EVALUATION OF RABIES AWARENESS AND THE POPULATION DYNAMICS OF FREE-ROAMING AND OWNED DOGS IN HERAT CITY, AFGHANISTAN

By

ZABIHULLAH NASIRY

Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for Master of Veterinary Science

July 2022

FPV 2022 25

COPYRIGHT

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Master of Veterinary Science

EVALUATION OF RABIES AWARENESS AND THE POPULATION DYNAMICS OF FREE-ROAMING AND OWNED DOGS IN HERAT CITY, AFGHANISTAN

By

ZABIHULLAH NASIRY

July 2022

Chairperson : Mazlina binti Mazlan, PhD
Faculty : Veterinary Medicine

The existent uncontrolled dog population in Herat city has a negatively influenced public health leading to socioeconomic, and animal welfare problems. The objectives of the study were to characterize demographics and estimate the population size of both owned and free-roaming dogs, to assess dog bites cases, and knowledge, attitude, and practices of the community towards rabies and to estimate the post-exposure treatment costs associated with dog bites in Herat city, Afghanistan. These aims were achieved by a Door to door household questionnaire survey, Random-digit dial telephone questionnaire survey and Photographic sight-re-sight method. A total of 928 Free-roaming dogs (FRD) were identified through 3172 sightings, and total of free-roaming population were estimated 1821 (95% Confidence Interval (CI): 1565-2077), which led to an estimate of 10 dogs/km^2 with the human: free-roaming dog ratio of 315:1. The male to female ratio was 2.85:1. Majority of them were healthy and had ideal body condition score. Approximately 24.6% of the households owned one or more dogs. The total owned dogs were estimated to be 20,642 (95% CI= 22,764 – 18,630) dogs with density of 113 dogs/km^2. The owned dog: human ratio was 1: 27.79 (0.035 dog per person). The male to female ratio of owned dog was 5.1:1. Almost 76.7% of households kept dogs confined and only 19% of dogs were vaccinated against rabies. Approximately 4,845 dog bite cases had been referred to health centres of Herat city from December 22, 2019 to March 20, 2021, and seven fatality cases due to rabies have been recorded. Out of 581 dog bite victims interviewed, majority of them (90.8%) were bitten by free-roaming dogs. This study revealed that the extremities were the most (90.3%) inflicted parts. Most dog bite victims were predominantly male and children. More than half (58%) of bite victims took measures to treat the bite wound before seeking health centre and 88.8% of them were visited health centres immediately. Majority of dog bite victims (92.3%) received rabies Post-exposure prophylaxis (PEP) and 67% completed the PEP course. Besides that, the majority of the respondents (83.5%) had previously heard about rabies, 77.5% believed that rabies is a dangerous and lethal disease and more than half (61.6%) of also believed that rabies is a preventable disease. There was high level (97.3%) of awareness that dog bite is the main cause of rabies. The total direct medical and indirect costs due

to dog bites were estimated to be 9.658992 million Afghani (120,737 USD) and 2.88 million Afghani (36044 USD) per year respectively. The total societal costs (direct medical costs plus indirect costs) were estimated to be 12.538992 million Afghani (156,781 USD) per year. Although the dog density is considered low, the dog bites rate and economic costs are considerable, so it still warrants caution since a proportion of the population is not well-versed about dogs and their importance of them in the transmission of zoonotic diseases like rabies. The information generated by this research can help to identify considerations for the design and implementation of dogs and rabies control programs.

Keywords: dog population dynamics, demography, dog bites, rabies, Herat city.

Abstrak tesis yang dikemukakan kepada Senat of Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains Veterinar

PENILAIAN KESEDARAN RABIES DAN DINAMIK POPULASI ANJING BERKELIARAN BEBAS DAN ANJIN PELIHARAAN DI BANDAR HERAT, AFGHANISTAN

Oleh

ZABIHULLAH NASIRY

Julai 2022

Pengerusi : Mazlina binti Mazlan, PhD
Faculti : Perubatan Veterinar

Kewujudan populasi anjing yang tidak terkawal di bandar Herat memberi kesan negatif kepada kesihatan awam dan membawa kepada masalah sosioekonomi, politik, dan kebajikan haiwan. Objektif kajian ini adalah untuk mencirikan demografi dan membuat anggaran saiz populasi anjing bertuan dan anjing yang bebas berkeliaran, untuk menaksir kes gigitan anjing dan pengetahuan, sikap dan amalan komuniti terhadap rabies serta untuk mendapatkan anggaran kos rawatan pasca-pendedahan akibat gigitan anjing di bandar Herat, Afghanistan. Matlamat ini dicapai melalui tinjauan soal selidik dari pintu ke pintu, soal selidik dail digit telefon secara rawak dan kaedah pandang-semula fotografi di bandar Herat, Afghanistan. Sebanyak 928 ekor anjing yang bebas berkeliaran (FRD) telah dikenalpasti melalui 3172 tinjauan, dan sebanyak 1821 (95% interval keyakinan (CI): 1565-2077) populasi yang berkeliaran-bebas telah dianggarkan yang membawa kepada nisbah anggaran 10 anjing/km^2 dengan nisbah manusia:anjing yang berkeliaran-bebas iaitu 315:1. Nisbah anjing jantan kepada betina adalah sebanyak 2.85:1. Majoriti anjing tersebut didapati sihat dan mempunyai skor keadaan badan yang unggul. Kira-kira 24.6% daripada isi rumah memiliki satu atau lebih anjing. Jumlah anjing yang bertuan dianggarkan sebanyak 20,642 (95% CI= 22,764 – 18,630) ekor anjing dengan kepadatan 113 anjing/km^2. Nisbah anjing yang bertuan kepada manusia adalah 1:27.79 (0.035 anjing setiap satu orang). Nisbah anjing yang bertuan dalam kalangan anjing jantan kepada betina adalah 5.1:1. Hampir 76.7% isi rumah memelihara anjing dalam kurungan dan hanya 19% anjing telah diberi vaksin rabies. Kira-kira 4,845 kes gigitan anjing telah dirujuk ke pusat kesihatan bandar Herat daripada Disember 22, 2019 hingga Mac 20, 2021, dan tujuh kes merekodkan kematian disebabkan rabies. Daripada 581 mangsa gigitan anjing yang telah diwawancara, majoriti daripada mereka (90.8%) telah digigit oleh anjing-anjing yang berkeliaran-bebas. Kajian ini menunjukkan bahawa bahagian hujung kaki dan tangan (90.3%) adalah bahagian yang sering digigit. Majoriti mangsa gigitan anjing terdiri daripada lelaki dan kanak-kanak. Lebih daripada separuh (58%) mangsa gigitan anjing telah mengambil langkah-langkah yang sepatutnya untuk merawat luka gigitan sebelum mendapatkan rawatan di pusat kesihatan dan 88.8% daripada mereka telah hadir ke pusat kesihatan dengan segera. Majoriti mangsa gigitan

anjing (92.3%) telah menerima profilaksis pasca-pendedahan rabies (PEP) dan 67% daripada mereka telah melengkapkan siri rawatan PEP. Selain itu, majoriti responden (83.5%) pernah mendengar mengenai rabies, 77.5% percaya bahawa rabies adalah penyakit berbahaya serta membawa maut dan lebih daripada separuh (61.6%) juga percaya bahawa rabies adalah penyakit yang boleh dicegah. Terdapat tahap kesedaran yang tinggi (97.3%) bahawa gigitan anjing merupakan faktor utama rabies. Jumlah kos perubatan langsung dan tidak langsung akibat gigtan anjing dianggarkan masing-masing sebanyak 9.658992 million Afghani (120,737 USD) dan 2.88 million Afghani (36044 USD) setahun. Jumlah kos kemasyarakatan (kos perubatan langsung dengan kos tak langsung) pula dianggarkan sebanyak 12.538992 million Afghani (156,781 USD) setahun. Walaupun kepadatan anjing didapati rendah, kadar gigitan anjing dan kos ekonomi adalah agak besar, maka langkah berjaga-jaga perlu dilaksanakan memandangkan sebahagian daripada populasi tidak begitu memahami perihal anjing dan kepentingan anjing dalam penularan penyakit zoonotik seperti rabies.

