction and rabies in Jaipur, India by the sterilisation and vaccination of neighbourhood dogs. *Veterinary Record* 159, 379–383
REECE, J. F., CHAWLA, S. K., HIBY, E. F. & HIBY, R. F. (2008) Fecundity and longevity of free-roaming dogs in Jaipur, India. *BMC Veterinary Research* 4, 6. http://www.biomedcentral.com/1746–6148/4/6
REECE, J. F., NIMESH, M. K., WYLIE, R. E., JONES, A. K. & DENNISON, A. W. (2012) Description and evaluation of a right flank mini-laparotomy approach to canine ovariohysterectomy. *Veterinary Record* 171, 248
SHARMA, N., VINOD KUMAR, S. V. & CHAWLA, M. (2002) Profile of animal-bite cases in ARC, SMS Hospital, Jaipur. Apricon Souvenir, July 6& 7 2002, Jaipur, India Association for the Prevention and Control of Rabies in India
SHETTY, R. A., CHATURVEDI, S. & SINGH, Z. (2005) Profile of animal-bite cases in Pune. *Journal of Communicable Diseases* 37, 66–72
SRIAROON, C., SRIAROON, P., DAVIRATANASILPA, S., KHAWPLOD, P. & WILDE, H. (2006) Retrospective: animal attacks and rabies exposures in Thai children. *Travel Medicine Infectious Diseases* 4, 270–4.
SUDARSHAN, M. K., MADHUSUDANA, S. N., MAHENDRA, B. J., RAO, N. S., ASHWATH NARAYANA, D. H., ABDUL RAHMAN, S., MESLIN, F.-X., LOBO, D., RAVIKUMAR, K. & GANGABORAIAH (2007) Assessing the burden of human rabies in India: results of a national multi-center epidemiological survey. *International Journal of Infectious Diseases* 11, 29–35
SUDARSHAN, M. K., MAHENDRA, B. J., MADHUSUDANA, S. N., ASHWOATH NARAYANA, D. H., RAHMAN, A., RAO, N. S., MESLIN, F.-X., LOBO, D., RAVIKUMAR, K. & GANGABORAIAH (2006) An epidemiological study of animal-bites in India: results of a WHO sponsored national multi-centric rabies survey. *Journal of Communicable Diseases* 38, 32–9
TOTTON, S. C., WANDELER, A. I., GARTLEY, C. J., KACHHAWAHA, S., SUMAN, M., RIBBLE, C. S., ROSATTE, R. C. & MCEWEN, S. C. (2010) Assessing reproductive patterns and disorders in free-ranging dogs in Jodhpur, India to optimize a population control program. *Theriogenology* 74, 1115–1120

Downloaded from veterinaryrecord.bmj.com on December 31, 2013 - Published by group.bmj.com

Veterinary Record

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

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

Veterinary Record 2013 172: 473 originally published online March 14, 2013
doi: 10.1136/vr.101079

Updated information and services can be found at:
http://veterinaryrecord.bmj.com/content/172/18/473.full.html

These include:

References This article cites 16 articles, 4 of which can be accessed free at:
http://veterinaryrecord.bmj.com/content/172/18/473.full.html#ref-list-1

Email alerting service Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/