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ASSESSMENT OF THE RISK FOR RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

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A thesis submitted in fulfilment of the requirements for the degree of Masters of Veterinary Science

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Declaration of authorship

This thesis contains the original work of the author except where due acknowledgement is explicitly made. To the best of my knowledge the results from this study have not been submitted for any other degree or diploma at this or any other university.

Ana Mustiana

BVSc,

30 August 2013

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Abstract

Rabies, a zoonotic disease, is maintained in the domestic dog population in Indonesia and has caused human fatalities since its introduction to this country in the 1880s. Although rabies control strategies have been implemented on rabies-infected islands, this disease is still spreading to other parts of Indonesia, with newly infected islands as recent as 2012. Live dog movement on fishing or cargo boats is believed to have facilitated the introduction of rabies virus into previously rabies-free islands in Indonesia, such as to Bali and Flores. Until today, of the total 33 provinces, only nine provinces remain rabies-free including Lombok Island in West Nusa Tenggara (NTB) Province.

This research was conducted from 2011 to 2013 to investigate pathways for rabies entry to Lombok Island via dog movement and to assess the probability of rabies entry and exposure to the susceptible dog population on Lombok. Further, this research aimed to provide knowledge of the pathways and probability of rabies entry to Lombok in order to inform development of quarantine and surveillance strategies to prevent rabies entry and establishment on Lombok. Pathways for rabies entry to Lombok were first defined based on the literature and then refined and prioritised based on expert opinion. After this process, two pathways of release of a rabies-infected dog were identified: boat and ferry pathways. Scenario trees were developed for each pathway to describe the release of a rabies-infected dog to Lombok, as well as scenario trees to describe the exposure of a rabies-infected dog to the susceptible dog population on Lombok. Four surveys were conducted on Bali and Lombok islands to obtain data used to refine the pathways and to inform the release and exposure models.

The first survey obtained data on dog numbers and dog management practices of dog owning households belonging to different ethnic groups at an urban site and a rural site on Lombok. A total of 400 households were interviewed, 300 at the urban site and 100 at the rural site. The majority of the interviewed households belonged to Balinese ethnic group. Sasakese households owning dogs were more frequent at the rural site compared to the urban site. Owning dogs born on Lombok was common (96% households), however, 4% of households reported owning dogs obtained from outside Lombok (Bali and Java). The latter was more common at the urban site and among

Balinese ethnic group. All households that reported imported dogs mentioned transporting the dog/s in a vehicle by ferry from Padang Bai harbour Bali to Lembar harbour Lombok. All these households also reported that the imported dogs did not have the documentation required by the quarantine agency and 11 reported that the imported dogs had been vaccinated but were not able to identify the type of vaccination. The dog owning households kept their dogs either fully restricted, semi-free roaming or free-roaming but full restriction was reported only at the urban site. Dog bite cases were reported to be higher at the urban site.

For the second survey, to investigate dog transportation on boats docking on Lombok, interviews were conducted with captains of boats that originated from other parts of Indonesia and of local Lombok boats at seven informal ports (no quarantine post). Over three consecutive days at each port, a total of 117 captains of outside boats and 52 captains of local boats were interviewed. This survey found that dogs are not common on boats. All of the captains interviewed, except one captain from Bali, reported never having a dog on board their boat. More than half (61.5%) of the captains of outside boats knew that rabies is transmitted to people through dog bites compared to only 7.7% of captains of local boats.

Dog observation was also conducted during the survey visits to these ports to document the presence of dogs on boats, and the presence of dogs and interactions between people and dogs at the port area. No dogs were seen on boats, which confirmed the finding of the boat captain survey.

To further investigate the role of illegal dog movement through ferry route, the third survey interviewed people travelling with a vehicle to Lombok by ferry from Padang Bai Bali. Interviews were conducted at Padang Bai harbour over ten days and 158 people were interviewed. The people interviewed consisted of Lombok residents (51.3%) and non-residents (48.7%); 10.8 % of which reported experience bringing dogs to Lombok. All of the 21 imported dogs were pedigree dogs; majority were male; and all had originated from Bali, Jakarta or West Java. Although these dogs were transported in several types of vehicles, the majority had been transported in a truck. Transportation for most of these dogs (14) was done at the request of dog owners living in Lombok and payment provided by the dog owners. Only two dogs were reported to have been vaccinated against rabies. None of the people who had transported these imported dogs reported the dogs undergoing quarantine inspection at either Padang Bai harbour or Lembar harbour Lombok.

A fourth survey was undertaken to estimate the number of unowned dogs at the urban and rural sites on Lombok where the household survey was conducted. A photographic-recapture method was employed and the number of unowned dog was estimated using a Chapman estimate from Beck (1973). A higher number of unowned dogs was observed at the urban site than at the rural site.

Information obtained from the surveys was incorporated into the risk assessment models to quantify the probability of that one rabies-infected dog is released at Lombok via boat and ferry pathway and the probability of a susceptible dog at the informal port, urban site and rural site becoming infected with rabies virus after the release of a rabies-infected dog via the boat and ferry pathway. Data from published literature and expert opinion were also utilised. Monte Carlo stochastic simulation modelling was performed with @Risk 6.0 (Palisade Corporation, USA). Each simulation consisted of 5,000 iterations sampled using the Latin hypercube method with a fixed random seed of one. Sensitivity analysis was also conducted to identify which input parameters were the most influential to the overall outputs of the release and exposure assessment models. This was performed using the @Risk 6.0 Advanced Sensitivity Analysis (Palisade Corporation, USA).

Based on the results of this study, the probability of rabies being introduced into Lombok via both boat and ferry pathways was very low. However, these estimates were not negligible and to estimate the overall risk of virus introduction into Lombok for a specific period of time, the total number of boats, ferries and passengers in each ferry coming into Lombok should be considered.

The sensitivity analyses for the release assessments indicate that the prevalence of rabies in Bali has a significant influence on the probability of rabies virus being introduced into Lombok. The presence of dogs on boats travelling to Lombok and the probability of ferry passengers bringing dogs to Lombok were also influential parameters.

The exposure assessments suggest that the overall median probability of a rabid dog released in Lombok exposing and infecting a susceptible dog in Lombok was low. This probability was similar for a rabid dog being released at an informal Lombok port and for a rabid dog released by a person travelling in a ferry that resided in rural/urban Lombok. These results suggest that the probability of exposure is not negligible. The probability of the rabid dog confinement was an influential parameter on the probability of susceptible dogs in Lombok being exposed.

These findings have provided information on pathways and probability for rabies entry to Lombok and for rabies exposure to the susceptible dog population on Lombok. The practice of illegal dog movement via the ferry route can now be addressed to prevent rabies entry to Lombok, through rabies control at source (that is, on rabies-infected islands); improvement of performance of the quarantine agency ; and through education about rabies for the general public and dog owners as well as for animal health and public health officials. Preventing establishment in the event of rabies incursion through early disease detection and preparedness planning is also important. Early disease detection includes animal disease surveillance and monitoring the level of human dog bite cases. Preparedness can include responsible dog ownership that incorporates dog registration and identification, dog vaccination, neutering and confinement; dog population control through a better waste collection and disposal system by government agencies to reduce food sources for roaming dogs; and dog rabies vaccination for Lombok. In particular vaccination in advance of an incursion deserves serious consideration because it can create a barrier to prevent rabies transmission to people.

Conference presentations and proceedings

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Glossary and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ARAV	Aravan virus
AUD	Australian Dollar (currency)
BAWA	Bali Animal Welfare Association
CAC	the Codex Alimentarius Commission
CNS	Central Nervous System
DFA	Direct Fluorescent Antibody Test
DGLAHS	Directorate General of Livestock and Animal Health Services
DIC	Disease Investigation Centre
EBLV-1	European Bat Lyssavirus type 1
EBLV-2	European Bat Lyssavirus type 2
ELISA	Enzyme-linked Immunosorbent Assay
ERA	Evelyn-Rokitnicki-Abelseth
FAO	Food and Agriculture Organization of the United Nations
G	Glycoprotein
GPS	Geographical Positioning System
HPAI	Highly Pathogenic Avian Influenza
IAQA	Indonesian Agricultural Quarantine Agency
IDR	Indonesian Rupiah (currency)
IRKV	Irkut virus
IU	International Unit
KHUV	Khujand virus

L	Polymerase
M	Matrix protein
MIT	Mouse Inoculation Test
N	Nucleoprotein
NTB	West Nusa Tenggara
OIE	World Organisation for Animal Health
P	Phosphoprotein
PEP	Post-exposure Prophylaxis
PLS	Provincial Livestock Services (Dinas Peternakan Propinsi)
PUSVETMA	Pusat Veterinaria Farma
RABV	Rabies virus
RNA	Ribonucleic Acid
SD	Standard Deviation
USA	the United States
USD	United States Dollar (currency)
V-RG	Vaccinia-rabies Glycoprotein
WCBC	West Caucasian Bat Virus
WHO	World Health Organisation
WSPA	the World Society for the Protection of Animals
WTO	World Trade Organisation
95% CI	95% Confidence Interval
Lingkungan	term for village in an urban setting
Dinas Kebersihan	an agency at municipal level that is responsible for waste management

Undang-undang	legislation

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CHAPTER 1: GENERAL INTRODUCTION

Rabies is a zoonotic disease that has caused human suffering for centuries (Warrell and Warrell, 2004). If infected people do not receive prompt initiation of rabies post-exposure prophylaxis, rabies is always fatal.

Animals act as reservoirs for the rabies virus: dogs are the main reservoir for the urban (domestic dog) rabies cycle, and wild animals (such as raccoons, skunks, foxes, coyotes, mongooses and bats) are the main reservoir for the sylvatic rabies cycle. The urban rabies cycle is the predominant source of infection for humans (Franka et al., 2013). It is estimated that the annual number of human rabies deaths across the globe resulting from dog bite exposure is 55,000 (95% CI 24,000–93,000), with virtually all of these deaths occurring in Africa and Asia (Knobel et al., 2005). Thus, while developed countries in North America and Europe have successfully eliminated rabies from their dog populations through dog vaccination and population control, rabies continues to be a problem for developing countries. Some reasons for difficulty with control in developing countries are the presence of inaccessible free-roaming dogs; uncertainty about the dog population size, making it difficult to achieve adequate vaccination coverage; and lack of resources. However at least in Africa, rabies control through dog vaccination is considered to be a feasible goal (Lembo et al., 2010).

Rabies was first seen in Indonesia during the 1880–1890s, with documented records of animal and human cases (Adjid et al., 2005; Putra et al., 2011b), and is still maintained in the domestic dog populations of the majority of Indonesian islands today. The number of human rabies deaths in Indonesia during 2012 was reported to be 662 (Indonesia Ministry of Agriculture, 2013); however, this is considered an underestimation of the national human loss due to unreported cases (drh. Syafrison Idris personal communication, 2013). Rabies eradication efforts in most infected provinces have not been successful for several reasons. These include difficulties with vaccinating free-roaming dogs and maintaining the vaccine cold chain, problems with vaccine delivery to remote locations, different attitudes to dog vaccination between cultural groups across the country, and lack of resources (Putra et al., 2013; Scott-Orr H, 2009; Susetya et al., 2008). The failure to control and contain rabies has been demonstrated by the spread of rabies to rabies-free islands in recent years. This spread has included Bali in 2008, Nias and Larat Islands in 2010, and most recently Kisar Island in 2012 (Indonesia Ministry of Agriculture, 2013).

The absence of wildlife rabies reservoirs in Indonesia (Putra et al., 2011b) strongly suggests that the spread of rabies from island to island across the archipelago mainly occurs via human-mediated movement of dogs incubating rabies (Townsend et al., 2013). However, to date no research has been conducted in this country to investigate the pathways for rabies entry through an infected dog being moved from a rabies-infected island or region to a rabies-free island.

The research presented in this thesis was undertaken to address this knowledge gap. The study site for this research was Lombok, a rabies-free island situated in close proximity to rabies-infected Bali. The focus was to investigate pathways for the entry of rabies to Lombok via dog movement, and assess the probability of rabies entry and exposure to the susceptible dog population on Lombok. The research, conducted from 2011 to 2013, aimed to provide knowledge of the pathways for, and probability of, rabies entry to Lombok. This information could inform the development of quarantine and surveillance strategies to prevent rabies entry and establishment on Lombok.

Pathways for rabies entry to Lombok were first defined based on the literature, and then refined and prioritised based on expert opinion, as described in detail in Chapter 8. The three release pathways considered in depth were infected dog entry via one of three modes: boats from other parts of Indonesia docking at informal ports on Lombok, boats owned by Lombok people who visit rabies-infected islands and return to Lombok, and passenger ferries.

To inform the understanding of these pathways, several surveys were conducted to obtain information on dog ownership, management and movement. Chapter 3 reports a survey of dog-owning households at a rural site and an urban site on Lombok. Chapter 4 reports a survey of boat captains at informal ports on Lombok and dog observation at these ports. Chapter 5 reports a survey of people bringing a vehicle by passenger ferry from Bali to Lombok. Chapter 6 documents semi-structured interviews conducted with veterinarians, pet shop personnel, dog traders and dog breeders on both the islands of Bali and Lombok.

In order to consider the potential for a rabies-infected dog that has arrived on Lombok to transmit the rabies virus to a susceptible dog on Lombok, some information about the dog population size and structure at typical sites was needed. Chapter 7 reports on a photographic capture method implemented to estimate the size of the population of unowned dogs at a rural site and an urban site on Lombok.

The data obtained from these various activities was used to parameterise the quantitative risk assessment model for rabies release and exposure on Lombok, reported in Chapter 8.

This thesis concludes in Chapter 9 with an overall discussion of the research findings and recommendations for quarantine and surveillance strategies. These findings and recommendations will be presented and discussed with relevant provincial government authorities at a workshop in Mataram City, Lombok in October 2013.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Rabies is a zoonotic viral disease affecting the central nervous system of a wide range of mammals. The virus is transmitted primarily by the bite of an infected animal and infection is invariably fatal once clinical symptoms appear. There is no treatment for animals affected by rabies; in humans, clinical cases are preventable by post-exposure prophylaxis (PEP) immediately following the bite of a rabid animal. Although rabies has a worldwide distribution, in the developing countries of Africa and Asia, dogs are the principal reservoir of rabies. Here, rabies has caused a significant public health problem despite the fact that the disease can be prevented. It is estimated that Asia has the highest number of human rabies cases worldwide. For example, in India the most recent published literature estimates that more than 20,000 deaths occur annually due to exposure to rabid dogs (Burki, 2008). In Bangladesh, 2,100 people die from bites by rabid dogs every year (Hossain et al., 2012). In China, due to the high number of dogs (130 million), the majority of which are free-roaming, human rabies is a major public health problem (Montgomery et al., 2012). The high number of human deaths in Asian countries is due largely to the fact that post-exposure prophylaxis is not always affordable for resource-limited countries. The high cost of treatment, long travel distances to health centres, lack of knowledge of rabies transmission and of the need to seek PEP treatment, and the limited availability of rabies vaccine for humans (Dimaano et al., 2011; Hu et al., 2009; Ly et al., 2009; Meslin and Briggs, 2013) contribute to this high death rate.