Kata kunci: dinamik populasi anjing, demografi, gigitan anjing, rabies, bandar Herat

ACKNOWLEDGEMENTS

First and foremost, I would like to extend my deepest gratitude to my Supervisor Dr. Mazlina Mazlan for her constant guidance, encouragement, timely feedback and understanding throughout my graduate program. My sincere appreciation goes to my supervisory committee members, Professor Dr. Noordin Mohamed Mustapha, and Professor Dato' Dr. Mohd Azmi Mohd Lila for the extensive personal and professional guidance and they taught me a great deal about scientific research. I extend my sincere thanks to all academic members of the Faculty of Veterinary Medicine, Universiti Putra Malaysia, and all those who contributed directly or indirectly to the research. I sincerely thank academic authorities of Universiti Putra Malaysia who gave me this opportunity to improve my knowledge and experiences. I am extremely thankful and indebted to academic members of Faculty of Veterinary Science, Herat University, Afghanistan for their sharing experiences, sincere and valuable guidance and encouragement. Also I want to thank all my friends for their encouragement. Finally, I would like to thank all members of my family, especially my dear wife for her patience, encouragement, support, and love during this time.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree Master of Veterinary Science. The members of the Supervisory Committee were as follows:

Mazlina binti Mazlan, PhD
Senior Lecturer
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Chairman)

Noordin Mohamed Mustapha, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Mohd Azmi bin Mohd Lila, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 April 2023

Declaration by Members of the Supervisory Committee

This is to certify that:

- The research conducted and the writing of the thesis was under our supervision
- Supervision of responsibilities as slated in Rule 41 in Rule 2003 (Revision 2012-2013) were adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Dr. Mazlina binti Mazlan

Signature: _____
Name of Member of Supervisory Committee: Professor Dr. Noordin Mohamed Mustapha

Signature: _____
Name of Member of Supervisory Committee: Professor Dr. Mohd Azmi bin Mohd Lila

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CI	Confidence Interval
CNS	Central Nervous System
DALYs	Disability-adjusted life years
DBV/s	Dog Bite Victim/s
DFA	Direct fluorescent Antibody
DNA	Deoxyribonucleic Acid
DPM	Dog Population Management
ERIG	Equine Rabies Immunoglobulin
FAO	Food and Agriculture Organization
FRD	Free-roaming dog/s
GIS	Geographic Information System
GPS	Global positioning System
HRIG	Human Rabies Immunoglobulin
HU	Herat University
ICAM	International Companion Animal Management Coalition
Km^2	Kilometre Square
MIT	Mouse Inoculation Test
OIE	World Organization for Animal Health
PCR	Polymerase Chain Reaction
PEP	Post-Exposure Prophylaxis
PET	post-exposure treatment
PSR	Photographic Sight re-sight
RIG	Rabies Immunoglobulin

RNA	Ribonucleic Acid
TT	tetanus toxoids
USD	United States Dollar
WHO	World Health Organization
WSPA	World Society for Protection of Animal

CHAPTER 1

INTRODUCTION

1.1 Background

The long known ubiquitously distributed and phenotypically diversified domestic dog (*Canine Lupus familiaris*) is one of our closest companions in the animal kingdom (Acosta-Jamett et al., 2010; Galibert et al., 2011; Larson et al., 2012; Wang et al., 2015). Following this historical relationship, humans have transformed domesticated dogs as pets, companions, security dogs, draught animals or for other economic advantages (Stafford, 2006).

Owing to their behavioural, and cognitive abilities, dogs serve a wide range of roles in society, including tracking down criminals, search and rescue work, herding, companionship, sporting activities and illegal goods trafficking (Stafford, 2006; Wang et al., 2015). Despite being considered unclean by Afghans; many people still keep dogs for some of the roles mentioned above.

Nevertheless, with an estimate of almost 500 million being strays globally (Hughes & Macdonald, 2013; Kisiel et al., 2016; Wallace et al., 2017; Smith et al., 2019). their potential health risks associated with aggression and bites, allergies and zoonotic diseases should never be underestimated (Westgarth et al., 2013; Sparkes et al., 2014; Hambolu et al., 2014; Hiby & Hiby, 2017).

The management of stray dogs are mostly difficult (often involves capture, treatment, neutering and release), and still considered a significant problem in developing and developed countries (Sparkes et al., 2014), considering the potential threat of being reservoirs and vectors of diseases of more than 100 zoonoses (Chomel, 2014; Özen et al., 2016; Kisiel et al., 2016). More than 100 zoonotic diseases are recognized to be transmitted from dogs and cats to humans). Likewise, other negative effects include environmental contamination, traffic accident, cynophobia, noise pollution, and spreading garbage (Tiwari et al., 2019).

Apart from rabies, 29 million cases of dog bites were reported annually in humans (Ma et al., 2020), leading to serious medical consequences such as trauma (Cleaveland et al., 2006; Hambolu et al., 2014) and wound infection (Hossain et al., 2013; Ghaffari-Fam et al., 2016). Approximately 96.5% of the financial losses amounting to 1.7 billion USD (Ma et al., 2020) inflicted by rabies treatment occurred in low and middle-income countries (Ghaffari-Fam et al., 2016; Ma et al., 2020). In the absence of a known dog population, accurate data and an effective rabies control program, dog bites are a serious public health problem in Afghanistan (Wallace et al., 2002). However, it is estimated that daily around 3-10 dog bite cases are referred to health centers of each province of Afghanistan. In Herat province, a total of 4845 dog bites cases were referred to health

centers from December 22, 2019 to March 20, 2021 and majority of the victims were unable to receive proper treatment due to poverty (CDC department of Herat province, 2021).

This ancient deadly disease has risked more than 3.3 billion people globally (Gill et al., 2019) with the world poorest regions being at high risk (Hampson et al., 2015). Domestic dogs especially those free-roaming are responsible for 99% of human cases and deaths with an estimated yearly statistics of 59,000 people globally (Sambo et al., 2018; Gill et al., 2019; Cleaton et al., 2019). Almost all mammalian species are susceptiable to rabies where it has encroached living-stock yielding an estimated loss of 12.3 billion USD in Africa and Asia (Gill et al., 2019). At the same time, the annual number of anti-rabies treatments in humans is estimated to be around 6.5 million worldwide resulting a significant healthcare costs (Bouaddi et al., 2018).

Dog-mediated rabies is responsible for around 35,172 human deaths (59.6% of rabies global deaths) each year in Asia and most (71%) of these deaths occurred in south Asia countries (Ward, 2012).

Harbouring 34 endemic rabies province with hundreds of death annually (Wallace et al., 2002; Tenzin and M. P. Ward, 2012), signifies beyond doubt that Afghanistan is one of the many developing Asian countries still struggling with rabies. The likely root problems of the ongoing rabies endemicity in Afghanistan is attributed to inaccurate epidemiological information and absence of specific rabies prevention and control measures (Tenzin and M. P. Ward, 2012).

As the previously explained, the negative effects of free-roaming dogs can be off-set if population size, demographic structures and dynamics of dogs are known to allow an effective management and control of rabies (Cleaton et al., 2019; Ntampaka et al., 2019) in addition to vaccination (Amaku et al., 2010; Otolorin *et al*., 2014; Özen et al., 2016; Wongphruksasoong et al., 2016, Ntampaka et al., 2019). Because an understanding of dog ecology has been recognised as a key factor in designing and implement of an effective rabies control program in rabies endemic countries where dogs are the main transmitter of rabies (Pimburage et al., 2017). Sadly, the size of dog population in the most rabies-endemic area is generally unknown (Sambo et al., 2018).

Nowadays a wide variety of effective methods of enumeration are applicable, from simple counts and surveys to sophisticated models (Cleaton et al., 2019; Meunier et al., 2019). But notwithstanding all the current methodological advances, the WHO and World Organization for Animal Health (OIE) suggested just four methods to be used in the estimation of the abundance of free-roaming dogs including total or indirect counts, regression method, estimates of capture-recapture method and Beck (photographic capture) method. However, methods for estimating and evaluating free-roaming dogs are described in the WHO and World Society for Protection of Animal (WSPA) Guidelines for Dog Population Management (1990), the WSPA guidelines for surveying roaming dog population (2009), the OIE Terrestrial Animal Health Code (2010) and FAO Report on Dog Population Management (2014).

1.2 Problem Statement

The lack of epidemiological data on the canine population and dog-bite-related rabies coupled with ineffective control measures, canine rabies remains to be endemic in Herat province. Thus, in view of the lack of data and realizing importance of dog population demography and dynamics in prevention and control of rabies, forms the basis of the current study with the following objectives:

- to evaluate demographic structure and estimate the population size of Free-roaming dogs in Herat city, Afghanistan
- to evaluate demographic structure and estimate the population size of owned dogs in Herat city, Afghanistan
- to evaluate the knowledge, attitudes and practices of community towards rabies in Herat city, Afghanistan
- to assess dog bite cases and estimate the post-exposure treatment cost associated with dog bites in Herat city, Afghanistan.

REFERENCES

Abat, A. S., & Guadu, T. (2015). Challenges of Rabies. *International Journal of Basic and Applied Virology*, *4*(2), 41–52.

Acharya, K. P., Acharya, N., Phuyal, S., Upadhyaya, M., & Lasee, S. (2020). One-health approach : A best possible way to control rabies. *One Health*, *10*(August), 100161.

Acosta-Jamett, G., Cleaveland, S., Cunningham, A. A., & Bronsvoort, B. M. d. C. (2010). Demography of domestic dogs in rural and urban areas of the Coquimbo region of Chile and implications for disease transmission. *Preventive Veterinary Medicine*, *94*(3–4), 272–281.

Ahmad, T., Musa, T. H., & Jin, H. (2018). Rabies in Asian Countries : Where we are stand ? *Biomedical Research and Therapy*, *5*(10), 2719–2720.

Ahmed, T., Hussain, S., Zia, U., Rinchen, S., Yasir, A., Ahmed, S., Khan, W. A., Tahir, M. F., & Ricketson, R. (2020). Knowledge , attitude and practice (KAP) survey of canine rabies in Khyber Pakhtunkhwa and Punjab Province of Pakistan. *BMC Public Health*, *10*(20), 1–12.

Aiyedun, J. O., & Olugasa, B. O. (2012). Identification and analysis of dog use , management practices and implications for rabies control in Ilorin , Nigeria. *Sokoto Journal of Veterinary Sciences*, *10*(October), 1–6.

Aiyedun, J., & Olugasa, B. (2012). Use of aerial photograph to enhance dog population census in Ilorin, Nigeria. *Sokoto Journal of Veterinary Sciences*, *10*(1), 22–27.

Alam, A. N., Siddiqua, M., & Casal, J. (2020). Knowledge and attitudes about rabies in dog-bite victims in Bangladesh. *One Health*, *9*(October 2019), 100126.

Amaku, M., Dias, R. A., & Ferreira, F. (2010). Dynamics and control of stray dog populations. *Mathematical Population Studies*, *17*(2), 69–78.

Ameh, V. O., Dzikwi, A. A., & Umoh, J. U. (2014). Assessment of Knowledge , Attitude and Practice of Dog Owners to Canine Rabies in Wukari Metropolis , Taraba State Nigeria. *Global Journal of Health Science*, *6*(5), 226–240.

Amparo, A. C. B., Jayme, S. I., Roces, M. C. R., Quizon, M. C. L., Villalon, E. E. S., Quiambao, B. P., Baquilod, M. S., Hernandez, L. M., Taylor, L. H., & Nel, L. H. (2018). The evaluation of operating Animal Bite Treatment Centers in the Philippines from a health provider perspective. *PLoS ONE*, *13*(7), 1–25.

Arief, R. A., Hampson, K., Jatikusumah, A., Widyastuti, M. D. W., Sunandar, Basri, C., Putra, A. A. G., Willyanto, I., Estoepangestie, A. T. S., Mardiana, I. W., Kesuma, I. K. G. N., Sumantra, I. P., Doherty, P. F., Salman, M. D., Gilbert, J., & Unger, F. (2017). Determinants of vaccination coverage and consequences for rabies control in Bali, Indonesia. *Frontiers in Veterinary Science*, *3*(JAN), 1–8.

Atuman, Y. J., Ogunkoya, A. B., Adawa, D. A. Y., Nok, A. J., & Biallah, M. B. (2014). Dog ecology, dog bites and rabies vaccination rates in Bauchi State, Nigeria. *International Journal of Veterinary Science and Medicine*, *2*(1), 41–45.

Augusto, R., Gil, A., Guilloux, A., Riegert, M., Cristina, M., Guarnieri, D. L., Prist, R., Ferreira, F., Amaku, M., Soares, J., Neto, F., & Stevenson, M. (2013). Size and spatial distribution of stray dog population in the University of São Paulo campus , Brazil. *Preventive Veterinary Medicine*, *110*(2), 263–273.

Awuni, B., Tarkang, E., Manu, E., Amu, H., Ayanore, M. A., Aku, F. Y., Ziema, S. A., Bosoka, S. A., Adjuik, M., & Kweku, M. (2019). Dog Owners ' Knowledge about Rabies and Other Factors That Influence Canine Anti-Rabies Vaccination in the Upper East Region of Ghana. *Tropical Medicine and Infectious Disease*, *4*(115), 1–13.

Bailey, J. L. B., Gamble, L., Gibson, A. D., Barend, M., Handel, I. G., Mellanby, R. J., & Mazeri, S. (2018). A rabies lesson improves rabies knowledge amongst primary school children in Zomba , Malawi. *PLoS Neglected Tropical Diseases*, *12*(3), 1–16.

Barrios, C. L., Bustos-l, C., Pavletic, C., Parra, A., Vidal, M., Bowen, J., & Fatj, J. (2021). Epidemiology of Dog Bite Incidents in Chile : Factors Related to the Patterns of Human-Dog Relationship. *Animals*, *11*(96), 1–25.

Baneth, G., Thamsborg, S. M., Otranto, D., Guillot, J., Blaga, R., Deplazes, P., & Solano-Gallego, L. (2016). Major Parasitic Zoonoses Associated with Dogs and Cats in Europe. Journal of Comparative Pathology, 155(1), S54–S74.

Belo, V. S., Struchiner, C. J., Werneck, G. L., Teixeira Neto, R. G., Tonelli, G. B., De Carvalho, C. G., Ribeiro, R. A. N., & Da Silva, E. S. (2017). Abundance, survival, recruitment and effectiveness of sterilization of free-roaming dogs: A capture and recapture study in Brazil. *PLoS ONE*, *12*(11), 1–19.

Belo, V. S., Werneck, G. L., Da Silva, E. S., Barbosa, D. S., & Struchiner, C. J. (2015). Population estimation methods for free-ranging dogs: A systematic review. *PLoS ONE*, *10*(12), 1–15.

Beran, G. W., & Frith, M. (1988). Domestic Animal Rabies Control : An Overview. *REVIEWS OF INFECTIOUS DISEASES*, *10*(December), 672–677.

Beyene, T. J., Mourits, M. C. M., Kidane, A. H., & Hogeveen, H. (2018). Estimating the burden of rabies in Ethiopia by tracing dog bite victims. *Plos One*, *13*(2), 1–18.

Bilinski, A. M., Fitzpatrick, M. C., Rupprecht, C. E., Paltiel, A. D., & Galvani, A. P. (2016). Optimal frequency of rabies vaccination campaigns in Sub-Saharan Africa. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1842), 1–9.

Bouaddi, K., Bitar, A., Ferssiwi, A., Bouslikhane, M., Fitani, A., Mshelbwala, P. P., & Audu, S. W. (2018). Socioecology of the canine population in the Province of El Jadida, Morocco. *Veterinary Medicine International*, *2018*.