It has long been recognised that prevention of rabies in humans through dog vaccination is more cost-effective than post-exposure prophylaxis alone, as vaccination of an adequate percentage of a dog population can stop the spread of the rabies virus (Bogel and Meslin, 1990). Recent studies also highlighted that the most effective method of preventing human rabies cases in canine rabies-endemic countries is through elimination of the virus at its source, which is the dogs (Brown, 2011; Wunner and Briggs, 2010). Vaccination of 70% of a dog population is adequate to control rabies in dogs, which leads to prevention of the disease in humans (Coleman and Dye, 1996). The United States successfully eradicated rabies in its dog population through responsible dog ownership, dog registration, dog vaccination and free-roaming dog control (Blanton et al., 2012; Centers for Disease Control and Prevention, 2007). A recent study concluded that implementation of a well-planned mass dog vaccination campaign will prevent human deaths, which will reduce expenditure for PEP (Tenzin et al., 2012b). Therefore it is clear that to control the disease in both dogs and humans, it is extremely important to eradicate the virus in the dog population, rather than to rely only on control in humans through post-exposure prophylaxis.

As well as dog vaccination, there should be strict control of dog movement between regions or countries to ensure the success of rabies elimination and to prevent its re-emergence in a region that has succeeded in eradicating rabies. This is important because rabies appears to be a disease that is easily carried across borders, as was seen recently when a puppy was imported to the Netherlands from Morocco. The puppy was later found to be rabid (van Rijckevorsel et al., 2012). The implementation of strict controls on dog movement out of rabies-endemic areas could prevent rabies emergence in a disease-free region or nation.

2.2 RABIES VIRUS

Rabies is caused by the rabies virus (RABV), which is an enveloped, bullet-shaped virus of 75 × 100–300 nm in size. This virus is a single-stranded, minus-sense RNA virus with five viral proteins: nucleoprotein (N), phosphoprotein (P), matrix protein (M), glycoprotein (G) and polymerase (L) (World Health Organisation, 2005a). The rabies virus is a member of the order Mononegavirales, family Rhabdoviridae, genus Lyssavirus. The genus consists of rabies and rabies-related viruses including the Australian Bat Lyssavirus.

Rabies is phylogenetically divided into two groups: phylogroup I, including the rabies virus, Duvenhage virus, European bat lyssavirus types 1 and 2, and Australian bat lyssavirus; and phylogroup II, including Lagos bat virus and Mokola virus (Smith, 2002; World Health Organisation, 2005a). Recent molecular research on rabies-related viruses collected from bats (Arai et al., 2003; Kuzmin et al., 2005; Kuzmin et al., 2003; Nel and Markotter, 2007) has led to the definition of four new genotypes. The new genotypes are Aravan virus (ARAV), Khujand virus (KHUV) and Irkut virus (IRKV) belonging to phylogroup I, and West Caucasian bat virus (WCBV) belonging to phylogroup II.

Rabies virus is inactivated by lipid solvents (such as soap, chloroform, ether and acetone), iodine preparations, 1% sodium hypochlorite, 2% glutaraldehyde, 45–75% ethanol, quaternary ammonium compounds and formaldehyde. It is also easily inactivated by ultraviolet radiation, heating for one hour at 50 °C and direct exposure to sunlight (Usa et al., 2009).

2.3 THE EPIDEMIOLOGY OF RABIES

While all mammals are susceptible to rabies virus infection, the degree of susceptibility among mammals is varied. Animals that are highly susceptible to rabies infection are carnivores such as dogs, foxes, coyotes, jackals, raccoons, skunks, and mongooses and their relatives (Krebs et al., 2001; Rupprecht et al., 2002). Mammals of the order Chiroptera, such as insectivorous and vampire bats (Microchiroptera) and frugivorous bats (Megachiroptera), are also highly susceptible to infection with the rabies virus (Hanlon et al., 2007; Niezgoda et al., 2002).

Felids, mustelids (badgers, ferrets, minks), ungulates, equids, tapirs, rhinoceros, rodentia and primates, as well as 10 families from the order Artiodactyla (including pigs, camels, hippopotamus, cervids, giraffes and bovids), are at moderate to low risk for natural rabies infection (Hanlon et al., 2007; Niezgoda et al., 2002). Monotremes, marsupials, insectivorous mammals (such as moles and hedgehogs) and cetaceans have a very low incidence of natural rabies virus infection (Hanlon et al., 2007; Niezgoda et al., 2002).

Species that act as a reservoir for rabies – maintaining the virus cycle in their population – are primarily in the orders Carnivora and Chiroptera (Niezgoda et al., 2002). Cats are not considered to be reservoir hosts because there are no cat-associated rabies virus variants; however, cats are able to transmit rabies effectively (Hanlon et al., 2007; Rupprecht et al., 2002).

There are two cycles that maintain the rabies virus: the urban rabies cycle with dogs as the main reservoir, and the sylvatic rabies cycle with wild animals as the main reservoir. Urban rabies is seen as a major problem in Africa and Asia, where the domestic dog population remains poorly controlled. In many developing countries, the domestic dog is the major reservoir of rabies, and most human rabies deaths in these countries are a consequence of infection with the rabies virus variant maintained by the domestic dog (Cleaveland et al., 2006; Knobel et al., 2005; World Health Organisation, 2005a). Of the estimated 55,000 annual human deaths due to canine rabies in the developing world (95% CI 24,000–93,000), 44% occur in Africa and 56% occur in Asia (Dodet, 2006; Dodet et al., 2008; Knobel et al., 2005). Meanwhile, rabies in wildlife (sylvatic rabies) is rarely reported in Africa and Asia (Childs and Real, 2007).

In Africa and Asia, the rabies virus is widely distributed and is generally neglected by the public health community and policy makers, although it causes a high number of human deaths in these regions, and thus remains a public health threat (Lembo et al., 2010; Wilde et al., 2005). Only a few countries in Asia, such as Japan and Singapore, have a history of successfully eradicating the disease through dog population control and vaccination (Windiyaningsih et al., 2004).

The sylvatic rabies cycle is maintained by wildlife such as foxes, racoons, skunks and bats. These animals are the main rabies reservoirs in America and Europe. According to the World Organisation for Animal Health (OIE), some European countries have successfully eradicated rabies in wildlife by the implementation of oral vaccination campaigns. These countries are Switzerland, which eliminated wildlife rabies in 1999; France, in 2000; Belgium and Luxembourg, in 2001; and Czech Republic in 2004 (OIE, 2013). Vaccination programs and dog population control have effectively eliminated rabies in domestic dogs in many of these countries.

2.4 TRANSMISSION AND PATHOGENESIS

2.4.1 TRANSMISSION IN HUMANS

Possible routes of rabies transmission in humans can include direct contact, airborne transmission and organ transplantation. Ingestion of the raw meat of a rabies-infected dog may also cause infection via oral exposure (Wallerstein, 1999). However, direct contact from the bite of a rabid animal is the most common route of infection (Centers for Disease Control and Prevention, 1999). The rabies virus cannot enter intact skin, but contact between saliva from a rabid animal (Dodet, 2006) and human mucous membranes (World Health Organisation, 2005a), such as conjunctivae, the nasal lining, the oral cavity, anus and external genitalia, and open wounded skin, enables infection to occur (Banyard and Fooks, 2011). Human to human transmission via organ transplantation, although rare, is a possible infection pathway and has been documented. In the USA, four patients were diagnosed with rabies after receiving kidneys, a liver and an arterial segment from a donor with symptoms consistent with rabies (Srinivasan et al., 2005). Other cases of patients diagnosed with rabies after receiving corneal transplants were reported in Iran (Javadi et al., 1996), India (Gode and Bhide, 1988), Thailand (Centers for Disease Control and Prevention, 1981) and the USA (Houff et al., 1979). Inhalation of droplets or aerosols containing rabies virus may cause rabies infection. Rabies infection from air-borne transmission can occur in exceptional circumstances, such as in a cave with very high numbers of bats where rabies virus is present among the bat population (Constantine, 1962; Humphrey et al., 1960), or in laboratory accidents involving aerosolised rabies virus (Winkler et al., 1973).

2.4.2 TRANSMISSION IN ANIMALS

As with rabies transmission in humans, a bite from a rabid animal is the most likely potential route for infection in animals (Centers for Disease Control and Prevention, 1999). Exposure of mucous membranes and broken skin to infected saliva and central nervous system (CNS) tissue may also allow rabies transmission (Hanlon et al., 2007). Ingestion of the carcasses of rabies-infected prey may cause infection via oral exposure (Hanlon et al., 2007; Niezgoda et al., 2002). Inhalation of the virus in aerosols may be a route for infection, but this would happen under unusual circumstances such as in a laboratory setting (Centers for Disease Control and Prevention, 1999).

2.4.3 PATHOGENESIS

Rabies virus enters the body of a human or animal through the bite of a rabies-infected animal, or via contact of the saliva of an infected animal with mucosal surfaces, or open or wounded skin. After entry, the virus replicates in non-nervous tissues at the site of entry and an immune response is not stimulated, so this phase is not easily detected (Usa et al., 2009). This is called the eclipse phase of infection. The virus then enters peripheral nerves and moves up to the CNS by retrograde axoplasmic flow (World Health Organisation, 2005a). After spreading in the CNS, the virus then travels back along the peripheral nerves by anterograde axoplasmic flow to the salivary glands. In animals, at this stage, the rabies virus can be transmitted to humans or to other animals. Once clinical symptoms are shown, death is inevitable (World Health Organisation, 2005a).

2.5 CLINICAL FEATURES

All rabies-infected species show paralysis and changes in temperament.

2.5.1 IN HUMANS

The incubation period of rabies in humans and dogs is influenced by the site and severity of the bite, degree of innervation at the bite site (the richer the nerve supply to the bitten area, the shorter the incubation period), the quantity of virus inoculated, the age of the bitten individual and the immune status of the individual (Banyard and Fooks, 2011; Krauss, 2003). Bites nearer the head and bites in highly innervated regions of the body such as the face, neck and hands result in a shorter incubation period (Banyard and Fooks, 2011).

The incubation period in humans (time from being bitten by a rabid dog to when clinical signs appear) is between 14 and 90 days (Murphy et al., 1999) or 20 and 90 days (Jackson, 2013), and may be longer. Longer incubation periods of two to seven years after exposure to a rabid dog have been observed in human cases (Murphy et al., 1999).

There are three stages of clinical rabies in humans: prodromal, furious and paralytic (dumb).

The prodormal stage usually lasts for up to ten days (Jackson, 2012). Symptoms include pain at the bite site, feeling unwell, loss of appetite, restlessness, anxiety, vomiting, headache and fever (Krauss, 2003). This is followed by one or both of the two other stages. Patients that progress to the furious stage may show extreme excitability, difficulty swallowing, hydrophobia, aerophobia and muscle spasms, and death may occur during a spasm attack within days of commencement of this stage. The furious stage may or may not be followed by the paralytic stage which is characterised by sensory disturbances and weakness of extremities and facial muscles (Krauss, 2003).

2.5.2 In canines

In naturally occurring cases of urban rabies, the incubation period in dogs is between three weeks and 12 weeks, although in a few cases incubation periods may be longer (Kaplan et al., 1986).

There are two forms of this disease: furious and paralytic. Animals show either one of these forms one to three days after the rabies virus reaches the CNS. There may be a prodromal phase in rabid animals before the onset of the two clinical forms (Murphy et al., 1999).

In the paralytic form (also known as dumb rabies), animals show signs of paralysis in the throat and the chewing muscles, and profuse salivation. They have difficulty swallowing, are not aggressive and do not attempt to bite (Romich, 2008). Paralysis progresses to all parts of the body and death may occur rapidly within a few hours.

In the furious form, sometimes called 'mad dog' rabies, there are clinical signs of mydriasis, and a state of aggression, anxiety and alertness. Animals at this stage become aggressive with only slight provocation, and attempt to bite or attack with auditory stimulation. In addition, these animals lose any fear of humans, bite anything within sight, have excessive salivation and display hydrophobia (Murphy et al., 1999; Romich, 2008). As the encephalitis progresses, clinical signs as seen in the paralytic form occur. Death (usually 2 to 14 days after the first clinical signs) always follows the convulsive seizures, coma and respiratory arrest phase (Murphy et al., 1999).

2.5.3 CLINICAL FEATURES IN WILDLIFE

The incubation periods of the other lyssaviruses are varied. With Duvenhage virus, the incubation period is at least four weeks (Paweska et al., 2006), European bat lyssavirus type 1 (EBLV-1) has a 45-day incubation period (Botvinkin et al., 2005) and EBLV-2 has a 19-week incubation period (Fooks et al., 2003).

Clinical signs in rabid wildlife are most commonly aggression or abnormal behaviour. Rabid foxes, coyotes, raccoons, skunks and bats do not fear people; they invade yards, attack people and pets, and they become ataxic. Rabid raccoons, skunks and bats become active during the day (Romich, 2008). Paralysis then progresses rapidly in all parts of the animal's body, with death occurring in a few hours.

2.5.4 CLINICAL FEATURES IN OTHER ANIMALS

Behavioural changes and paralysis are seen in all animals infected with the rabies virus. Rabid equines show symptoms of distress and agitation and may roll; thus, they are often misdiagnosed with colic. Rabid cattle are seen yawning and with tail paralysis, and dairy cattle stop lactating suddenly. Rabid goats and sheep exhibit symptoms such as increased bleating, weakness in the hind legs, difficulty in walking, excessive sexual activity and paddling. These animals may bite objects. Rabid pigs exhibit biting and aggression (Romich, 2008). In all these species, death occurs in a few hours following paralysis, which occurs in all parts of the animal's body.

2.6 DIAGNOSIS

Rabies diagnosis based on clinical symptoms alone is not totally reliable, as animals exhibit no specific clinical signs apart from behavioural changes. Behavioural changes emerge only after the virus has reached the central nervous system. During the incubation period, it is impossible to detect the virus because neither the antigen nor any RNA is expressed. This is because the distribution of rabies virus in the host is unpredictable during this period (Trimarchi and Nadin-Davis, 2007). In addition, the antibody titre does not increase until a week or more into the clinical phase (Crepin et al., 1998). Consequently, a post mortem diagnosis based on laboratory testing of brain tissue is required to confirm rabies virus is the causative agent of the disease (Trimarchi and Nadin-Davis, 2007; World Health Organisation, 2005a).

Whilst an initial diagnosis based on clinical signs in a rabies infected region is sufficient to trigger commencement of post-exposure prophylaxis in humans that have been bitten by an animal, a definite positive rabies diagnosis based on samples from the suspect rabid animal is important as confirmation for human treatment. A definite diagnosis when this is possible also strengthens surveillance reports based on clinical suspect cases and is a useful tool for understanding rabies epidemiology in an infected region. Some laboratory diagnostic tests for rabies are described below.

2.6.1 Histologic examination

Histological examination is carried out on a simple preparation of brain tissue applied to a slide and stained with combination of basic fuchsin and methylene blue (Tierkel and Atanasiu, 1996). Tissues such as hippocampus, cerebrum or cerebellum are used. This slide is then examined under a light microscope for the presence of typical acidophilic intracytoplasmic inclusions called Negri bodies (Lepine and Atanasiu, 1996). Among the hippocampus, cerebrum and cerebellum, the hippocampus is less important for the direct flourescent antibody (DFA) test, described below, but it is a valuable sample for rabies diagnosis by histologic examination to demonstrate Negri bodies (Trimarchi and Nadin-Davis, 2007).

Negri bodies are specific for rabies and their presence is generally accepted as a sign of rabies infection. However, the presence of Negri bodies depends upon the length of the clinical period before death. The longer the rabid animal is allowed to live, the better the chance of obtaining a positive microscopic diagnosis (Tierkel and Atanasiu, 1996). On the other hand, this could delay the initiation of post-exposure prophylaxis for the bite victim. Thus, the value of this method for public health purposes is limited.