Brown, S. K., Pedersen, N. C., Jafarishorijeh, S., Bannasch, D. L., Ahrens, K. D., Wu, J. Te, Okon, M., & Sacks, B. N. (2011). Phylogenetic distinctiveness of Middle Eastern and Southeast Asian village dog Y chromosomes illuminates dog origins. *PLoS ONE*, *6*(12).

Brunker, kirstyn & Mollentze Nardus. (2018). Rabies virus. Trends in Microbiology. 26 (10), 886-887.

Burgos-cáceres, S. (2011). Canine Rabies: A Looming Threat to Public Health. *Animals*, *4*(1), 326–342.

Butler, J.R.A; du Toit, Johan T and Bingham, J. (2004). Free-ranging domestic dogs (Canis familiaris) as predators and prey in rural Zimbabwe : Threats of competition and disease to large wild carnivores Free-ranging domestic dogs (Canis familiaris) as predators and prey in rural Zimbabwe : threats of comp. *Biological Conservation*, *115*(3), 360–378.

Beyene, T. J., Mourits, M. C. M., Kidane, A. H., & Hogeveen, H. (2018). Estimating the burden of rabies in Ethiopia by tracing dog bite victims. *Plos One*, *13*(2), 1–18.

Chomel, B. B. (2014). Emerging and Re-Emerging Zoonoses of Dogs and Cats. *Animals*, *4*, 434–445.

Cinquepalmi, V., Monno, R., Fumarola, L., & Ventrella, G. (2013). Environmental Contamination by Dog ' s Faeces : A Public Health Problem ? *International Journal of Environmental Research and Public Health*, *10*(1), 72–84.

Cleaton, J. M., Blanton, J. D., Dilius, P., Ludder, F., Crowdis, K., Medley, A., Chipman, R., Estime, F., Maciel, E., & Wallace, R. M. (2019). Use of photography to identify free-roaming dogs during sight-resight surveys: Impacts on estimates of population size and vaccination coverage, Haiti 2016. *Vaccine: X*, *2*, 100025.

Cleaveland, S., Kaare, M., Knobel, D., & Laurenson, M. K. (2006). Canine vaccination-Providing broader benefits for disease control. *Veterinary Microbiology*, *117*(1), 43–50.

Cleaveland, S., Mlengeya, T., Kaare, M., Haydon, D. A. N., Lembo, T., Laurenson, M. K., & Packer, C. (2007). The Conservation Relevance of Epidemiological Research into Carnivore Viral Diseases in the Serengeti. *Conservation Biology*, *21*(3), 612–622.

Conan, A., Akerele, O., Simpson, G., Reininghaus, B., van Rooyen, J., & Knobel, D. (2015). Population Dynamics of Owned, Free-Roaming Dogs: Implications for Rabies Control. *PLoS Neglected Tropical Diseases*, *9*(11).

Consales, Cleide and Bolzan, V. (2007). RABIES REVIEW: IMMUNOPATHOLOGY, CLINICAL ASPECTS AND TREATMENT. *Enomous Animals and Toxins Including Tropical Diseases*, *13*(1), 5–38.

Cornelissen, J. M. R., & Hopster, H. (2009). Dog bites in The Netherlands : A study of victims , injuries , circumstances and aggressors to support evaluation of breed specific legislation Dog bites in The Netherlands : A study of victims , injuries , circumstances and aggressors to support evaluation of breed specific legislation. *The Veterinary Journal*, *186*(3), 292–298.

Corrieri, L., Adda, M., Miklósi, Á., & Kubinyi, E. (2018). Companion and free-ranging Bali dogs: Environmental links with personality traits in an endemic dog population of South East Asia. *PLoS ONE*, *13*(6), 1–12.

Cortez-Aguirre, G. R., Jiménez-Coello, M., Gutiérrez-Blanco, E., & Ortega-Pacheco, A. (2018a). Stray Dog Population in a City of Southern Mexico and Its Impact on the Contamination of Public Areas. *Veterinary Medicine International*, *2018*(10), 6.

Cortez-Aguirre, G. R., Jiménez-Coello, M., Gutiérrez-Blanco, E., & Ortega-Pacheco, A. (2018b). Stray Dog Population in a City of Southern Mexico and Its Impact on the Contamination of Public Areas. *Veterinary Medicine International*, *2018*.

Costa, G. B., Gilbert, A., Monroe, B., Blanton, J., Ngam, S., Recuenco, S., & Wallace, R. (2018). The influence of poverty and rabies knowledge on healthcare seeking behaviors and dog ownership , Cameroon. *PLoS ONE*, *13*(6), 1–19.

CVMA. (2011). Canada's pet wellness report: A snapshot of Canada's pet health and wellness from the Canadian Veterinary Medical Association (CVMA), in partnership with Hill's Science Diet.

Deviatkin, A. A., Lukashev, A. N., Poleshchuk, E. M., Dedkov, V. G., Tkachev, S. E., Sidorov, G. N., Karganova, G. G., Galkina, I. V., Shchelkanov, M. Y., & Shipulin, G. A. (2017). The phylodynamics of the rabies virus in the Russian Federation. *PLoS ONE*, *12*(2), 1–12.

Dhand, N. K., Gyeltshen, T., Firestone, S., Zangmo, C., & Dema, C. (2011). Dog Bites in Humans and Estimating Human Rabies Mortality in Rabies Endemic Areas of Bhutan. *PLOS Neglected Tropical Diseases*, *5*(11), 30–32.

Dhand, N. K., Rai, B. D., Tenzin, S., Tsheten, K., Singye, K., Ward, M. P., Livestock, R., Centre, D., & Health, I. (2012). Community-based study on knowledge , attitudes and perception of rabies in Gelephu , South − C entral Bhutan. *International Health*, *4*(3), 210–219.

Digafe, R. T., Kifelew, L. G., & Mechesso, A. F. (2015). Knowledge, attitudes and practices towards rabies: Questionnaire survey in rural household heads of Gondar Zuria District, Ethiopia. *BMC Research Notes*, *8*(1), 1–7.

do Vale B, Lopes AP, Fontes MdC, Silvestre M, Cardoso L, C. A. (2021). A Cross-Sectional Study of Knowledge on Ownership, Zoonoses and Practices among Pet Owners in Northern Portugal. *Animals*, *11*(12), 3543.

Downes, M. J., Dean, R. S., Stavisky, J. H., Adams, V. J., Grindlay, D. J. C., & Brennan, M. L. (2013). Methods used to estimate the size of the owned cat and dog population: A systematic review. *BMC Veterinary Research*, *9*(1), 1.

Drake, A. G., Coquerelle, M., Kosintsev, P. A., Bachura, O. P., Sablin, M., Gusev, A. V., Fleming, L. S., & Losey, R. J. (2017). Three-Dimensional Geometric Morphometric Analysis of Fossil Canid Mandibles and Skulls. *Scientific Reports*, *7*(1), 1–8.

FAO. (2014). Dog Population Management *FAO/WSPA/IZSAM Expert meeting*. Banna, Italy, 14 -19 March 2011: Food and Agriculture Organization of the United Nations, Rome

Fei, S. Y., Chiang, J. T., Fei, C. Y., Chou, C. H., & Tung, M. C. (2012). Estimating stray dog populations with the regression method versus Beck's method: A comparison. *Environmental and Ecological Statistics*, *19*(4), 485–498.

Fisher, C. R., Streicker, D. G., Schnell, M. J., & Health, A. (2019). The spread and evolution of rabies virus: conquering new frontiers. *Nat Rev Microbiol*, *16*(4), 241–255.

Fooks, A. R., Banyard, A. C., Horton, D. L., Johnson, N., McElhinney, L. M., & Jackson, A. C. (2014). Current status of rabies and prospects for elimination. *The Lancet*, *384*(9951), 1389–1399.

Freedman, A. H., Gronau, I., Schweizer, R. M., Vecchyo, D. O., Han, E., Silva, P. M., Galaverni, M., Fan, Z., Marx, P., Lorente-galdos, B., Beale, H., Kusak, J., Boyko, A. R., Parker, H. G., Lee, C., Tadigotla, V., Siepel, A., Bustamante, C. D., Harkins, T. T., … Novembre, J. (2014). Genome Sequencing Highlights the Dynamic Early History of Dogs. *PLoS Genetics*, *10*(1).

Galibert, F., Quignon, P., Hitte, C., & Andre, C. (2011). Comptes Rendus Biologies Toward understanding dog evolutionary and domestication history Histoire de la domestication du chien. *Comptes Rendus Biologies*, *334*, 190–196.

Gamble, L., Gibson, A. D., Shervell, K., Lohr, F., & Otter, I. (2018). The problem of stray dogs. *Revue Scientifique et Technique de l'OIE*, *37*(2), 543–550.

Garde, E., Acosta-jamett, G., & Bronsvoort, B. M. (2013). Review of the Risks of Some Canine Zoonoses from Free-Roaming Dogs in the Post-Disaster Setting of Latin America. Animals : An Open Access Journal from MDPI, 3(3), 855–865.

Gebeyaw, S., & Teshome, D. (2019). Study on Community Knowledge , Attitude and Practice of Rabies in and Around Dessie City. *Austin Journal of Veterinary Science & Animal Husbandry*, *3*(1), 1–4.

Ghaffari-Fam, S., Hosseini, S. R., Daemi, A., Heydari, H., Malekzade, R., Ayubi, E., & Nikbakht, H. A. (2016). Epidemiological patterns of animal bites in the Babol County, North of Iran. *Journal of Acute Disease*, *5*(2), 126–130.

Ghasemzadeh, I., & Namazi, S. H. (2015). Review of bacterial and viral zoonotic infections transmitted by dogs. *Journal of Medicine and Life*, *8*(Spec Iss 4), 1–5.

Ghosh, S., Chowdhury, S., Haider, N., Bhowmik, R. K., Rana, S., Marma, A. S. P., Hossain, M. B., Debnath, N. C., & Ahmed, B. (2016). Original Article Awareness of rabies and response to dog bites in a Bangladesh community. *Veterinary Medicine and Science*, *3*(30), 161–169.

Gibson, A. D., Mazeri, S., Lohr, F., Mayer, D., Burdon, J. L., Wallace, R. M., Handel, I. G., Shervell, K., Bronsvoort, B. M., Mellanby, R. J., & Gamble, L. (2018). One million dog vaccinations recorded on mHealth innovation used to direct teams in numerous rabies control campaigns. *PLoS ONE*, 1–19.

Gill, G. S., Singh, B. B., Dhand, N. K., Aulakh, R. S., Sandhu, B. S., Ward, M. P., & Brookes, V. J. (2019). Estimation of the incidence of animal rabies in Punjab, India. *Plos One*, *14*(9), e0222198.

Greene, C. E., Schultz, R. D., & Ford, R. B. (2001). Canine vaccination. *Veterinary Clinics of North America - Small Animal Practice*, *31*(3), 473–492.

Grijalva Rosero, Colon Jaime. 2014. Estimating The Population of Free-Roaming and Owned Dogs and the Gastrointestinal Parasite Burden in Owned Dogs in the Capital City of Quito, Ecuador: A Baseline Study for Future Animal Health and Welfare Interventions, Master of Thesis, University of Florida.

Gsell, A. S., Knobel, D. L., Kazwala, R. R., Vounatsou, P., & Zinsstag, J. (2012). Domestic dog demographic structure and dynamics relevant to rabies control planning in urban areas in Africa: The case of Iringa, Tanzania. *BMC Veterinary Research*, *8*(1), 1.

Hambolu, S. E., Dzikwi, A. A., Kwaga, J. K. P., Kazeem, H. M., Umoh, J. U., & Hambolu, D. A. (2014). Dog ecology and population studies in Lagos State, Nigeria. *Global Journal of Health Science*, *6*(2), 209–220.

Hambolu, S. E. mmanue., Dzikwi, A. A., Kwaga, J. K. P., Kazeem, H. M., Umoh, J. U., & Hambolu, D. A. (2014). Rabies and dog bites cases in lagos state Nigeria: a prevalence and retrospective studies (2006-2011). *Global Journal of Health Science*, *6*(1), 107–114.

Hampson, K., Coudeville, L., Lembo, T., Sambo, M., Kieffer, A., Attlan, M., Barrat, J., Blanton, J. D., Briggs, D. J., Cleaveland, S., Costa, P., Freuling, C. M., Hiby, E., Knopf, L., Leanes, F., Meslin, F., Metlin, A., Miranda, M. E., Müller, T., … Zinsstag, J. (2015). Estimating the Global Burden of Endemic Canine Rabies. *PLOS Neglected Tropical Diseases*, *9*(4), 1–20.

Hiby, E., Agustina, K. K., Atema, K. N., Bagus, G. N., Girardi, J., Harfoot, M., Haryono, Y., Hiby, L., Irawan, H., Kalalo, L., Purnama, S. G., Subrata, I. M., Swacita, I. B. N., Utami, N. W. A., Januraga, P. P., & Wirawan, D. N. (2018). Dog ecology and rabies knowledge of owners and non-owners in Sanur, a sub-district of the Indonesian Island province of Bali. *Animals*, *8*(7).

Hiby, E., & Hiby, L. (2017). Direct observation of dog density and composition during street counts as a resource efficient method of measuring variation in roaming dog populations over time and between locations. *Animals*, *7*(8), 1–13.

Hiby, L. R., Reece, J. F., Wright, R., Jaisinghani, R., Singh, B., & Hiby, E. F. (2011). A mark-resight survey method to estimate the roaming dog population in three cities in Rajasthan, India. *BMC Veterinary Research*, *7*(August).

Hossain, M., Ahmed, K., Marma, A. S. P., Hossain, S., Ali, M. A., Shamsuzzaman, A. K. M., & Nishizono, A. (2013). A survey of the dog population in rural Bangladesh. *Preventive Veterinary Medicine*, *111*(1–2), 134–138.

Hotez, P. J., Bottazzi, M. E., Strych, U., Chang, L. Y., Lim, Y. A. L., Goodenow, M. M., & AbuBakar, S. (2015). Neglected Tropical Diseases among the Association of Southeast Asian Nations (ASEAN): Overview and Update. *PLoS Neglected Tropical Diseases*, *9*(4), 1–15.

Hsu, Y., Severinghaus, L. L., & Serpell, J. A. (2003). Dog keeping in Taiwan: Its contribution to the problem of free-roaming dogs. *Journal of Applied Animal Welfare Science*, *6*(1), 1–23.

Hughes, J., & Macdonald, D. W. (2013). A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation*, *157*, 341–351.

Hudson, E. G., Brookes, V. J., Dürr, S., & Ward, M. P. (2019). Modelling targeted rabies vaccination strategies for a domestic dog population with heterogeneous roaming patterns. *PLOS Neglected Tropical Diseases*, *13*(7), e0007582.

Id, A. I. A., Tijani, A. A., Bamidele, F. O., Muftau, O., Ibrahim, A., Abdulrahim, I., Osu, M. S., Kia, G., Patrick, N., & Endie, W. N. (2021). Awareness and knowledge of canine rabies : A state-wide cross-sectional study in Nigeria. *PLOSONE*, *16*(3), 1–11.

ICAMC. (2007). Humane Dog Population Management Guidance (pp. 24): International Companion Animal Management Coalition.

ICAMC. (2015). Humane Dog Population Management Guidance (pp.17): International Companion Animal Management Coalition.

Irion, D. N., Schaffer, A. L., Grant, S., Wilton, A. N., & Pedersen, N. C. (2005). Genetic variation analysis of the Bali street dog using microsatellites. *BMC Genetics*, *6*(12), 1–13.

Jackson, A. C. (2003). Rabies virus infection: An update. *Journal Of Neurovirology*, *9*(2), 253-258.

Jeon, S., Cleaton, Julie Meltzer, M. I., Kahn, E. B., Pieracci, E. G., Blanton, J. D., & Wallace, R. (2019). Determining the post-elimination level of vaccination needed to prevent re-establishment of dog rabies. *PLoS Neglected Tropical Diseases*, *13*(e0007869), 1–16.