2.6.2 Direct fluorescent antibody (DFA) test

The DFA test is the gold standard for rabies diagnosis. The most valuable sample for demonstrating rabies virus infection is the brainstem, which is not surprising since the virus route to the central nervous system is through the peripheral nerves. Cerebellum tissue provides the next most valuable sample. Examination of these two tissue samples is adequate for rabies diagnosis using the DFA test (Trimarchi and Nadin-Davis, 2007).

The principle of the DFA test is to demonstrate rabies antigen in touch impressions of brain tissue through the binding of rabies antigen-specific fluorescent-labelled antibody. If rabies antigen is present, the fluorescent antibody will bind to it and the antigen/antibody complex will be seen as a fluorescent green area under a fluorescent microscope (Dean et al., 1996).

2.6.3 VIRUS ISOLATION

Virus isolation is used in circumstances of uncertainty, to confirm a result obtained from another rabies diagnostic test (Rudd and Trimarchi, 1987). Virus isolation can be achieved by a mouse inoculation test (MIT) or rabies tissue culture infection test (RTCIT). The difference between MIT and tissue culture is that MIT uses living mice to grow the rabies virus, while in tissue culture a cell suspension is used.

In the MIT, a dilution of homogenised brain is used as the test specimen. This dilution is then inoculated intracerebrally into weanling mice. The mice are then checked daily for 30 days and killed at the first sign of a clinical infection. The mouse brain tissues are examined using the DFA test for verification of rabies infection (Rudd et al., 1980).

In the RTCIT, brain suspension in buffered saline is added to a monolayer cell suspension. The cell suspension and homogenised suspected brain is added to a growth chamber and incubated for a few days. After the incubation, the cells are examined using the DFA test. Results are determined as negative if no antigen is detected, or positive if one or more positive cells are found (Rudd and Trimarchi, 1987). In many laboratories, RTCIT has replaced the mouse inoculation test, because RTCIT is relatively easy to perform, less expensive than MIT and the result is obtained much more quickly, within four days, compared with 30 days using the MIT (Webster and Casey, 1996).

2.6.4 Reverse Transcriptase Polymerase chain reaction (RT-PCR)

In rabies diagnosis, the DFA test is adequate to confirm infection caused by rabies and other lyssavirus isolates. However, the DFA test cannot distinguish between different isolates. PCR testing can distinguish isolates, and it can be used on decomposed brain samples that are too degraded for DFA testing (Heaton et al., 1997). Detection of rabies RNA in saliva and cerebrospinal fluid is also possible using RT-PCR (Crepin et al., 1998). Another advantage of RT-PCR is that, together with other techniques of rabies gene sequencing, RT-PCR can be used to characterise the strain of infecting rabies virus (Bourhy et al., 1993; Susetya et al., 2008; Whitby et al., 1997). The principle of RT-PCR is that it amplifies a certain fraction of the virus RNA, which is then visualised by gel electrophoresis. The amplified RNA is then sequenced, leading to identification of the virus strain. Meticulous laboratory conditions are necessary for this method to function as an effective tool for rabies diagnosis and epidemiological studies.

2.6.5 Enzyme-linked immunosorbent assays (ELISA)

The aim of the ELISA test is to determine the level or concentration of virus-neutralising antibodies. The test measures the amount of antibody bound to rabies virus-specific proteins that are attached to a substrate, typically a slide, microtitre plate or bead. Bound antibody is detected with an anti-antibody or Fc-binding protein labelled with an enzyme (Trimarchi and Nadin-Davis, 2007). The microtitre plate ELISA method is simple and inexpensive and can yield reliable survey results for the presence of rabies antibody in animals in areas of enzootic rabies in which rabid animals are regularly seen (Cleaveland et al., 1999; Cliquet et al., 2004). ELISA can also be used for testing the potency of rabies vaccines (Perrin et al., 1996).

2.7 THERAPY AND PREVENTION OF RABIES IN HUMANS

2.7.1 Therapy

Rabies is a fatal zoonotic disease, once clinical symptoms appear: no therapy is known to save victims. Survival from clinical rabies has only been documented in six patients; all except one received rabies vaccination before the onset of clinical disease (Jackson, 2007). The survivor who was not given rabies immunisation was documented in

Wisconsin in 2004. During hospitalisation, the victim underwent several diagnostic tests and was given drug treatment, and showed progressive improvement. This is the first documented survivor who was not given rabies immunisation prior to the onset of clinical rabies (Willoughby Jr et al., 2005). However, similar cases of survival are very rare, and taking preventive measures is the most effective method to avoid rabies disease. Providing supportive therapy and palliative care such as adequate sedation and analgesia are necessary for the care of clinical patients.

2.7.2 PREVENTION

2.7.2.1 Pre-exposure vaccination

Pre-exposure vaccination is important in order to protect humans against an unrealised exposure to the rabies virus and to simplify post-exposure prophylaxis in the event of rabies exposure. It reduces the required number of post-exposure injections of vaccine from the usual five doses to two doses (Briggs and Mahendra, 2007). Pre-exposure prophylaxis should be given to people with a high risk of rabies exposure, such as rabies laboratory workers, veterinarians, animal handlers, wildlife workers, people living in high risk areas and travellers to high risk areas (Centers for Disease Control and Prevention, 1999; Krause et al., 1999; World Health Organisation, 2013). These groups are classified in Table 2.1.

Table 2.1: Recommendation for pre-exposure vaccination (Centers for Disease Control and Prevention, 2013)

Risk category	Typical population	Pre-exposure recommendation
Continuous	Rabies research laboratory workers, rabies biologics production workers	Primary course. Serologic testing every six months; booster vaccination if antibody titre is below acceptable level (the acceptable level is at least 0.5 IU/mL)
Frequent	Rabies diagnostic laboratory workers, veterinarians, animal handlers, wildlife workers and people living in rabies-enzootic areas	Primary course. Serologic testing every two years; booster vaccination if antibody titre is below acceptable level.
Infrequent	Veterinarians and animal handlers in areas where rabies is uncommon to rare. Travellers in high risk areas where immediate access to appropriate medical care is limited	Primary course. No serologic testing or booster vaccination.
Rare	People living in area where rabies is rarely seen	No vaccination necessary.

Pre-exposure vaccination should be administered in the upper arm (m. deltoideus) or in young children (under one year of age) into the anterolateral thigh area. Administration to the gluteal area is not recommended as it will result in lower neutralising antibody titres. The vaccination scheme follows a schedule of day 0, 7 and either day 21 or 28. For active immunisation pre-exposure and post-exposure, the vaccine used is cell-culture or embryonated-egg vaccine (World Health Organisation, 2013).

Post-exposure prophylaxis

Post-exposure prophylaxis is given following exposure to a rabies-infected animal. PEP includes immediate wound care and administration of active and passive immunisation (World Health Organisation, 2010). Wound care consists of thorough washing of the wound for at least 15 minutes using water and soap or detergent, followed by application of povidone iodine or other virucidal compounds (World Health Organisation, 2005b). Administration of the PEP vaccine must follow wound care. Post-exposure prophylaxis helps to reduce rabies virus infection by eliminating or inactivating the viral particles in the wound before they reach the nervous system (Kaplan et al., 1962; Warrell and Warrell, 2004). The PEP vaccination is always urgent and needs to be started immediately.

According to WHO, there are three categories of rabies exposure. Category 1 is touching or feeding of animals or licks on intact skin; no vaccination is needed for this exposure category if the case history is reliable. Category 2 is minor scratches or abrasions without bleeding; post-exposure vaccination is required for this category, and administration of immunoglobulin (passive immunisation) is recommended for immunosuppressed persons. Category 3 is single or multiple transdermal bites, licks on broken skin, scratches, or contamination of mucus membrane with saliva (such as via licks). In this category both active and passive immunisation are necessary. Exposure to a rabid bat is always considered as category 3 unless the exposed person is confident that no bites or scratches have occurred during contact with the bat (World Health Organisation, 2013).

For active immunisation post-exposure, the administration route is either intramuscular or intradermal. For the intramuscular regimen, the five-dose (Essen) regimen is commonly used with administration into the deltoid muscle on days 0, 3, 7, 14 and 28. For intradermal administration, the vaccine is administered by injection at two body sites (usually the left and right upper arm) on days 0, 3, 7 and 28 (World Health Organisation, 2013). Passive immunisation by using equine or human (rarely) rabies immunoglobulin should be administered once into and around the bite wound site just before or shortly after the first dose of anti-rabies vaccine. If it is not immediately available, the immunoglobulin can be administered up until the seventh day after the first vaccine dose (World Health Organisation, 2013).

Besides the category of exposure, the decision to give post-exposure vaccination is also influenced by the presence of rabies in the area from which the animal originates, the clinical status and vaccination history of the animal, and the availability of animal examination or observation to assess the rabies status of the animal (World Health Organisation, 2005a).

2.8 CONTROL STRATEGIES

2.8.1 CONTROL OF HUMAN RABIES

The development of clinical rabies can be prevented by thorough wound cleansing followed by administration of active and passive rabies vaccination to people exposed to a rabid animal. Yet thousands of human deaths occur annually as a consequence of rabies, mainly in Africa and Asia, where dogs are abundant and are not often controlled. In less developed countries, the reason for the high number of human deaths is often inadequate access to PEP vaccines and immunoglobulin due to inadequate distribution of the vaccines, long travel distances to health centres and the high cost of treatment (Rupprecht et al., 2002). The cost of post-exposure treatment is a large expenditure for resource limited countries, involving direct costs such as that of the rabies vaccine, rabies immunoglobulin, material costs (syringe, needles, swab and antiseptic) and operating costs. There are also indirect costs including transport costs to and from rabies treatment centres and loss of income while receiving treatment (Knobel et al., 2005; Meltzer and Rupprecht, 1998; Tenzin et al., 2011b). The total cost per PEP course, including direct and indirect costs, is estimated to be US$39.57 in Africa and US$49.41 in Asia. This is much higher than the estimated cost per dog vaccination: the cost per dog vaccination is US$1.30 in Asia and Africa (Knobel et al., 2005).

Thus, the most feasible and cost-effective rabies prevention in these countries would be through control of canine rabies, which would involve vaccination and control of the dog population, as well as education of dog owners, people at high risk of rabies exposure and health practitioners, and the general public (Lembo et al., 2010; Rupprecht et al., 2002; Wilde, 2007).

Although human deaths due to rabies do occur in developed countries, deaths are few, and usually where victims have failed to recognise that they have been exposed, especially to wildlife rabies. The prevention of human rabies in developed countries where wildlife rabies is present takes the form of education of the general public and health professionals about rabies and post-exposure treatment (Rupprecht et al., 2002).

2.8.2 Control of canine rabies

Many developed countries have successfully eradicated rabies in their canine population through effective control of the dog population. In countries where canine rabies has been eliminated, human deaths due to canine rabies are often people that have contracted rabies overseas (McKay and Wallis, 2005). Thus, in developed countries, canine rabies is not seen as major problem.

The highest number of human deaths occur in developing countries, where canine rabies is still endemic (Knobel et al., 2005). Vaccination of 70% of the canine population against rabies would be necessary to reduce the number of human fatalities (Coleman and Dye, 1996; World Health Organisation, 1987). However, 70% vaccination coverage cannot be easily achieved due to high numbers of free-roaming dogs. Thus, effective rabies control in communities with free-roaming dog populations must incorporate dog population control.

2.8.3 Challenges to vaccine distribution

In countries with a high number of free-roaming dogs, maintaining an adequate (70%) vaccination coverage is difficult due to a high dog population turnover and failures in sustaining the cold chain for the vaccine. These problems affect the level of population immunity, as seen in Tanzania (Hampson et al., 2009). The rabies vaccine needs to be administered yearly to dogs, and the revaccination schedule can have an influence on vaccination success.

2.8.4 Challenges to dog population control

Dog population control through culling of free-roaming dogs is well known to be ineffective. A study conducted by WHO in Sri Lanka and Guayaquil Equador showed that in Sri Lanka, although dog elimination campaigns had removed between 35,000 and 50,000 dogs annually, these programs were only reaching 5% or less of the targeted dog population. In Guayaquil Equador, removal of 24% of dogs over a period of 12 months was found to have no lasting impact on the dog population or on the incidence of canine rabies. Furthermore, the dog elimination program resulted in the community acquiring new puppies or adopting free-roaming dogs into the area (World Health Organisation, 1988). The failure of dog elimination to reduce the incidence of rabies has also been seen in Indonesia. In Flores Island, rabies was first introduced in 1997, and approximately 295,565 dogs or 48% of the island's dog population were destroyed over four years (1998–2001) (Windiyaningsih et al., 2004). However, rabies remains present in the island. In Bali, following rabies introduction in 2008, 108,000 dogs were killed over a three-year period, but nonetheless rabies spread across the island with an increasing incidence of cases, resulting in 137 human deaths to 2011. PEP was given to more than 130,000 people with dog bites, but a decrease in rabies cases was not seen until the implementation of systematic island-wide vaccination of dogs (Putra et al., 2013). Vaccination remains the best tool to tackle canine rabies. Successful vaccination campaigns can only be achieved through a combination of education campaigns for dog owners, intersectoral cooperation, community participation, local commitment in planning and execution, good quality of vaccine, media support and effective general coordination of the vaccination campaign (Matter et al., 2000; World Health Organisation, 2002).

2.8.5 Control of rabies in wildlife

In general, the approach to the control of wildlife rabies is similar that for canine rabies. It involves modification of habitats by effective waste disposal in order to avoid contact between wildlife and domesticated dogs, parenteral vaccination through trap-vaccinate-release (TVR) programs, oral vaccination and passive disease surveillance (Hanlon et al., 1999). As in the control of canine rabies, a reduction of the reservoir population does not eliminate rabies in wildlife. In the past, a reduction in the numbers of wild carnivores has been conducted to attempt to control rabies; however, many of these attempts were unsuccessful because this reduction method cannot reduce and maintain the wildlife population below a certain level (Rosatte, 2011; World Health Organisation, 2012). In Canada, oral vaccination using baits containing the attenuated Evelyn-Rokitnicki-Abelseth (ERA) strain of rabies proved to be effective in controlling rabies in foxes (MacInnes et al., 2001; Rosatte et al., 1993). Oral vaccination in baits containing vaccinia-rabies glycoprotein (V-RG) recombinant was effective in controlling rabies in coyotes and grey foxes in Texas (Farry et al., 1998; Sidwa et al., 2005). The trap-vaccine-release (TVR) method – capturing animals and administering conventional animal vaccines – has been successful in controlling rabies in skunks in Canada (Rosatte et al., 1990; Rosatte et al., 1992). The development of an oral vaccine using bait for skunks is showing good results in controlling rabies (Hanlon et al., 2002).

2.9 RABIES DISTRIBUTION AND CONTROL IN INDONESIA

As seen in other countries in Asia and Africa, rabies is being maintained in Indonesia by domestic dogs (the urban rabies). There is no evidence of the involvement of wildlife.

2.9.1 RABIES IN INDONESIA

Rabies first occurred in Indonesia in the late 1880s, with the first animal rabies case recorded during the Dutch occupation in 1884 in a horse in West Java. Five years later (1889), rabies in a buffalo was documented in the same region. Rabies was documented in dogs in 1890 in the nearby region of Tangerang (Adjid et al., 2005; Soedijar and Dharma, 2005). The first human rabies case was recorded in 1894 in West Java. Rabies spread further to Sumatra in 1953 (Adjid et al., 2005; Sarosa et al., 2000).

Activities to control rabies have been implemented since 1889 (Soedijar and Dharma, 2005); however, the details are not well documented. In 1916, a locally manufactured post-exposure rabies vaccine for human use was produced for the first time in Bandung (capital city of West Java) using macaque brain (*Macacus gynomolgus*). It was the only vaccine available in Indonesia until 1978 (Soedijar and Dharma, 2005).

In 1926, the Dutch East Indies administration in Indonesia established a rabies regulation: Rabies Ordinance Articles Number 451, 452. This regulation stated that animal rabies mitigation is the responsibility of the Agricultural Department (and its Animal Health agencies) and the dog bite victim (the human) is the Public Health Department’s responsibility (Soedijar and Dharma, 2005). This approach remains essentially the same today.

Following the 1926 law, a national rabies control program was implemented, involving culling of free-roaming dogs, and mass vaccination of dogs, cats and owned monkeys. These animals were vaccinated using a local manufactured tissue culture vaccine

(Akoso, 2001). No vaccination program has been implemented in wildlife because in Indonesia there have not been any reports of rabies in wildlife.

In 1967, 22 years after Indonesia declared its independence, the Indonesian government released legislation regarding animal health: Undang-undang No. 6 Tahun 1967. This legislation clearly outlined the rabies control and eradication methods. In 1978, a joint decree by the Ministry of Agriculture, Ministry of Health and Ministry of Home Affairs was established. This joint decree was to regulate the implementation of the 1926 and 1967 legislations (Disease Investigation Centre Tanjung Karang, 1983).

By the 1980s, rabies had spread to the larger islands in the Indonesian archipelago, including the remaining provinces in Java, as well as all regions of Sumatra, Kalimantan and Sulawesi (Adjid et al., 2005). Although for each region the year of rabies introduction has been well recorded (Table 2.2, Figure 2.1), documentation about the method of rabies introduction is rare.

Table 2.2: Year of first rabies case report across Indonesia (Directorate General of Livestock and Animal Health Service, 1985; Indonesia Ministry of Agriculture, 2013)

Name of province/island	Name of island	Year of the first report
West Java	Java	1884
Central Java	Java	1953
East Java	Java	1953
West Sumatra	Sumatra	1953
North Sumatra	Sumatra	1956
South Sulawesi	Sulawesi	1958
North Sulawesi	Sulawesi	1958
South Sumatra	Sumatra	1959
Lampung	Sumatra	1969
Aceh	Sumatra	1970
Jambi	Sumatra	1971
Yogyakarta	Java	1971
Jakarta	Java	1972
Bengkulu	Sumatra	1972
Central Sulawesi	Sulawesi	1972
South East Sulawesi	Sulawesi	1972
East Kalimantan	Kalimantan	1974
Riau (mainland)	Sumatra	1975
Central Kalimantan	Kalimantan	1978
South Kalimantan	Kalimantan	1981
Flores	Flores	1997
Ambon in Maluku Province	Maluku	2003
North Maluku Province	Maluku	2005
South Buru Island in Maluku Province	South Buru	2006
Bali	Bali	2008
Nias Island in North Sumatra Province	Nias	2010
Larat Island in Maluku Province	Larat	2010
Kisar Island in South West Maluku Province	Kisar	2012

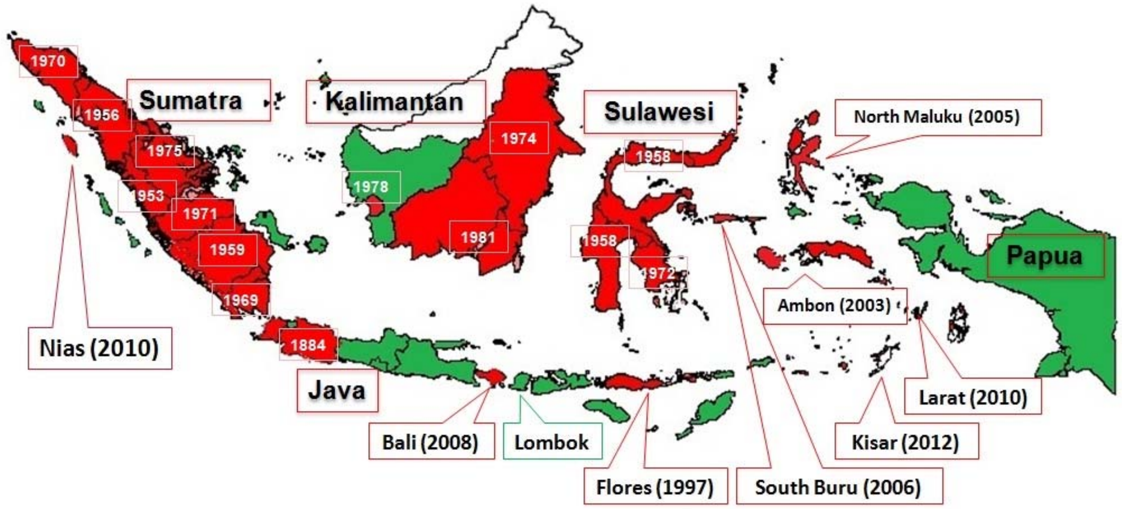


Figure 2.1: Geographical distribution of rabies in Indonesia and year of first rabies case report across the country.

A study of the dynamics of rabies transmission in Indonesian was conducted over 10 years (1975–1985) to understand the distribution across species and to obtain information about the presence of rabies in Indonesian wildlife (Suroso and Simanjuntak, 1997). During the active and passive surveillance program, brain specimens from thousands of microbats and macrobats, rodents, civet cats and tigers were collected; none of these specimens were rabies positive. Therefore, dogs were the principle target in the eradication program conducted later in 1989 (Simanjuntak and Suroso, 1997).

In 1989, a five-year campaign to eradicate rabies began, based on the 1926 and 1967 legislation and the 1978 joint decree, with intensive activities in Java, Sumatra, Sulawesi and Kalimantan. The main actions of the campaign were mass vaccination of dogs, cats and domesticated monkeys, and culling of free-roaming dogs. This control focus was based on the knowledge that for Indonesia, 98% of animal rabies cases were due to dogs and 2% to cats and domesticated monkeys. The monkeys reported as rabies-positive were mainly in West Sumatra, and were domesticated monkeys kept for the purpose of picking ripe coconuts (Simanjuntak and Suroso, 1997).

After three years of the five-year campaign, in 1992, a decrease in canine rabies was seen in three provinces in Java. In 1992, the total number of canine rabies cases seen on the four islands was 1199; only 1.3% of these cases occurred in Java (World Health Organisation 1993). Since 1992, no rabies cases have been reported on Java, except from the western region. In 1997, three regions of Java – Jogjakarta, Central Java and East Java – were declared rabies-free by the Indonesian government (Tim Koordinasi Pembebasan Rabies Tingkat Pusat, 1998). By 2000, no rabies cases were reported in West Java. In 2004, rabies freedom was declared by the Indonesian government for Jakarta, Banten and West Java provinces (Pusat penelitian pengembangan peternakan, 2011). Five years later, however, rabies re-emerged in West Java. Rabies is still prevalent in Sumatra, Sulawesi and Kalimantan (Susetya et al., 2008).

2.9.2 Rabies spread further to other rabies-free regions in Indonesia

In order to prevent the spread of rabies to rabies-free islands or regions, the Indonesian government, through the Indonesia Animal Quarantine Agency (IAQA), released legislation to regulate dog movement. In 1992, legislation was released by the Quarantine agency stating that the penalty for importing dogs from a rabies-infected area to a rabies-free area was IDR 150,000,000 (Badan Karantina Pertanian, 2011b) (approximately AUD$15,000). However, rabies spread further to Flores in late 1997 (Bingham, 2001b; Scott-Orr H, 2009). The rabies incursion pathway to Flores is well documented to be a fishing boat from Flores that illegally brought a dog incubating rabies from South-East Sulawesi (Windiyaningsih et al., 2004).

In late 2008, rabies occurred in Bali (Putra et al., 2009; Susilawathi et al., 2012). As in Flores, a rabies-incubating dog in a fishing or cargo boat was implicated as the pathway for rabies introduction to Bali (Putra et al., 2009; Putra et al., 2013). Rabies has continued to spread in recent years in Indonesia, with some islands that were previously rabies-free, such as Nias Island in North Sumatra Province and Larat Island in Maluku province, being reported as new rabies-infected islands in 2010, as well as Kisar Island in South West Maluku province in 2012 (Indonesia Ministry of Agriculture 2013).

2.9.3 Number of human deaths due to rabies in Indonesia

The number of human deaths due to rabies throughout Indonesia fluctuated between 2008 and 2010. In 2008, the total number of human deaths from rabies was 837, decreasing in 2009 to 620 deaths, and increasing in 2010 to a total of 1166 deaths. In 2011, the number of human deaths reported was 898, which was 23% lower than the total number reported in 2010. In 2012, the number of human deaths was down to 662

(Indonesia Ministry of Agriculture, 2013). However, this decreasing trend was not seen in some provinces in Indonesia, including provinces in Sumatra, and some provinces in Kalimantan, Flores Island, South Sulawesi province, Central Sulawesi province, Gorontalo and North Maluku, where the number of human deaths due to rabies has not shown a significant decrease in the last three years (Indonesia Ministry of Agriculture, 2013).

2.9.4 RABIES SITUATION ON BALI

In Bali, rabies was first confirmed in November 2008 in the southernmost peninsula (Bukit Peninsula), and it spread throughout the province by June 2010 (Clifton, 2010; Wirata et al., 2011). Between 2008 and 2010, rabies control activities in Bali were underfunded and reactive, involving culling to control free-roaming dogs and vaccination of dogs in areas where rabies cases were seen. A locally manufactured rabies vaccine was used, which required revaccination a month after the first vaccination to maintain immunity for a year. In these three years, 108,000 dogs were euthanased, more than 137 humans died of rabies, and post-exposure prophylaxis was given to more than 130,000 people with dog bites (Putra et al., 2013; Putra et al., 2011b).

With support from national and international organisations, the Bali Provincial Government commenced a three phase island-wide dog vaccination campaign. The first phase was undertaken from October 2010 to April 2011 with support from the Bali Animal Welfare Association, Bali Street Dog Foundation Australia, the World Society for the Protection of Animals and the Australian Government. The second phase, from May to December 2011, was implemented by the Bali Provincial Government, coordinated by the United Nations Food & Agriculture Organisation (FAO). The third phase was conducted by Bali Provincial Government from June to October 2012, and was coordinated by FAO.

Since commencement of the island-wide dog vaccination campaign, there has been a significant decline in human deaths due to rabies on Bali. From 94 deaths between rabies incursion and the start of the mass dog vaccination program (4.3 deaths/month), to 34 deaths during the first round of vaccination (4.8 deaths/month), and then to nine deaths (1.1/month) during the second round (Putra et al., 2013). Bali plans to eradicate rabies by 2015.

2.9.5 CURRENT RABIES CONTROL STRATEGIES

2.9.5.1 Human rabies control

The control of human rabies in Indonesia is the responsibility of the Ministry of Health. Activities include the provision of rabies treatment clinics at community health centres in rabies-infected regions or islands, administration of post-exposure prophylaxis (PEP) to dog bite victims, provision of adequate stocks of post-exposure prophylaxis vaccines, and improvement of the cold chain for the vaccines. In addition, pre-exposure rabies vaccine is provided to humans at high risk of exposure (Suroso et al., 2001).

2.9.5.2 Animal rabies control

The Ministry of Agriculture, through the Directorate General of Livestock and Animal Health Services, is responsible for animal rabies control. Control programs have been implemented in rabies-infected provinces and are similar in each of these divisions. Program activities include mass rabies vaccination of dogs, evaluation of the vaccination results, surveillance and tracing of the spread of rabies, improvement of the cold chain, registration of owned dogs, targeted culling of dogs and observation of dogs that bite people as suspect for rabies. The program also includes legislation and increasing public awareness about rabies through communication and education programs in the community (Geong, 2011; Putra et al., 2011b). Nonetheless, only a few of the rabies-infected regions or islands have successfully eradicated rabies. The four provinces in Java that attained rabies freedom achieved this by intensively implementing rabies eradication programs that were aided by the high proportion of confined owned dogs compared to free-roaming dogs in these regions of Java. Vaccination of these owned dogs is easier, and is sufficient to control rabies epidemics in these regions (Waltnertoews et al., 1990).

Obstacles that hamper other provinces in eradicating rabies in their dog population include problems in the distribution of rabies vaccine for dogs and for humans due to difficult geographical conditions such as in Kalimantan (presence of mountains, rivers and forests) and Flores Island (Kalianda et al., 2005; Scott-Orr H, 2009;

Wafiatiningsih et al., 2005). The implementation of rabies vaccination programs is inconsistent in some areas (Soedijar and Dharma, 2005), and many programs are hampered by an inadequate cold chain. Community culture is also seen as an obstacle. In some communities, dogs are used for sport (pig hunting). Many hunters believe that vaccination could affect their dogs' performance, thus they reject dog vaccination (Susetya et al., 2008). Dog population data is often not accurate (Adjid et al., 2005; Utami et al., 2008; Wafiatiningsih et al., 2005), and low levels of confinement of owned dogs and high numbers of ownerless dogs in these provinces can make it difficult to achieve the recommended 70% vaccination coverage (Utami et al., 2008). Inadequate cold chain, limited confinement of dogs and high numbers of free-roaming dogs also hamper rabies control efforts in the majority of Asian countries (Dodet, 2006).

In Indonesia, there are two types of rabies vaccine used for the government control program. The first is a locally manufactured rabies vaccine that is cheaper than the imported vaccine but has the same cold chain requirement, which is storage at 2–8 °C. The first vaccination with this vaccine requires two administrations one month apart to maintain immunity for one year, and then annual vaccination to sustain immunity (Pusat Veteriner Masyarakat, 2013). The effectiveness of this vaccine has been investigated annually by a local university researcher in the Jakarta area by evaluation of serum samples from owned dogs using ELISA. An antibody titre of 0.5 IU/ml was shown in 75% of the samples (drh. Susetya Heru personal communication, 2013). An antibody titre of 0.5 IU/ml and above for rabies virus-specific antibodies is considered adequate for protection against rabies (Kennedy et al., 2007). The initial dual vaccination schedule required by this local vaccine was a challenge for the rabies vaccination team in Bali; therefore, this vaccine was replaced with the imported rabies vaccine for use in the mass dog vaccination program in Bali (drh. Susetya Heru personal communication, 2013). The other vaccine used by the Government is an imported vaccine. It has the same cold chain requirement as the local vaccine; however, its revaccination interval is longer, at one year. Both of the local and imported vaccines are used in several provinces where rabies is still endemic (drh. Syafrison Idris personal communication, 2013).

2.9.6 RABIES-FREE ISLAND/REGIONS IN INDONESIA

In 2013, of the 33 provinces in Indonesia, only nine are rabies-free. These rabies-free provinces consist of five historically rabies-free provinces (Riau Islands Province, Bangka Belitung, West Nusa Tenggara, West Papua and Papua Province) and four previously rabies-infected provinces (Jakarta, Central Java, Jogjakarta and East Java province). Indonesia plans to eliminate rabies across the nation by 2020 (Indonesia Ministry of Agriculture, 2013).

Three of the historically rabies-free provinces consist of main islands and several smaller islands. Lombok Island, a rabies-free island that is the island of interest in this thesis, is one of two bigger islands belonging to West Nusa Tenggara province.