Johnson, N., Phillpotts, R., & Fooks, A. R. (2006). Airborne transmission of lyssaviruses. *Journal of Medical Microbiology*, *55*(1099), 785–790.

Joo, Y. S., Lee, J. H., Lee, K. K., Bang, H. A., & Lee, W. C. (2011). Retrospective study of extensive vaccination programs for canine rabies control and public health in Korea. *Japanese Journal of Infectious Diseases*, *64*(6), 513–515.

Kassiri, H., Kassiri, A., Lotfi, M., Shahkarami, B., & Hosseini, S. (2014). Animal bite incidence in the County of Shush , Iran. *Journal of Acute Disease*, *3*(1), 26–30.

Kato, Masahiko, Yamamoto, H. (2003). *Survey of the Stray Dog Population and the Health Education Program on the Prevention of Dog Bites and Dog-Acquired Infections:A Comparative Study in Nepal and Okayama Prefecture, Japan* (pp. 271–266). Acta medica Okayama.

Kato, M., Inukai, Y., Yamamoto, H., & Kira, S. (2003). *Acta Medica Okayama Survey of the stray dog population and the health education program on the prevention of dog bites and dog-acquired infections : a comparative study in Nepal and Okayama dog bites and dog-acquired infections : a comparative study in Ne*. *57*(5).

Kaufmann, S. H. E., Today, I., Ferguson, T. A., Yagita, H., Mazzaccaro, R. J., Flynn, J., Savolainen, P., Amorim, I. R., Rice, J. E., Honeycutt, R. L., Crandall, K. A., Lundeberg, J., & Wayne, R. K. (1997). Multiple and Ancient Origins of the Domestic Dog Carles Vila. *Sicience*, *276*(June), 1687–1690.

Kazadi, E. K., Tshilenge, G. M., Mbao, V., Njoumemi, Z., & Masumu, J. (2017). Determinants of dog owner-charged rabies vaccination in Kinshasa, Democratic Republic of Congo. *PLoS ONE*, *12*(10), 1–9.

Keatts, L. O., Robards, M., Olson, S. H., Hueffer, K., Insley, S. J., Joly, D. O., Kutz, S., Lee, D. S., Chetkiewicz, C. B., Lair, S., Preston, N. D., & Pruvot, M. (2021). Implications of Zoonoses From Hunting and Use of Wildlife in North American Arctic and Boreal Biomes : Pandemic Potential , Monitoring , and Mitigation. *Frontiers in Public Health*, *9*(May), 1–27.

Kisiel, L. M., Jones-Bitton, A., Sargeant, J. M., Coe, J. B., Flockhart, D. T. T., Reynoso Palomar, A., Canales Vargas, E. J., & Greer, A. L. (2016). Owned dog ecology and demography in Villa de Tezontepec, Hidalgo, Mexico. *Preventive Veterinary Medicine*, *135*, 37–46.

Kitala, P., McDermott, J., Kyule, M., Gathuma, J., Perry, B., & Wandeler, A. (2001). Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya. *Acta Tropica*, *78*(3), 217–230.

Knobel, D. L., Cleaveland, S., Coleman, P. G., Fèvre, E. M., Meltzer, M. I., Miranda, M. E. G., Shaw, A., Zinsstag, J., & Meslin, F. (2005). Re-evaluating the burden of rabies in Africa and Asia. *Bulletin of the World Health Organization*, *83*(8).

Krauss, H., Weber, A., & Appel, M. (2003). Zoonoses: infectious diseases transmissible from animals to humans (p. 456). B. Enders, H. D. Isenberg, H. G. Schiefer, W. Slenczka, A. Von Graevenitz, & H. Zahner (Eds.). Washington, DC: ASM press.

Kumar, H., Id, T., Robertson, I. D., Dea, M. O., & Vanak, A. T. (2019). Knowledge , attitudes and practices (KAP) towards rabies and free roaming dogs (FRD) in Panchkula district of north India : A cross- sectional study of urban residents. *PLOS Neglected Tropical Diseases* |, *13*(4), 1–17.

Kwaghe, A. V., Okomah, D., Okoli, I., Kachalla, M. G., Aligana, M., Alabi, O., & Mshelbwala, G. M.. (2019). Estimation of dog population in Nasarawa state Nigeria: a pilot study. *Pan African Medical Journal*, *34*(25), 1–12.

Laager, M., Mbilo, C., Madaye, E. A., Naminou, A., Léchenne, M., Tschopp, A., Naïssengar, S. K., Smieszek, T., Zinsstag, J., & Chitnis, N. (2018). The importance of dog population contact network structures in rabies transmission. *PLoS Neglected Tropical Diseases*, *12*(8), 1–18.

Larson, G., Karlsson, E. K., Perri, A., Webster, M. T., Ho, S. Y. W., Peters, J., Stahl, P. W., Piper, P. J., Lingaas, F., Fredholm, M., Comstock, K. E., Modiano, J. F., Schelling, C., Agoulnik, A. I., Leegwater, P. A., Dobney, K., Vigne, J. D., Vilà, C., Andersson, L., & Lindblad-Toh, K. (2012). Rethinking dog domestication by integrating genetics, archeology, and biogeography. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(23), 8878–8883.

Leung, A. K. C., Davies, H. D., & Hon, K. L. E. (2007). Rabies: Epidemiology, pathogenesis, and prophylaxis. In *Advances in Therapy* (Vol. 24, Issue 6, pp. 1340–1347).

Lunney, M., Fevre, S., Ly, S., & Vong, S. (2012). Knowledge , attitudes and practices of rabies prevention and dog bite injuries in urban and pen-urban provinces in Cambodia , 2009. *Royal Society of Tropical Medicine and Hygiene.*, *10*(4), 4–9.

Lyu, P. (2015). Proposal on Solutions to Stray Dog Problem in American Cities. *Journal of Political Sciences & Public Affairs*, *03*(03), 1–3.

Ma, X., Blanton, J. D., Millien, M. F., Medley, A. M., Etheart, M. D., Fénelon, N., & Wallace, R. M. (2020). Quantifying the risk of rabies in biting dogs in Haiti. *Scientific Reports*, *10*(1062), 1–10.

Mahadevan, A., Suja, M. S., Mani, R. S., & Shankar, S. K. (2016). Perspectives in Diagnosis and Treatment of Rabies Viral Encephalitis: Insights from Pathogenesis. *Neurotherapeutics*, *13*(3), 477–492.

McKay, N., & Wallis, L. (2005). Rabies: A review of UK management. *Emergency Medicine Journal*, *22*(5), 316–321.

Meunier, N. V., Gibson, A. D., Corfmat, J., Mazeri, S., Handel, I. G., Gamble, L., Bronsvoort, B. M. C., & Mellanby, R. J. (2019). A comparison of population

estimation techniques for individually unidentifiable free-roaming dogs. *BMC Veterinary Research*, *15*(1), 190.

Mohammad, S., Zaidi, A., Labrique, A. B., Khowaja, S., Lotia-farrukh, I., & Irani, J. (2013). Geographic Variation in Access to Dog-Bite Care in Pakistan and Risk of Dog-Bite Exposure in Karachi : Prospective Surveillance Using a Low-Cost Mobile Phone System. *PLOS Neglected Tropical Diseases*, *7*(12), 1–13.

Morey, D. F., & Jeger, R. (2015). Paleolithic dogs: Why sustained domestication then? *Journal of Archaeological Science: Reports*, *3*, 420–428.

Morters, M. K., Restif, O., Hampson, K., Cleaveland, S., Wood, J. L. N., & Conlan, A. J. K. (2013). Evidence-based control of canine rabies: A critical review of population density reduction. *Journal of Animal Ecology*, *82*(1), 6–14.

Mustiana, A., Toribio, J. A., Abdurrahman, M., Suadnya, I. W., Hernandez-Jover, M., Putra, A. A. G., & Ward, M. P. (2015). Owned and unowned dog population estimation, dog management and dog bites to inform rabies prevention and response on Lombok Island, Indonesia. *PLoS ONE*, *10*(5), 1–15.