2.9.5.1 Lombok Island

Lombok Island is located in the eastern part of Indonesia and is one of two large islands that comprise NTB province. The provincial capital, Mataram City, is located on Lombok Island. This island has a total land area of about 4,725 km^2 and is inhabited by 3,200,686 people as recorded in the NTB census of 2012, with fishing, agriculture and tourism as the important sources of income (NTB Bureau Statistic, 2012). It shares a similar cultural heritage with Bali and is linguistically related to the Balinese; however, Islam is the main religion on Lombok (Direktorat Jenderal Kebudayaan Republik Indonesia, 2013a; NTB Bureau Statistic, 2012). This island is served by two ferry harbours and one airport. The two harbours are Lembar Harbour in the southwest, which connects with Padang Bai Harbour in Bali, and Kayangan Harbour on the east coast, which connects Lombok with Sumbawa Island. Both of these harbours provide ferries for passengers and road vehicles (NTB Bureau Statistic, 2011). Lombok International Airport provides services to and from other parts of Indonesia (NTB Bureau Statistic, 2011).

Of note in relation to rabies-infected islands in eastern Indonesia, Lombok is situated just 35 km east of Bali, and approximately 350 km to the west of Flores (Figure 2.2). Lombok is not located immediately next to Flores; Sumbawa Island (rabies-free) lies approximately 10 km to the east of Lombok, between the two islands. However, due to its close proximity to Lombok, Flores is also considered a threat for rabies introduction.

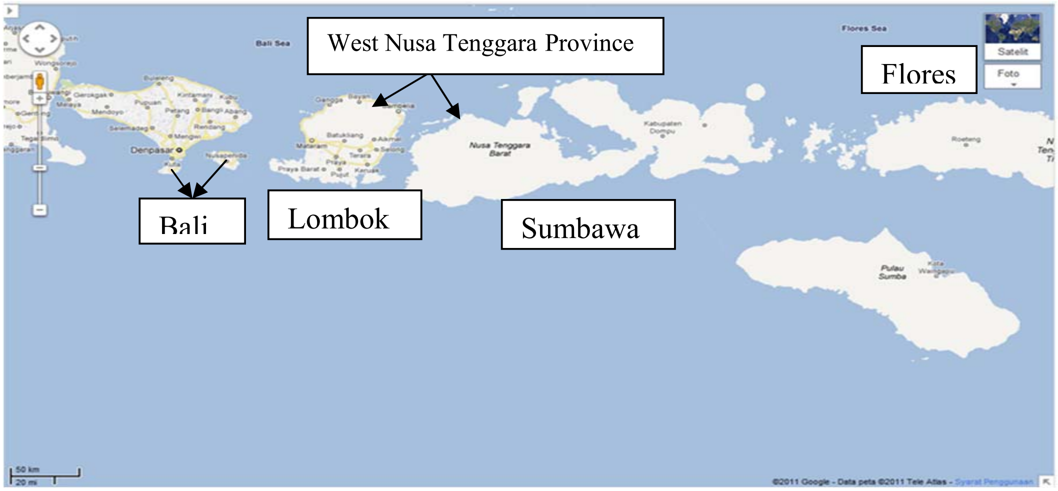


Figure 2.2: Geographical position of Lombok Island

The population of Lombok consists mainly of two community types: the Sasakese, which is the indigenous population of Lombok, and the Balinese. There are also smaller numbers of Chinese, Javanese, Timorese (Flores) and expatriates. The behaviour of these people towards dogs varies. The majority of people belonging to Sasakese and Javanese ethnic groups do not like to interact with dogs due to religious beliefs; thus, dogs are not common in their households (drh Aminurrahman personal communication, 2012; drh Heru Susetya personal communication, 2012). In contrast, Balinese and Timorese ethnic groups regard dogs as part of their culture. Dogs perform various functions in Balinese society, such as as pets and guard dogs, and dogs of certain coat colour are believed to protect households from evil spirits. Accordingly, it is rare for Balinese households not to own at least one dog (Putra et al., 2011a). Similar functions for dogs are observed in Timorese culture in Flores. In addition, dogs are used as wedding dowry and as an important meat delicacy that should always be present at ceremonies, such as the opening of a new house, graduation or promotion (Bingham, 2001b). These practices pose the risk of introducing the rabies virus onto Lombok Island, as they could encourage people to bring dogs to and from the island.

There is another factor that may increase the probability of dog movement from rabies-infected islands to Lombok. Lombok has a high number of informal ports, with no quarantine posts, around the coastline. These ports are often visited by boats for fishing or other types of activity from other parts of Indonesia, and the absence of a quarantine post means there is no inspection for plants, animals and their products on boat arrival, which is normally carried out by the quarantine service at border areas. On Lombok Island, quarantine stations are only located at the two formal sea ports and at the airport. Hence, there is a risk of dogs being moved from rabies-infected islands to Lombok through the traditional (informal) ports.

These geographic, demographic and quarantine features of Lombok may contribute to rabies virus entry to the island. Furthermore, the size and structure of the dog population on Lombok Island may increase the probability of rabies virus spreading among the Lombok dog population, if one rabid dog enters.

Structure of the dog population on Lombok Island

Many dog population studies have been conducted in African and Asian countries (Gsell et al., 2012; Hiby et al., 2011; Kato et al., 2003; Ratsitorahina et al., 2009; Totton et al., 2010), and all have found that free-roaming dogs are common. Similarly, on Lombok, high numbers of free-roaming dogs are observed. These free-roaming dogs seem to consist of ownerless dogs and poorly supervised owned dogs; however, it is difficult to distinguish the two groups. The evidence that some of these dogs are ownerless is seen during the commencement of local government programs to reduce dog numbers. Usually, for one or two days prior to a dog culling program, the community living in the area is told to tether or cage their dog/s in their households. On the day of commencement of the program, there are often still a relatively high number of dogs roaming, which are therefore eliminated. Thus, presumably, all of these dogs are ownerless. Furthermore, there are no cases of dog owners reporting that their dog/s may have been culled during such programs (drh. Nengah Dwiana personal communication, 2011).

There is no reliable dog registration data available on Lombok. An effort to register owned dogs was made by the Livestock and Animal Health Agency at provincial and district level in 2010 and 2011. The aim of this dog registration program was to estimate the number of owned dogs on Lombok Island. However, there was no specific recommendation on the method for dog registration. Thus, the data obtained may not be appropriate to use as scientific data (drh. Aminurrahman personal communication, 2011).

Rabies prevention strategies on Lombok Island

Strategies implemented by government authorities to prevent rabies incursion on Lombok Island consist mainly of dog culling programs and quarantine at formal sea ports. Active surveillance is conducted in conjunction with dog culling to detect whether or not rabies is present, by sending brain samples from the culled dogs to the Disease Investigation Centre in either Bali or South Sulawesi. Education to increase public awareness is also part of the rabies prevention program; this is carried out for school students and village leaders (drh. Aminurrahman personal communication, 2011).

Quarantine strategies to prevent rabies incursion on Lombok Island

Strategies applied by quarantine follow the legislation, and comprise procedures to regulate dog importation. Legislation was established, as detailed in Section 2.10.2 of this chapter, to prevent dog movement from rabies-infected areas to rabies-free areas. For a dog to be moved to Lombok, quarantine requires the dog owner to provide the following documentation for an imported dog: evidence that it is from a rabies-free area, a health statement from the Animal Health Agency at the dog's place of origin, identification (similar to a dog passport) and rabies vaccination records, laboratory ELISA antibody titre result (to determine antibody titre of $\geq$0.5 IU) and a pedigree record. Upon arrival at the destination, the dog owner must report immediately to the quarantine office. A contract stating that a veterinarian is appointed to observe the dog for a minimum of six months must be made and signed by the dog owner. However, education of the people of Lombok on these requirements is minimal.

Potential pathways for rabies introduction to Lombok Island

In order to calculate the probability of introducing rabies to Lombok, possible pathways for rabies virus to enter Lombok must be defined. Rabies in Indonesia is maintained by dogs, and other animals are not considered as pathways. Furthermore, based on the geographical position of Lombok, which is surrounded by sea, the main risk for Lombok will be through transportation of dogs with people. Since there are no existing studies of animal pathways to Lombok, the records of the entry of rabies to previously rabies-free Indonesian islands were reviewed to assist in defining pathways relevant to Lombok.

Possible pathways of rabies spread in Indonesia:

Pathway 1: Dogs on fishing boats.

Fishermen are ubiquitous in Indonesia. Historically, fishing or seafaring activities have been the main occupation for the majority of Indonesians across this diverse archipelago. Indonesian literature mentions that dogs on fishing or cargo boats provide the most likely route for the spread of rabies to Bali and Flores (Putra et al., 2013; Scott-Orr and Putra, 2009; Windiyaningsih et al., 2004). Other literature documents that dogs have an important function on Indonesian fishing boats, where they are believed to ensure a safer fishing journey (Badan Karantina Pertanian, 2011a).

Pathway 2: Human migration with dogs as pets or to trade.

For travel within Indonesia, ferry is the most common means of transport because it is relatively cheaper than plane travel. Large ferry companies provide services to all parts of Indonesia, with frequent trips (PT. PELNI Indonesia, 2013). The regulations of these ferry companies are unclear in relation to animal travel. Human migration by ferry, with dogs as pets or to trade in small numbers, could be a pathway for rabies incursion in the islands of Indonesia.

Pathway 3: Hunting dog trade.

On Sumatra Island, dogs are often used in the sport of pig hunting. For this sport, the hunters prefer dogs that are not vaccinated, because they believe that vaccination could greatly affect the performance of the dogs (Kementerian Koordinator Bidang Kesejahteraan Rakyat Republik Indonesia, 2013). Importation of dogs from another island for the purpose of hunting may be a route for rabies spread. Considering the hunters' belief, the imported dogs may not be vaccinated against any disease, including rabies. As in pathway 2, the ferry route is often used to transport these dogs.

Pathway 4: Dog meat trade.

For certain communities living in Indonesia, such as in Java, Manado (an area in Sulawesi), Ambon and other smaller islands in Maluku, Flores and Bali, dogs are a source of protein. It is likely that dogs are transported between provinces on Java Island for human consumption (drh. Susetya Heru personal communication, 2013). However, the number of dogs used for consumption in these islands is unknown.

Pathway 5: Dogs on military planes.

Military planes are used to transport people to remote islands or to fly to areas in cases of natural disaster (Wibowo, 2011). It is unclear whether these planes allow dogs to travel as passengers. However, in Nusa Tenggara Timor province, the movement of fighting cocks on military planes is known to have occurred, and this has been identified as a risk for entry of H5N1, the highly pathogenic avian influenza virus, to islands in this province (drh. Maria Geong personal communication, 2012).

2.10 RISK ASSESSMENT

Risk assessment is a stage in the conduct of a risk analysis. A risk analysis is commonly undertaken when evaluating the risk posed by the trade of a product between two countries or regions. For this purpose it is called import risk analysis. An import risk analysis is the estimation of the risk of entry of pathogens, pests or chemical residues with trade of a product. It also evaluates the impact on this risk of various mitigations; thus, it enables recommendations about the degree of disease risk to an importing country and options for risk minimisation. There are several frameworks for import risk analysis endorsed by the World Trade Organisation: the Codex Alimentarius Commission (CAC) of the Food and Agriculture Organisation of the United Nations (FAO)/World Health Organisation (WHO) framework for microbial food safety risk assessments; the International Plant Protection Convention framework for plant health; and the World Organisation for Animal Health (OIE) framework for animal disease.

The OIE import risk analysis is comprised of four components: hazard identification, risk assessment, risk management and risk communication (OIE, 2010), as seen in Figure 2.3.

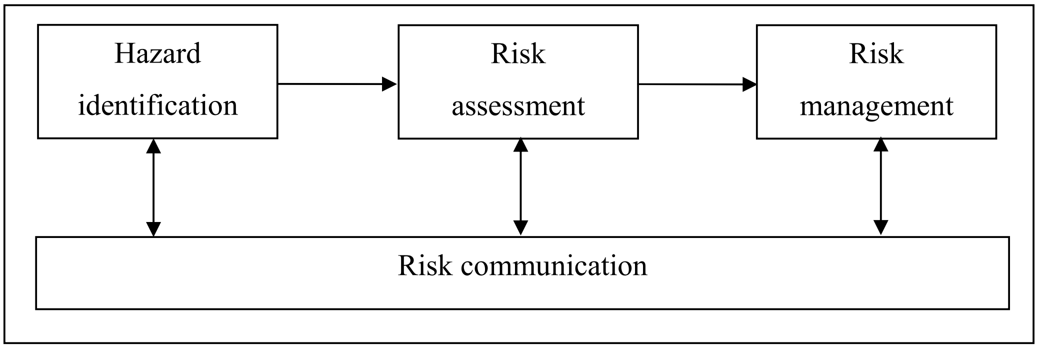


Figure 2.3: The four components of risk analysis (OIE, 2010).

Hazard identification involves identifying the pathogenic agents that have the potential to produce negative consequences for animal or human populations in the importing country. Risk assessment is the process of estimating any risks associated with a hazard. It consists of four steps: release or entry assessment, exposure assessment, consequence assessment and risk estimation (Figure 2.4). Release and exposure assessments can be expressed qualitatively or quantitatively. Release assessment describes the possible pathways for a specific identified pathogenic agent to enter a particular environment. Biological factors, country factors and commodity factors are the kinds of inputs required in this assessment. Exposure assessment estimates the probability of an exposure occurring following entry of a pathogen. If the result of the exposure assessment shows no significant risk, the risk assessment may conclude at this step. Consequence assessment estimates the probability of consequences of the hazard exposure occurring. The consequences can be direct, such as mortality and morbidity, or indirect, such as adverse economic and environmental outcomes. Risk estimation is the last step of risk assessment. It provides an estimation of the risk associated with the hazard by incorporating the results from the release assessment, exposure assessment and consequence assessment (OIE, 2010).

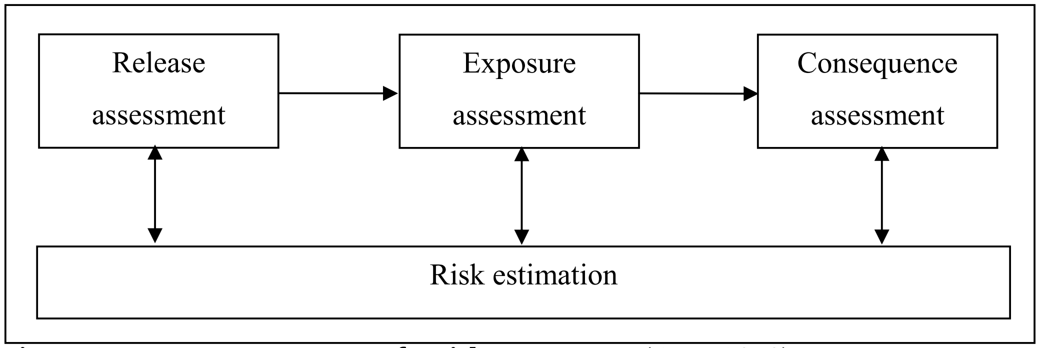


Figure 2.4: Four components of a risk assessment (OIE, 2010).

Risk management is the next step of the import risk analysis. This step includes risk evaluation, option evaluation, implementation, and monitoring and review (Figure 2.5). The risk evaluation compares the risk estimated in the risk assessment to the appropriate level of protection according to the importing country. Option evaluation is to identify, evaluate and select measures to reduce the risk of importation to the appropriate level of protection required by the importing country. The identified measures, when implemented, are monitored and reviewed to ensure that the intended results are achieved.

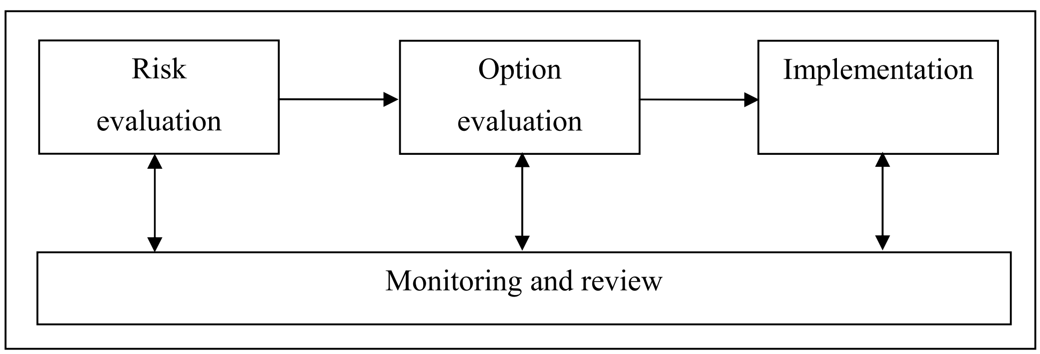


Figure 2.5: Four components of risk management (OIE, 2010).

The last component of import risk analysis is risk communication. Risk communication involves information sharing and data gathering from interested stakeholders that are potentially affected by an importation. It is conducted in an open, interactive and transparent manner through a consultation process to ensure that information and opinions are well communicated throughout the entire course of the risk analysis (OIE, 2010).

In this study, only the release and exposure assessments were undertaken. The hazard identification component was identified by examining the literature. The release assessment was conducted to identify possible pathways through which rabies virus may enter rabies-free Lombok, and to estimate the probability of the event occurring via each pathway. The exposure assessment was conducted to estimate the probability of a susceptible dog being exposed to the rabies virus from a rabies-infected dog introduced into Lombok (Chapter 8). Both of the assessments in this thesis were determined quantitatively. Consequence assessment and risk estimation were beyond the scope of this study.

Research on risk assessment in animal health implementing the OIE framework has been conducted on various topics, such as estimating the probability of release, exposure and consequence of *Mycobacterium bovis* from badgers to livestock (Gallagher et al., 2003), the probability of transmission of foot and mouth disease virus from antelope to livestock (Morgan et al., 2006), and the relative risk of *Brucella* spp. moving from bison to livestock (Kilpatrick et al., 2009). A more recent study that used the OIE import risk analysis framework was conducted in Australia to estimate the probability of release, exposure and consequences of an exotic West Nile Virus strain carried by an infected mosquito in an aircraft from the US landing at Sydney airport (Hernández-Jover et al., 2013).

The current study aims to determine the pathway for rabies release and exposure from rabies-infected islands to Lombok Island, and to assess the overall likelihood of introduction and exposure based on these pathways. The results will inform the consideration of various mitigation strategies, such as dog vaccination and targeting groups for education. The risk assessment step of the OIE import risk analysis framework was used in this research.

CHAPTER 3: DOG MANAGEMENT BY DOG-OWNING HOUSEHOLDS ON LOMBOK

3.1 INTRODUCTION

Globally, dogs are closely associated with humans, having the closest relationship with people of all the domesticated animals (Beck 2000). Dogs are kept in households as companions and are often considered as part of the family, especially in developed countries (Beck, 2000; Westgarth et al., 2013). In some communities, for instance Indigenous communities in Australia as well as ethnic groups living in Indonesia, dogs play an important role in the culture of the community (Bingham, 2001b; Constable, 2012; Putra et al., 2011a). However, when dogs are not fully provided for by people, with inadequate food, shelter and health care, then dogs will roam if not confined, to scavenge for food, for example, leading to the presence of semi-roaming and free-roaming dog populations. The level and type of interaction between people and dogs creates a risk for public health in relation to zoonotic diseases transmitted from dogs to humans, such as rabies. Thus, understanding the dog–human relationship is necessary to support planning for rabies prevention and control.

In Indonesia, where rabies is a major public health problem, domestic dogs are the only hosts observed to maintain rabies: there is no evidence of a wildlife role for the disease in this country (Putra et al., 2011b). Dogs are common in Indonesia and are kept for a range of purposes. Interestingly, attitudes towards dogs vary across the islands of Indonesia and are highly influenced by ethnic groups or cultural and religious beliefs. For instance, dogs are highly valued by Balinese and Timorese ethnic groups. Dogs are closely involved with community life, being kept not only as pets but also as guards to protect crops and to protect households from evil spirits, as a source of protein and for cultural reasons (wedding dowry and various ceremonial events). For Chinese ethnic groups, dogs are also valued, although mainly kept in the household as companions. For Javanese in Java, dogs are not commonly kept by households, but households with dogs provide proper care and only a small proportion of free-roaming dogs are seen on this island (Waltnertoews et al., 1990). For the ethnic groups that highly value dogs, it is possible that they will transport dogs within

Indonesia, leading to concern about the potential for disease spread. Evidence of animal disease spread through intentional movement of animals such as livestock has been documented (Fèvre et al., 2006). Recently, a dog that was moved from Morocco to the Netherlands via Spain was later found to be rabid, leading to costly efforts by authorities in the Netherlands and Spain to investigate people and animals that may have been exposed to the dog (van Rijckevorsel et al., 2012). Intentional dog movement is also a likely cause of rabies spread across Indonesia. One example of transported dogs being responsible for rabies spread in Indonesia is the documented spread of rabies to Flores Island (Bingham, 2001b).

The successful containment of rabies to the western end of Java Island (Chapter 2) most likely contributed to neighbouring Bali Island remaining rabies-free for a long period. Successful rabies control on Java was largely influenced by community attitudes towards dogs: the communities living in Java are majority Muslim, and thus have lower dog ownership. For Lombok Island, a rabies-free island neighbouring rabies-infected Bali Island, a mixed attitude towards dogs is likely to exist due to various ethnic groups living on Lombok. The main ethnic groups are the Sasakese (comprising 51.8% of the Lombok population), who are similar to the majority of communities living on Java in that dogs are not common in their households, and the Balinese (41.4% of the Lombok population), who commonly keep dogs. Understanding the presence of dogs within ethnic groups living on Lombok Island, and their management of their dogs, is necessary to develop strategies to prevent rabies incursion into Lombok Island. However, no study in Indonesia has yet been conducted on rabies-free islands in order to understand role of ethnicity in rabies introduction. Hence, this survey sought to understand the roles of ethnic groups living on Lombok Island in relation to the potential for introduction of rabies to this rabies-free island.

The objective of this survey was to obtain data on dog numbers and the dog management practices of dog-owning households belonging to different ethnic groups at an urban and a rural site on Lombok.

3.2 METHODS

3.2.1 STUDY SITES

The study sites purposely selected for this survey were one city and one district on Lombok which represent an urban area and a rural area considered high risk for the entry of rabies and inhabited by more than one ethnic group. Mataram City, the selected urban area, is located near the west coast of Lombok. It is the provincial capital of West Nusa Tenggara and the major commercial center on the island. This site was selected because Mataram City represents all ethnic communities living on Lombok Island, and it has a higher socio-economic status with a high density of people and dogs.

The selected rural area was West Lombok District. This district was chosen for the following reasons: its close proximity to rabies-infected Bali, the presence of several informal ports, and the presence of more than one ethnic group.

Within the two areas, two sites were purposively chosen: Cakranegara District in the urban area, and Batu Putih village in the rural area (the location of the survey sites on Lombok is shown in Figures 7.2 and 7.3). Cakranegara District was selected as it is inhabited predominantly by Balinese and Sasakese ethnic groups, with other ethnic groups in smaller numbers. It is a central business area in Mataram City and has a high density of people and dogs compared to other districts. Batu Putih village was selected because it has an informal port that is the closest to Bali of all the ports in Lombok, being approximately 45 minutes by boat to the south-eastern coast of Bali. This informal port has no quarantine post and is often visited by boats from Bali. Furthermore, this village is inhabited predominantly by Balinese and Sasakese ethnic groups and fishing is the main occupation for some households.

3.2.2 STUDY POPULATION

The study population for this survey was dog-owning households at the urban and rural sites. These were divided into two categories according to ethnic group: the Balinese ethnic group and the Non-Balinese ethnic group.

The standard formula for sample size to estimate a proportion determined a target sample size of 235 households per ethic group at the urban site, based on a population of 5000, 95% confidence, 5% precision and 20% expected prevalence of pedigree dog ownership, using Win Episcope 2.0 (http://www.clive.ed.ac.uk). For the rural site, the standard formula for sample size to estimate a proportion determined a target sample size of 198 households per ethnic group, based on a population of 1000, 95% confidence, 5% precision and 20% expected prevalence of pedigree dog ownership, using Win Episcope 2.0 (http://www.clive.ed.ac.uk). However, the total number of households per ethnic group at the rural site was considered to be lower than 198; thus, it was decided to interview 100 households per ethnic group at this site.

At the urban site, we aimed to interview 250 households of the Balinese ethnic group and 250 households of the Non-Balinese ethnic group. Twelve Lingkungan (a term for a village in an urban setting) at the urban site were selected for interviews (details of the selection process are provided in Chapter 7). The 12 locations are listed in Table 3.1.

Table 3.1: The 12 locations selected at the urban site.

Urban site	Name of the location
Cakranegara district	Lingkungan Sayang Daye (SD)
	Lingkungan Lendang Re (LR)
	Lingkungan Gubug Panaraga (GP)
	Lingkungan Karang Sampalan (KS)
	Lingkungan Pamotan (P)
	Lingkungan Sweta Selatan (SS)
	Lingkungan Seganteng Karang Monjok (SKM)
	Lingkungan Karang Tageban (Ktag)
	Lingkungan Karang Tulamben (Kta)
	Lingkungan Karang Wana Sara (KWS)
	Lingkungan Karang Bungkulan (Kbg)
	Lingkungan Karang Jasi (Kja)

At each of these locations, the interview team consulted with the community leader (Kepala Lingkungan) to seek information on dog-owning households in the area. Of the 12 locations, five locations were known to be inhabited by a majority Balinese ethnic group. These five locations are listed in Table 3.2 and shown in Figure 7.2. At each of these locations, 50 Balinese dog-owning households were interviewed. Convenience sampling was conducted to obtain these households. At each location, one interview team proceeded with the Kepala Lingkungan and the Kepala

Lingkungan appointed households that owned dogs. The interviewee then interviewed the household if the dog owner or the person who took care of the dog was present.

Table 3.2: The five locations at the urban site inhabited by a majority Balinese ethnic group.

Urban site	Name of location
Cakranegara district	Lingkungan Karang Sampalan
	Lingkungan Karang Jasi
	Lingkungan Karang Wana Sara
	Lingkungan Karang Tulamben
	Lingkungan Karang Bungkulan

In contrast, at the remaining seven locations, none of the community leaders had information on Non-Balinese (Sasakese, Chinese and other ethnic group) dog-owning households residing at these locations. However, each community leader was helpful and did ask around the Lingkungan to find the names of dog-owning households. In this way, two Chinese dog-owning households were identified in Lingkungan Sweta Selatan; however, only one of them was willing to be interviewed. The other one refused due to being busy.

In order to address this deficiency of Non-Balinese dog-owning households, an alternative approach to sampling was then implemented. A veterinarian that worked in Mataram City was consulted to obtain information regarding the addresses of Non-Balinese dog-owning households at the urban site. The veterinarian provided approximately 80 addresses, of which only 32 were able to be identified. Snowballing was used to obtain data from the Non-Balinese households interviewed about other Non-Balinese dog-owning households in Mataram City. Information on 19 other households was gathered; however, only 17 were identified. The 49 Non-Balinese households interviewed lived across Mataram City (not only in Cakranegara District).

At the rural site, we aimed to interview 100 households each of Balinese and Non-Balinese ethnic groups. However, the village leader informed us that the number of Balinese households at this site was 60, all of whom owned dogs, but he could not provide a list of Sasakese households owning dogs; therefore, we aimed to interview the same number of Balinese and Non-Balinese dog-owning households at this site. For the Balinese households, each household in the village was visited and an interview conducted when the occupant was at home at time of visit, if they currently owned dog/s. A total of 50 interviews were completed. For the Sasakese households, 50 dog-owning households were interviewed, and the snowballing method was used to identify the dog-owning households. We estimate that these households represent 80% of the Sasakese dog owners in this village.

3.2.3 QUESTIONNAIRE DESIGN

A structured questionnaire was designed for dog-owning household respondents, to obtain data on number of dogs owned, dog source, dog function, dog management, dog bite victim and knowledge of rabies. The questionnaire was developed in English and translated into Bahasa Indonesian by an independent university academic, then back translated from Bahasa into English by a member of the Indonesian research team. Points of difference were identified and discussed by the two translators and clarified to determine the correct final wording in Bahasa. Minor modification of the questionnaire was performed after trialling with ten dog-owning households at the urban and rural sites. Of these, the five dog-owning households living at the urban site included two Sasakese and three Balinese households, and the five dog-owning households at the rural site included three Sasakese and two Balinese households. The data obtained from the pilot trial were included in the data analysis. During the conduct of the survey, each questionnaire was coded with a unique dog-owning household identification code. The questionnaire is presented in Appendix 1.

3.2.4 CONDUCT OF SURVEY

This survey was conducted from January to April 2012 by the author and a team of 8 people at the Research Centre for Rural Development, University of Mataram,West Nusa Tenggara Province. This team was well-trained and had extensive experience in conducting questionnaire surveys, including for ACIAR projects on cattle and poultry movement conducted in NTB province. Before the pilot trial of the questionnaire, a training day took place for the team to familiarise themselves with the questionnaire. After the pilot trial, another training day took place for the team to familiarize themselves with the modified questionnaire.

The questionnaire was administered by face-to-face interview with the person responsible for dog management at the household residence. The interviews were usually completed in 30 to 35 minutes and a rabies brochure and incentive of 20,000 IDR were given to participants on completion of the interview.

Ethics approval for this survey was obtained from the Ethics Committee at the University of Mataram, since the data collection was conducted in Lombok, Indonesia. Informed consent was obtained from the survey participants.

3.2.5 DATA MANAGEMENT AND ANALYSIS

Data were entered into Microsoft Excel and subsequently checked for missing and extreme values against the hardcopy questionnaires. Standard descriptive analyses were conducted using Genstat 14th edition (PC/Windows, 2007, VSN International Ltd., Hemel Hempsted, UK). Categorical data were described using frequency tables and continuous variables using mean, median and range. Standard statistical tests were used to determine statistical difference between categories for categorical variables (chi-square) and between means for continuous variables (t-test).

3.3 RESULTS

3.3.1 DOG OWNERSHIP

A total of 400 dog-owning households were interviewed in this survey. At the urban site, the households were comprised of 250 Balinese and 50 Non-Balinese, including seven different ethnic groups (Table 3.3). At the rural site, there were 50 Balinese and 50 Non-Balinese households, with all Non-Balinese being Sasakese at this site.

Among the urban dog-owning households, 186/300 (62.0%) households owned one dog, 81/300 (27.0%) owned two dogs, 22/300 (7.3%) owned three dogs and 11/300 (3.7%) owned between four and six dogs. Of the 100 rural dog-owning households, 57 (57.0%) households owned one dog, 31 (31.0%) owned two dogs, three (3.0%) owned three dogs and nine (9.0%) owned between four and seven dogs. When comparing the number of dogs owned per household at the urban (mean 1.6) and rural sites (mean 1.7), no statistically significant difference was found ($p = 0.938$).

Table 3.3: Number of each ethnic group within the Non-Balinese interviewed at the urban and rural sites in survey of dog owning households on Lombok in 2012.