Ntampaka, P., Nyaga, P. N., Niragire, F., Gathumbi, J. K., & Tukei, M. (2019). Knowledge, attitudes and practices regarding rabies and its control among dog owners in Kigali city, Rwanda. *Plos One*, *14*(8), e0210044.

OIE. (2008). Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Paris, France: World Organization for Animal Health (OIE).

OIE. (2013). Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Paris, France: World Organization for Animal Health (OIE).

OIE. (2018). Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Paris, France: World Organization for Animal Health (OIE).

Otolorin, G. R., Umoh, J. U., & Dzikwi, A. A. (2014). Demographic and Ecological Survey of Dog Population in Aba, Abia State, Nigeria. *ISRN Veterinary Science*, *2014*, 1–5.

Otranto, D., Dantas-Torres, F., Mihalca, A. D., Traub, R. J., Lappin, M., & Baneth, G. (2017). Zoonotic Parasites of Sheltered and Stray Dogs in the Era of the Global Economic and Political Crisis. *Trends in Parasitology*, *33*(10), 813–825.

Ovodov, N. D., Crockford, S. J., Kuzmin, Y. V., Higham, T. F. G., Hodgins, G. W. L., & van der Plicht, J. (2011). A 33,000-Year-Old incipient dog from the Altai Mountains of Siberia: Evidence of the earliest domestication disrupted by the last Glacial Maximum. *PLoS ONE*, *6*(7), 4–10.

Özen, D., Böhning, D., & Gürcan, I. S. (2016). Estimation of stray dog and cat populations in metropolitan Ankara, Turkey. *Turkish Journal of Veterinary and Animal Sciences*, *40*(1), 7–12.

Park, N., Hu, C., Yu, P., Kang, C., Ling, H., & Yen, S. (2019). Demography and welfare status of free-roaming dogs in Yangmingshan. *Preventive Veterinary Medicine*, *166*(March), 49–55.

Penjor, K., Tenzin, T., & Jamtsho, R. K. (2019). Determinants of health seeking behavior of animal bite victims in rabies endemic South Bhutan : a community-based contact-tracing survey. *BMC Public Health*, *19*(237), 1–11.

PFMA. (2014). Pet Population. Retrieved from http://www.pfma.org.uk/pet-population-2014

Pimburage, R. M. S., Harischandra, P. A. L., Gunatilake, M., Jayasinhe, D. N., Balasuriya, A., & Amunugama, R. M. S. K. (2017). Erratum to 'a cross-sectional survey on dog ecology and dog anti-rabies vaccination coverage in selected areas in Sri Lanka' [S.L.Vet.J. 2017, 64:1(A): 1-9]. *Sri Lanka Veterinary Journal*, *64*(2), 17.

Premaalatha, B., Chandrawathani, P., Jamnah, O., Zaini, C. M., Mariappan, C., Ramlan, M., Losheni, S., & Banumathy, G. (2018). A Survey Of Parasite Pathogens in Stray Dogs From Pudu Pasar and Chow Kit Area of Kuala Lumpur. *Malaysian Journal Of Veterinary Research*, *9*(2), 130–135.

Pulczer, A. S., Jones-Bitton, A., Waltner-Toews, D., & Dewey, C. E. (2013). Owned dog demography in Todos Santos Cuchumatán, Guatemala. *Preventive Veterinary Medicine*, *108*(2–3), 209–217.

Punjabi, G. A., Athreya, V., & Linnell, J. D. C. (2012). Using natural marks to estimate free-ranging dog canis familiaris abundance in a MARK-RESIGHT framework in suburban Mumbai, India. *Tropical Conservation Science*, *5*(4), 510–520.

Ratsitorahina, M., Rasambainarivo, J. H., Raharimanana, S., Rakotonandrasana, H., Andriamiarisoa, M. P., Rakalomanana, F. A., & Richard, V. (2009). Dog ecology and demography in Antananarivo, 2007. *BMC Veterinary Research*, *5*, 1–7.

Rattanavipapong, W., Thavorncharoensap, M., Youngkong, S., Genuino, A. J., Anothaisintawee, T., Chaikledkaew, U., & Meeyai, A. (2018). The impact of transmission dynamics of rabies control: Systematic review. *Vaccine*, *37*, A154–A165.

Rinzin, K., Tenzin, T., & Robertson, I. (2016). Size and demography pattern of the domestic dog population in Bhutan: Implications for dog population management and disease control. *Preventive Veterinary Medicine*, 1–9.

Rothe, K., Tsokos, M., & Handrick, W. (2015). Animal and Human Bite Wounds. *Deutsches Arzteblatt International*, *112*(25), 433–443.

Rowan, A., & Kartal, T. (2018). Dog population & dog sheltering trends in the United States of America. *Animals*, *8*(5), 1–20.

Sambo, M., Hampson, K., Changalucha, J., Cleaveland, S., Lembo, T., Lushasi, K., Mbunda, E., Mtema, Z., Sikana, L., & Johnson, P. C. D. (2018). Estimating the size of dog populations in Tanzania to inform rabies control. *Veterinary Sciences*, *5*(3).

Sambo, M., Johnson, P. C. D., Hotopp, K., Changalucha, J., Cleaveland, S., Kazwala, R., Lembo, T., Lugelo, A., Lushasi, K., Maziku, M., Mbunda, E., Mtema, Z., Sikana, L., Townsend, S. E., & Hampson, K. (2017). Comparing methods of assessing dog rabies vaccination coverage in rural and urban communities in Tanzania. *Frontiers in Veterinary Science*, *4*(MAR).

Savolainen, P. (2007). Domestication of dogs. In P. Jensen (Ed.), *The Behaviour Biology of Dogs* Cromwell Press.

Shah, A. M., Leghari, A., Sciences, A., Mirbahar, K. H., & Sciences, A. (2016). A Review of Rabies Disease, its Transmission and Treatment. *Animal Health and Production*, *4*(4), 140–144.

Sharma, S., Agarwal, A., Am, K., & Gk, I. (2016). Prevalence of Dog Bites in Rural and Urban Slums of Delhi : A Community ‐ based Study. *Annals of Medical and Health Sciences Research*, *6*(2), 115–119.

Shwiff, S. A., Hatch, B., Id, A. A., Kotze, J., Slootmaker, C., Conan, A., Knobel, D., & Nel, L. H. (2019). A bioeconomic model for the optimization of local canine rabies control. *PLOS Neglected Tropical Diseases*, *13*(5), 1–24.

Silva, J. E., Rodrigues, T. de O., Silva, A. J. A. e, Queiroz, L. H., De Oliveira Rodrigues, T., Silva e Alves, A. J., & Queiroz, L. H. (2019). Evaluating the movement of free-roaming dogs using georeferencing and the photographic capture-recapture method. *Acta Veterinaria Brasilica*, *13*(2), 70–76.

Singh, R., Singh, K. P., Cherian, S., Saminathan, M., Reddy, G. B. M., Panda, S., & Dhama, K. (2017). *Rabies – epidemiology , pathogenesis , public health concerns and advances in diagnosis and control : a comprehensive review*. *2176*.

Smith, L., Munteanu, A., Quinnell, R. J., & Collins, L. M. (2019). The Effectiveness of Dog Population Management : A Systematic Review The Effectiveness of Dog Population Management : A Systematic Review. *Animals*, *9*, 10–20.

Soler-rangel, S., Rosselli, D., Jiménez-restrepo, N., & Nariño, D. (2020). Rabies encephalitis and extra-neural manifestations in a patient bitten by a domestic cat. *The SAO Paulo Instiutute of Tropiccal Medicine*, *5*(June 2019), 1–5.