Site	Non-Balinese ethnic group						
	Chinese	Sasakese	Javanese	Flores	Batak	Bima	Expatriate
Urban (n = 50)	44% (22/50)	22% (11/50)	16% (8/50)	12% (6/50)	2% (1/50)	2% (1/50)	2% (1/50)
Rural (n = 50)	0	100% (50/50)	0	0	0	0	0

3.3.2 DOG SOURCE

At both sites, the vast majority of households owned dog/s that originated from Lombok (96.0%). The remaining 16 (4.0%) households obtained dogs from outside Lombok (Table 3.4), and belonged to the following ethnic groups: Balinese (nine households), Chinese (three), Sasakese (two), Javanese (one) and Timorese (Flores) (one).

Of these 16 households, the 15 at the urban site reported obtaining dogs from Java and Bali, and the one household at the rural site reported obtaining dogs from Bali. All reported that the dog/s was transported in a vehicle and the vehicle was transported on the ferry from the Padang Bai ferry port of Bali to the Lembar ferry port of Lombok on a night trip. Two of the households reported that the dog/s were sedated. The total number of dogs brought was 22: 18 dogs were from Bali Island and four were from Java; 19 were pedigree dogs and the remainder were non-pedigree dogs. None of these dogs were reported to have had documents to travel. Eleven households reported that the dogs they brought in had been vaccinated; however, they were not able to identify the type of vaccination.

Table 3.4: Source of dog reported by the 400 dog-owning households interviewed at the two sites on Lombok Island in 2012.

Site / Ethnic group	Number of households		
	Household owned dog/s that originated from Lombok	Household owned dog/s that originated from outside Lombok	Household owned dogs that originated from Lombok and outside Lombok
Urban			
Balinese (n=250)	96.4% (241/250)	2.4% (6/250)	1.2% (3/250)
Non-Balinese (n=50)	88% (44/50)	12% (6/50)	0
Total	95% (285/300)	4% (12/300)	1% (3/300)
Total number of the Balinese and Non-Balinese ethnic group = 300			
Rural			
Balinese (n=50)	100% (50/50)	0	0
Sasakese (n=50)	98% (49/50)	2% (1/50)	0
Total	99% (99/100)	1% (1/100)	0
Total number of the Balinese and Non-Balinese ethnic group = 100			

3.3.3 TYPE OF DOG KEPT

Overall, the most common type of dog kept by all ethnic groups interviewed was non-pedigree, except for the Chinese ethnic group, in which 77.3% of households owned pedigree dogs. The percentage of households owning pedigree dogs was higher at the urban site than the rural site (Table 3.5).

Table 3.5: Type of dog owned by the 400 dog-owning households interviewed at the two sites on Lombok in 2012.

Site / Ethnic group	Number of households		
	Owned local dog type (%)	Owned pedigree dog type (%)	Owned both local and pedigree dog type (%)
Urban			
Balinese (n = 250)	74% (185/250)	18.8% (47/250)	7.2% (18/250)
Non-Balinese (n = 50)	50% (25/50)	48% (24/50)	2% (1/50)
Chinese (n = 22)	18.2% (4/22)	77.3% (17/22)	4.5% (1/22)
Sasakese (n = 11)	72.7% (8/11)	27.3% (3/11)	0
Javanese (n = 8)	75% (6/8)	25% (2/8)	0
Timorese (Flores) (n = 6)	83.3% (5/6)	16.7% (1/6)	0
Other (n = 3)	66.7% (2/3)	33.3% (1/3)	0
Rural			
Balinese (n = 50)	96% (48/50)	2% (1/50)	2% (1/50)
Non-Balinese			
Sasakese (n = 50)	98% (49/50)	2% (1/50)	0

3.3.4 DOG FUNCTION

Guard dog was the main function of dogs kept by both ethnic groups (Balinese and Non-Balinese) at both sites, with dogs being used to guard the house at the urban site and to guard house and plantation at the rural site. Dogs were kept solely as pets by Balinese, Chinese, Javanese, Timorese and Expatriate households at the urban site, with the percentage notably higher for Chinese households. Only one Chinese household reported keeping dogs to trade (Table 3.6).

Table 3.6: Function of dog reported by the 400 dog-owning households interviewed at the two sites on Lombok in 2012.

Site / Ethnic group	Number of households keeping dog as			
	Guard dog	Pet dog	Pet as well as guard dog	Trading purpose
Urban				
Balinese (n = 250)	61.6% (154/250)	8.4% (21/250)	30% (75/250)	0
Non-Balinese (n = 50)				
Chinese (n = 22)	12% (6/50)[a]	16% (8/50)[a]	14% (7/50)[a]	2% (1/50)[a]
	27.3% (6/22)[b]	36.4% (8/22)[b]	31.8% (7/22)[b]	4.5% (1/22)[b]
Sasakese (n = 11)	20% (10/50)[a]	0	2% (1/50)[a]	0
	90.9% (10/11)[b]	0	9.1% (1/22)[b]	0
Javanese (n = 8)	6% (3/50)[a]	4% (2/50)[a]	6% (3/50)[a]	0
	37.5% (3/8)[b]	25% (2/8)[b]	37.5% (3/8)[b]	0
Timorese (Flores) (n = 6)	8% (4/50)[a]	2% (1/50)[a]	2% (1/50)[a]	0
	66.6% (4/6)[b]	16.7% (1/6)[b]	16.7% (1/6)[b]	0
Other[c] (n = 3)	2% (1/50)[a]	2% (1/50)[a]	2% (1/50)[a]	0
	33.3% (1/3)[b]	33.3% (1/3)[b]	33.3% (1/3)[b]	0
Rural				
Balinese (n = 50)	86% (43/50)	0	14% (7/50)	0
Non-Balinese				
Sasakese (n = 50)	100% (50/50)	0	0	0

[a] The number indicates the percentage of households within Non-Balinese ethnic groups (n = 50 households)
[b] The number indicates the percentage of households within each ethnic group
[c] Batakese ethnic group, Bimanese ethnic group and Expatriate

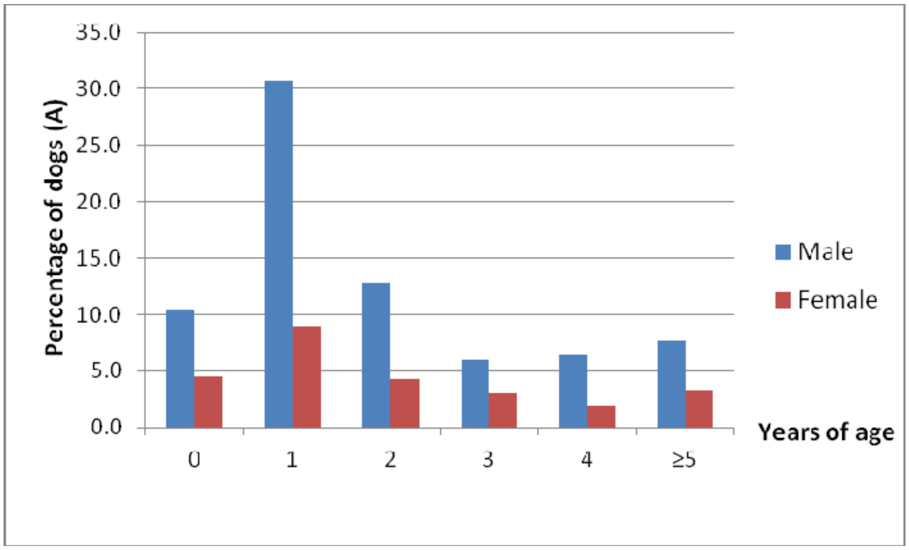
3.3.5 DOG DEMOGRAPHICS AND CONFINEMENT

A total of 638 dogs were kept by the households surveyed. Male dogs were more numerous at both study sites (X^2 = 2.64, p = 0.104), constituting 74.1% of dogs at the urban site (*n* = 468) and 67.6% at the rural site (*n* = 170) (Figure 3.1), with a sex ratio (male: female) of 1:0.3 at the urban site and 1:0.5 at the rural site. The same median age was seen for dogs living at the rural and urban sites (Table 3.7). The majority of dogs owned at both sites were non-pedigree or local breed, with the highest percentage of non-pedigree dogs at the rural site (Table 3.7).

The movement of dogs living at the urban site was better controlled than at the rural site. Of the 468 dogs at the urban site, 137/468 (29.3%) were restricted at all times, whereas dogs at the rural site were either always allowed to roam outdoors or allowed semi-free roaming (roaming freely for some hours each day), and none of the dogs were restricted at all times (Table 3.7). A significant difference between the urban and rural sites was found in the number of dogs across the confinement categories (X = 65.61, d.f. = 2, $p < 0.001$). Among the 137 confined dogs at the urban site, the percentage of confined dogs was significantly higher for pedigree dogs at 59.9% (82/137) than for non-pedigree dogs at 40.1% (132/329) (X = 15.2, d.f. = 1, $p < 0.001$) (Table 3.8).

Table 3.7: Demographics and confinement of 638 dogs owned by households interviewed at the urban and rural sites on Lombok in 2012.

	Urban site	Rural site
Number	468	170
Demographics		
Age in years mean (median, range)	2.9 (2, 0.08–15)	2.1 (2, 0.08–10)
Sex		
Male	74.1% (347/468)	67.6% (115/170)
Female	25.9% (121/468)	32.4% (55/170)
Dog type		
Pedigree	29.7% (139/468)	1.8% (3/170)
Non-pedigree	70.3% (329/468)	98.2% (167/170)
Confinement		
Totally confined	29.3% (137/468)	0
Semi-free roaming	25.6% (120/468)	29.4% (50/170)
None (always allowed to roam)	45.1% (211/468)	70.6% (120/170)



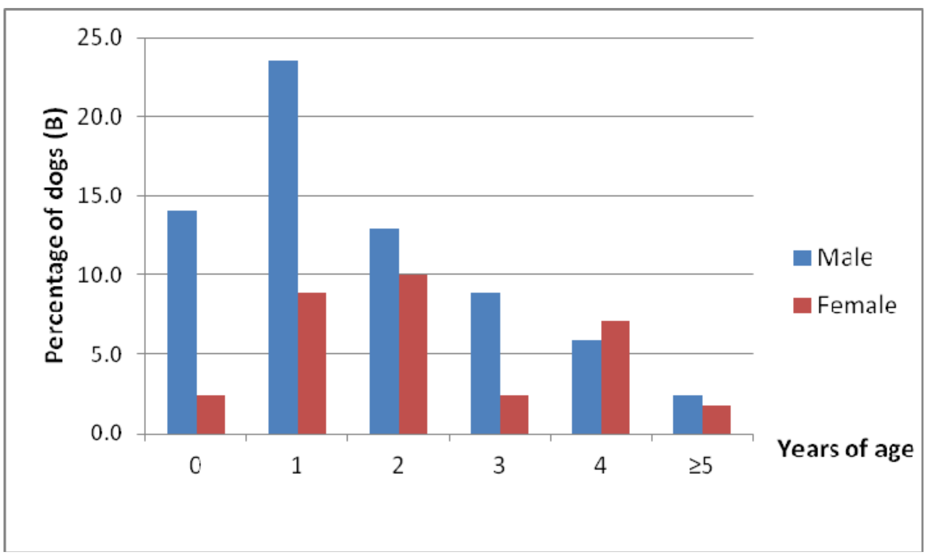


Figure 3.1: Age and sex distribution of the dogs owned by the households interviewed at the urban (A) and rural (B) sites on Lombok in 2012.

Table 3.8: Management of 635 dogs owned by 400 interviewed households in urban and rural sites on Lombok in 2012.

Site / Ethnic group	Dog Type	Number of dogs	Percentage of dogs		
			Confined	Semi free roaming	None (always allowed to roam)
Urban					
Balinese household	Pedigree dog	103	51.5% (53/103)	14.6% (15/103)	33.9% (35/103)
	Local breed dog	296	16.9% (50/296)	29.4% (87/296)	53.7% (159/296)
Non-Balinese household	Pedigree dog	26	92.3% (24/26)	7.7% (2/26)	0
Chinese	Local breed dog	6	66.7% (4/6)	33.3% (2/6)	0
	Pedigree dog	3	66.7% (2/3)	33.3% (1/3)	0
Sasakese	Local breed dog	9	0	0	100% (9/9)
	Pedigree dog	4	50% (2/4)	50% (2/4)	0
Javanese	Local breed dog	6	16.7% (1/6)	66.6% (4/6)	16.7% (1/6)
	Pedigree dog	1	100% (1/1)	0	0
Flores	Local breed dog	8	0	75% (6/8)	25% (2/8)
	Pedigree dog	2	0	0	100% (2/2)
Other ethnic	Local breed dog	4	0	25% (1/4)	75% (3/4)
Total	Pedigree dog	139	59% (82/139)	14.4% (20/139)	26.6% (37/139)
	Local breed dog	329	16.7% (55/329)	30.4% (100/329)	52.9% (174/329)
Rural					
Balinese household	Pedigree dog	2	0	0	100% (2/2)
	Local breed dog	73	0	42.5% (31/73)	57.5% (42/73)
Sasakese household	Pedigree dog	1	0	100% (1/1)	0
	Local breed dog	94	0	19.1% (18/94)	80.9% (76/94)
Total	Pedigree	3	0	33.3% (1/3)	66.7% (2/3)
	Local breed dog	167	0	29.3% (49/167)	70.7% (118/167)

3.3.6 DOG BITE CASES

A total of 27 households that were interviewed reported 29 dog bite cases in the last five years. One Balinese household reported 3 dog bite cases in the household.

At the urban site, 12 Balinese households reported 14 dog bite cases: the median age of the 14 people was 34 years (min 1, max 77). One Non-Balinese (Timorese-Flores) household reported 1 dog bite case, aged 17 years old.

At the rural site, 6 dog bite cases were reported by 6 Balinese households, with a median age of 14 years (min 5, max 65), while 8 Non-Balinese households reported 8 dog bite cases, with median age of 37.5 years (min 10, max 65).

Of the total 29 dog bite cases, the majority of them were children (aged between 1 and 15 years) (Figure 3.2). There were more dog bite cases in males (62.1%, 18/29) than in females (37.9%, 11/29) (X^2 = 1.69, p = 0.194). The leg was part of the body reportedly bitten the most (68.9%), then hand/arm (17.4%), stomach (6.9%), hip (3.4%) and shoulder/neck (3.4%).

The dog bite cases were frequently bitten by another person's dog or their own dog (48.3% and 44.8%, respectively) with only 6.9% of bite cases bitten by a free-roaming dog (Table 3.9).

Only five people at the urban site and one person at the rural site went to hospital for treatment of bite wounds: all belonged to the Balinese ethnic group. The other cases treated their wound/s at home by cleaning the wound with or without application of iodine. Other types of treatment, such as using traditional medication, were reported at both the urban and rural sites, but were more common at the rural site. Non-treatment of the wound was higher at the rural site (Table 3.10).

Table 3.9: Dog bite case reported by 27 dog owning households interviewed in the urban and rural sites on Lombok in 2012.