Sparkes, J., Körtner, G., Ballard, G., Fleming, P. J. S., & Brown, W. Y. (2014). Effects of sex and reproductive state on interactions between free-roaming domestic dogs. *PLoS ONE*, *9*(12), 1–13. https://doi.org/10.1371/journal.pone.0116053

Stafford, K. (Ed.). (2006). *The Domestication, Behaviour and Use of Dogs*. Dordrecht: Springer

Tang, X., Luo, M., Zhang, S., Fooks, A. R., Hu, R., & Tu, C. (2005). Pivotal role of dogs in rabies transmission, China. *Emerging Infectious Diseases*, *11*(12), 1970–1972.

Taylor, L. H., Wallace, R. M., Balaram, D., Lindenmayer, J. M., Eckery, D. C., Mutonono-Watkiss, B., Parravani, E., & Nel, L. H. (2017). The role of dog population management in rabies elimination-A review of current approaches and future opportunities. *Frontiers in Veterinary Science*, *4*(109), 1–15.

Tenzin, T., Ahmed, R., Debnath, N. C., Ahmed, G., & Yamage, M. (2015). Free-Roaming Dog Population Estimation and Status of the Dog Population Management and Rabies Control Program in Dhaka City , Bangladesh. *PLoS Neglected Tropical Diseases*, *5*(tropical diseases), 1–14.

Tenzin and M. P. Ward. (2012). Review of Rabies Epidemiology and Control in South , South East and East Asia : Past , Present and Prospects for Elimination Review of Rabies Epidemiology and Control in South , South East and East Asia : Past , Present and Prospects for Elimination. Zoonoses and Public Health, 5(December 2012), 451–467.

Thalmann, O., Shapiro, B., Cui, P., Schuenemann, V. J., Sawyer, S. K., Greenfiled, D. L., Germonpr, M. B., Sablin, M. V., López-Giráldez, F., Domingo-Roura, X., Napierala, H., Uerpmann, H.-P., Loponte, L. M., Acosta, A. A., Giemsch, L., Schmitz, R. W., Worthington, B., Buikstra, J. E., Druzhkova, A., Graphodatsky, A. S., Ovodov, N. D., Wahlberg, N., Freedman, A. H., Schweizer, R. M., Koepfli, K.-P., Leonard, J. A., Meyer, M., Krause, J., Pääbo, S., Green, R. E., & Wayne, R. K. (2013). Complete Mitochondrial Genomes of ancient canids suggest a European origin of domestic dogs. *Science*, *342*(November), 871–874.

Tian, H., Feng, Y., Vrancken, B., Cazelles, B., Tan, H., Gill, M. S., Yang, Q., Li, Y., Yang, W., Zhang, Y., Zhang, Y., Lemey, P., Pybus, O. G., Stenseth, N. C., Zhang, H., & Dellicour, S. (2018). Transmission dynamics of re-emerging rabies in domestic dogs of rural China. *PLoS Pathogens*, *14*(12), 1–18.

Tiwari, H. K., Robertson, I. D., O'Dea, M., & Vanak, A. T. (2019). Demographic characteristics of free-roaming dogs (FRD) in rural and urban India following a photographic sight-resight survey. *Scientific Reports*, *9*(1), 16562.

Totton, S. C., Wandeler, A. I., Zinsstag, J., Bauch, C. T., Ribble, C. S., Rosatte, R. C., & McEwen, S. A. (2010). Stray dog population demographics in Jodhpur, India following a population control/rabies vaccination program. *Preventive Veterinary Medicine*, *97*(1), 51–57.

Tschopp, R., Bekele, S., & Aseffa, A. (2016). Dog Demography , Animal Bite Management and Rabies Knowledge-Attitude and Practices in the Awash Basin , Eastern Ethiopia. *PLOS Neglected Tropical Diseases*, *10*(2), 1–14.

Undurraga, E. A., Meltzer, M. I., Atkins, C., & Vargas-pino, F. (2021). Cost-effectiveness of the national dog rabies prevention and control program in Mexico ,. *PLOS Neglected Tropical Diseases*, *15*(Mxn 2015), 1–17.

Verginelli, F., Capelli, C., Coia, V., Musiani, M., Falchetti, M., Ottini, L., Palmirotta, R., Tagliacozzo, A., Mazzorin, I. D. G., & Mariani-costantini, R. (2005). Mitochondrial DNA from Prehistoric Canids Highlights Relationships Between Dogs and South-East European Wolves. *Molecular Biology and Evolution*, *22*(12), 2541–2551.

Venters, B. J., Pugh, B. F., Kireeva, M. L., Komissarova, N., Waugh, D. S., Kashlev, M., Krebs, S., Graf, A., Feuillet, J. A., Soeding, J., & Sawicka, A. (2016). Genomic and archaeological evidence suggests a dual origin of domestic dogs. Science, 352(6290), 1228–1231.

Wallace, R. M., Undurraga, E. A., Blanton, J. D., Cleaton, J., & Franka, R. (2017). Elimination of dog-mediated human rabies deaths by 2030: Needs assessment and alternatives for progress based on dog vaccination. *Frontiers in Veterinary Science*, *4*(FEB), 1–14.

Wang, G., Zhai, W., Yang, H., Wang, L., Zhong, L., Liu, Y., Fan, R., Yin, T., Zhu, C., Poyarkov, A. D., Irwin, D. M., Hytönen, M. K., & Lohi, H. (2015). Out of southern East Asia : the natural history of domestic dogs across the world. *Nature Publishing Group*, *26*(1), 21–33.

Ward, M. P. (2012). Review of Rabies Epidemiology and Control in South , South East and East Asia : Past , Present and Prospects for Elimination Review of Rabies Epidemiology and Control in South , South East and East Asia : Past , Present and Prospects for Elimination. Zoonoses and Public Health, 5(December 2012), 451–467.

Wera, E., Velthuis, A. G. J., Geong, M., & Hogeveen, H. (2013). Costs of Rabies Control : An Economic Calculation Method Applied to Flores Island. *PLoS ONE*, *8*(12), 1–15.

Westgarth, C., Boddy, L. M., Stratton, G., German, A. J., Gaskell, R. M., Coyne, K. P., Bundred, P., McCune, S., & Dawson, S. (2013). Pet ownership, dog types and attachment to pets in 9-10 year old children in Liverpool, UK. *BMC Veterinary Research*, *9*.

Wongphruksasoong, V., Santayakorn, S., Sitthi, W., Ardkham, B., Pisek, S., Srisai, P., Chumkasian, P., Prarakamawongsa, T., Lekjareonsuk, C., & Siriarayaporn, P. (2016). Census versus Capture-recapture Method to Estimate Dog Population in Lumlukka District ,. *Outbreak, Surveillance and Investigation Reports*, *9*(1), 15–20.

WHO, & WSPA. (1990). Guidelines for dog population management: World Health Organization and World Society for the Protection of Animals, WHO/ZOO/90.166.

WHO. (2014). Guide for Rabies Pre and Post Exposure Prophylaxis in Humans: World Health Organization.

WHO. (2013). WHO expert consultation on rabies (Vol. WHO Technical Report Series 982, pp. 130): World Health Organization.

WSPA. (2009). Surveing roaming dog populations: guidelines on methodology (Vol. 1). London: WSPA.

WSPA, W. (1990). Guidelines for dog population management (pp. WHO/ZOO/90.166): World Health Organization and World Society for the Protection of Animals.

WSPA. (2008). Surveying roaming dog populations: guidelines on methodology. World Society for the Protection of Animal. www.wspa-international.org.

Young, J. K., Olson, K. A., & Richard, P. (2011). Is Wildlife Going to the Dogs ? Impacts of Feral and Free-roaming Dogs on Wildlife Populations. *Bio Science*, *61*(2), 125–132.

Yousaf, M. Z., Qasim, M., Zia, S., Rehman Khan, M. ur, Ashfaq, U. A., & Khan, S. (2012). Rabies molecular virology, diagnosis, prevention and treatment. *Virology Journal*, *9*(1), 50.

Zhou, H., Vong, S., Liu, K., Li, Y., Mu, D., Wang, L., Yin, W., & Yu, H. (2016). Human Rabies in China, 1960-2014: A Descriptive Epidemiological Study. *PLoS Neglected Tropical Diseases*, *10*(8), 1–12.