Ethnic group	Number of persons bitten	Age	Gender		Part of body bitten (number of person)					Category of dog that bite		
			Male	Female	Leg	Hand/arm	Stomach	Hip	Shoulder/ Neck	Own dog	Other person's dog	FD* dog
Urban Cakranegara district of Mataram city												
Balinese household	14	Mean: 32.3 Median: 34 Min: 1 Max: 77	10	4	7	5	2	0	0	8	5	1
Non-Balinese household	1	17 years old	1	0	1	0	0	0	0	1	0	0
Rural Batu Putih West Lombok												
Balinese household	6	Mean: 20.5 Median: 14 Min: 5 Max: 65	4	2	5	0	0	1	0	0	5	1
Non-Balinese household	8	Mean: 33.4 Median: 37.5 Min: 10 Max: 65	3	5	7	0	0	0	1	4	4	0
Total	**29**		18	11	20	5	2	1	1	13	14	2

FD: free-roaming

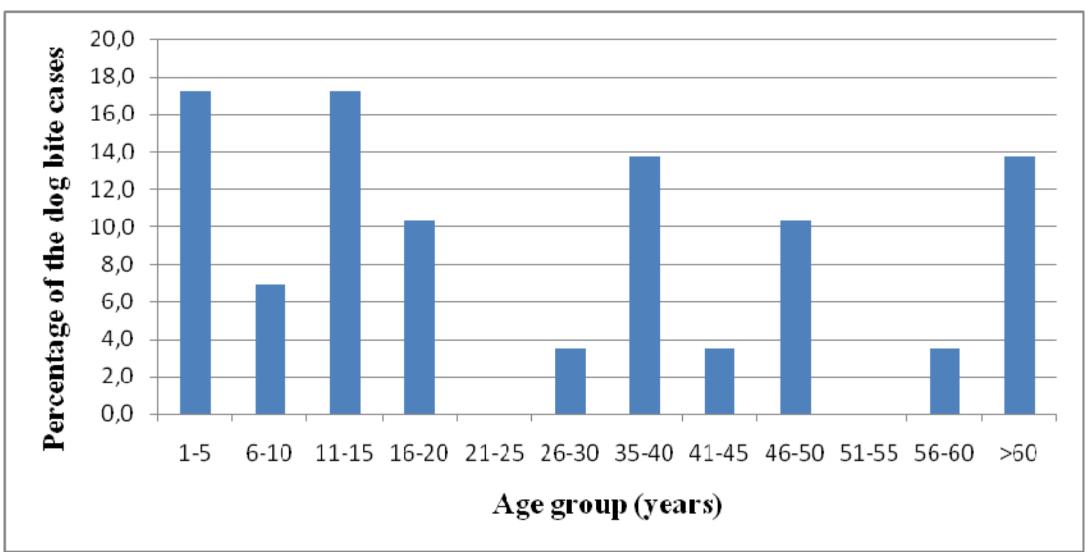


Figure 3.2: Age distribution of the 29 dog bite cases recorded during the survey of dog owning households on Lombok in 2012.

Table 3.10: Treatment applied to the dog bite wound of the 29 dog bite cases recorded during the survey of dog owning households on Lombok in 2012.

Site / Ethnic group	Treatment to wound				
	Seek treatment at hospital	Clean the wound and apply iodine	Only clean the wound	Traditional medication	No treatment at all
Urban					
Balinese (n =14)	35.7% (5/14)	35.7% (5/14)	0	21.4% (3/14)	7.1% (1/14)
Non-Balinese (n = 1)	0	100% (1/1)	0	0	0
Rural					
Balinese (n = 6)	16.7% (1/6)	16.7% (1/14)	16.7% (1/6)	33.2% (2/6)	16.7% (1/6)
Non-Balinese (n = 8)	0	0	0	62.5% (5/8)	37.5%(3/8)
Total of 29					

3.4 DISCUSSION

This survey documented dog management by ethnic groups living at an urban and a rural site on Lombok Island, Indonesia. Knowledge of dog management practices on this rabies-free island is valuable as they are likely to have important implications for the introduction of rabies to, and the spread of rabies on, Lombok.

In Balinese communities, dogs are a part of community life, and no Balinese village is without the presence of dogs (Putra et al., 2011a). During the conduct of this work, it was evident that Balinese households on Lombok do frequently keep dogs. At both sites, the vast majority of Balinese households visited owned dogs. Among the total of 3252 Balinese households at the urban site, 8% (250 households) of households were interviewed, with only minimum effort required to identify households with dog/s. At the urban site, although we attempted to interview dog-owning households that belong to Non-Balinese ethnic groups according to the required sample size, only 50 Non-Balinese households owning dogs were identified. This may be due to the fact that the Non-Balinese population living at the urban site is mainly comprised of Sasakese, with smaller numbers of other ethnic groups such as Chinese, Javanese, Sumbawa, Timorese-Flores and some other ethnic groups. The majority of Sasakese, Javanese and Sumbawa households on Lombok are Muslim (Direktorat Jenderal Kebudayaan

Republik Indonesia, 2013b; Sukri, 2005; Waltnertoews et al., 1990), and are known to be unlikely to keep dogs. Muslim communities are also known to be less likely to keep dogs in other places with a predominantly Muslim population, such as in Cairo and Bangladesh (Hossain et al., 2013). However, at the rural site this effect of religion on dog ownership was less evident. The majority of Sasakese households at the rural site in West Lombok district have a plantation in the mountains and need dogs to chase away monkeys and feral pigs, to prevent them from destroying their valuable crops. At the rural site, Sasakese were the only Non-Balinese in the village.

The results of this survey show that the majority of dog owners across the various ethnic groups at both sites owned dogs that originated from Lombok Island. However, 16 households interviewed had obtained dogs from another island in the last five years. These 16 households reported bringing a total of 22 dogs into Lombok, of which 18 dogs were from rabies-infected Bali Island. The legislation of the Indonesia Agriculture Quarantine Agency (IAQA), which states that dog importation from a rabies-infected area to a rabies-free area is prohibited (Chapter 2), indicates that these dog introductions to Lombok were illegal. Furthermore, none of the 16 households reported having a health statement and vaccination record for the imported dogs. Although 11 of the 16 households reported that the imported dogs had been vaccinated before being brought to Lombok, they did not know the type of vaccination and could not present the vaccination record when asked. Concern arises from this finding that dog owners are not aware of the health status of their dogs, clearly indicating that education is highly needed. This finding showed that there is opportunity for rabies exposure to the Lombok dog population by the introduction of dogs from rabies-infected islands, as there is no rabies vaccination program conducted on Lombok. This study has made an important finding: that there is dog movement from a rabies-infected island to rabies-free Lombok island. Although the percentage was small – 5% of the interviewed households at the urban site and 1% at the rural site – this practice poses a risk for rabies introduction to rabies-free Lombok island.

Of the 16 households that brought dogs to Lombok, nine households were Balinese, all living at the urban site. Seven households were Non-Balinese, with one of these living at the rural site. All of these households were considered by the interview team to have a middle to high socioeconomic level based on the type of residence, and because pedigree dogs are known to have high purchase prices. Interestingly, even though dog ownership is not common for Sasakese, two of the Sasakese households reported bringing dogs from another island to keep.

Our findings indicate that dog-owning households on Lombok prefer male dogs to females; both at the urban and rural sites, male dogs were predominant. The skewed sex ratio with predominance of males reflects a preference for male dogs. Based on common local understanding, female puppies are high likely to be abandoned soon after birth (drh. Aminurrahman personal communication, 2013). The preference appears to be also related to guarding duties, given the majority of interviewed households keep dogs for guard duty. A preference for keeping dog for guarding purposes is also seen in other countries such as Madagascar, Tanzania and the Philippines (Beran, 1982; Knobel et al., 2008; Ratsitorahina et al., 2009).

We found that among the Chinese households interviewed, most owned pedigree dogs rather than local non-pedigree dogs. The other ethnic groups were different, with the percentage of households owning non-pedigree dogs being higher than those owning pedigree dogs. However, of the 22 dogs that were obtained outside Lombok, the 19 pedigree dogs were brought to Lombok by more than one ethnic group, and most were brought to the urban site. This suggests that there is a growing trend among ethnic groups living in urban settings on Lombok to own pedigree dogs. Unlike Bali with its native dog breed (Kintamani) and a variety of dog breeds sold by pet shops, traditional live animal markets, dog traders and dog breeders; on Lombok Island, pedigree dogs are not easily found. This creates the possibility of further illegal dog movement from outside Lombok to Lombok not only for keeping purposes, but also for trading purposes.

In this survey, dogs were confined in a higher proportion of urban households than rural households, although free roaming owned dogs were also common at the urban site. Overall at the urban site, many (25.6%) owned dogs were semi-free roaming or allowed to roam for some hours, especially during the day, and 45.1% of dogs were free roaming. At the rural site, 29.4% of owned dogs were semi-free roaming and 70.6% were free roaming. These roaming dogs provide ideal conditions for the persistence of pathogenic infections in the dog population and for transmission of rabies virus between dogs and to other species. Furthermore, a substantial number of roaming dogs indicates a threat of zoonotic disease transmission from dogs to people, which is a concern for public health. Therefore, control and management of owned dogs is needed through education of dog owners by relevant government authorities and veterinarians. The presence of free roaming dogs is also seen elsewhere in North and Southern America, Africa, Asia and Southern Europe (Acosta-Jamett et al., 2010; Beran, 1982; Butler et al., 2004; Daniels and Bekoff, 1989; Slater et al., 2008).

This survey recorded dog bite cases both in urban and rural areas. The reported dog bite cases were mostly children (up to 15 years old) and the highest frequency of cases was in males. The finding that dog bite cases were more prominent in children and males has also been found in other countries in Asia, such as Bangladesh, Bhutan and India (Childs and Real, 2007; Hossain et al., 2012; Tenzin et al., 2011a). Human males and individuals below <20 years of age are mentioned as risk factors for rabies incidence related to dog bites (Cleaveland et al., 2002; Fekadu, 1982; Lakhanpal and Sharma, 1985). In this survey the leg was the body part most frequently bitten, as reported for dog bites in Bhutan (Tenzin et al., 2011a).

Information on bite wound treatment was also collected in this survey. Better wound treatment, such as washing the wound with soap, application of antiseptic after washing, and going to the hospital, was reported by only a small number of households, which were more often Balinese households at the urban and rural sites. For the remaining bite cases, treatment was traditional medication or none at all. The negligent care of animal bites found in this survey is similar to that found in Bangladesh (Hossain et al., 2012). Proper wound care is part of post-exposure prophylaxis for rabies (Chapter 2); thus, information on wound care should be made available in Lombok as part of a rabies prevention strategy. A reporting system also needs to be established at the village level, which would allow monitoring of dog bite incidence and support detection of an increase in dog bite reports that would provide an important tool to rapidly alert relevant authorities of the possibility of a rabies incursion.

In summary, the findings on dog management in Lombok are useful as a basis to estimate the probability of rabies introduction posed by Lombok dog owners. This survey suggests a pattern of dog ownership on Lombok that is affected by ethnic group in relation to cultural beliefs, which are similar to those of indigenous communities in Australia (Constable, 2012), and is also influenced by religious beliefs, as seen in Nigeria and in different islands within Indonesia (Eze and Eze, 2002; Hutabarat et al., 2003; Putra et al., 2011a; Waltnertoews et al., 1990). Education of dog owners is urgently needed regarding control and management of their dogs, the problem of rabies, and the quarantine regulations in terms of the requirements for legal introduction of dogs and the penalty for illegal dog movement.

CHAPTER 4: SURVEY AT INFORMAL PORTS ON LOMBOK

4.1 INTRODUCTION

Indonesia, as an archipelago country, uses sea transportation as a common method for travel between islands. Ferries from PT. Pelni and other major ferry companies in Indonesia provide affordable fares and offer travel to destinations on almost every island. Travelling by ferry also enables passengers to travel with their vehicle, as the ferries allow light vehicles (cars and motorbikes) and heavy vehicle (minibuses, buses and trucks) on board (PT ASDP Indonesia Ferry, 2013). Fishing boats are also common in Indonesia. It has been suggested in the literature that rabies spread to Flores in 1997 and to Bali in 2008 through dog movement on fishing or cargo boats (Section 2.9.2 Chapter 2). However, there has been no research in Indonesia to investigate the role that these types of transportation play in moving dogs.

For Lombok, which has a number of ports around its coastline, boating activity is common, and ferries are an important means of transportation for inter-island travel to Bali and Sumbawa via two formal ferry harbours (Section 2.9.5.1). As fishing or cargo boats are said to be the forms of transportation that moved dogs leading to the spread of rabies to Bali and Flores, it is necessary to investigate dog transportation on boats docking on Lombok to gain an understanding of the risk of rabies introduction posed by such crafts. Therefore, the objectives of the two surveys reported in this chapter were to describe the management of dogs transported to Lombok on fishing and other boats, and the frequency of this type of dog transport to Lombok. Interviews were conducted at informal ports with captains of boats that originated from other parts of Indonesia, and with captains of local Lombok boats. Dog observation was also undertaken at these ports.

4.2 METHODS

4.2.1 SURVEY SITES

According to the Marine and Fisheries Agency, West Nusa Tenggara Province, there are a total of 24 ports around the coastline of Lombok Island, comprising 22 informal ports (ports with no quarantine office) and two formal harbours. The informal ports are visited by fishing boats, small cargo boats and tourist boats from other parts of Indonesia, whereas the formal harbours are used for ferries connecting Lombok with Sumbawa Island from its east coast, and with Bali from its west coast.

For the survey of boats that originated from outside Lombok, study sites were purposively selected on the basis of three criteria: a high level of boat activity by local Lombok boats; a high frequency of visitation by boats from other parts of Indonesia; and close proximity to a rabies-infected island. To inform site selection, a preliminary visit was made to each of the 24 ports and interviews were conducted with the port manager or village leader to gather information about boat activity, and, where applicable, about ethnic groups living in the village associated with the port. Information was also obtained from the Marine and Fisheries Agency, West Nusa Tenggara Province, about the ports with a high frequency of visitations by boats from other parts of Indonesia. Initially, ten sites were selected for the survey, including eight informal ports and the two formal ports (Table 4.1). However, on completion of all preliminary visits, the two formal ports and the one informal port of Teluk Awang were removed. Consultation with port managers at the formal Lembar port and Kayangan port confirmed that no boats other than ferries dock at these ports, and the port managers stated they were not aware of dogs or other animals being transported on ferries since only passengers and vehicles are permitted to board the ferries. Consultation with the leader of the village associated with Teluk Awang port confirmed that this port was closed for several months due to construction in order to accommodate large fishing ships.

For the survey of boat captains from local Lombok households, the abovementioned three criteria were used to select the study site/s. One further criterion considered was the presence of Balinese and Sasakese households involved in boat activities living in the village associated with the port. Only one port (Bangko-bangko) met these four criteria for the survey of local boats. Figure 4.1 shows the location of all survey sites.

Table 4.1: Ports that met the three criteria for inclusion in a survey of captains of boats that originated from outside Lombok, conducted on Lombok Island in 2012.

No.	Name of port/harbour	Type of port	Location	Proximity to
1.	Tanjung Luar	Informal port	Eastern Lombok	Sulawesi, Sumbawa and Flores Island
2.	Labuhan Lombok	Informal port	Eastern Lombok	Sulawesi, Sumbawa and Flores Island
3.	Labuhan Haji	Informal port	Eastern Lombok	Sulawesi, Sumbawa and Flores Island
4.	Kayangan Lama	Informal port	Eastern Lombok	Sulawesi, Sumbawa and Flores Island
5.	Kayangan	Formal port	Eastern Lombok	Sulawesi, Sumbawa and Flores Island
6.	Teluk Awang	Informal port	Southern Lombok	Sumbawa Island
7.	Bangko-bangko	Informal port	Western Lombok	Bali
8.	Lembar	Formal port	Western Lombok	Bali
9.	Teluk Nara	Informal port	Northern Lombok	Sulawesi and Bali
10.	Bangsal	Informal port	Northern Lombok	Sulawesi and Bali

Figure 4.1: Study sites initially selected for the surveys of local boats (A) and boats originating from other islands (A&B) on Lombok. The three removed after preliminary visits are indicated with a yellow arrow.

4.2.2 Survey groups

Two surveys were conducted: a survey of captains of boats that originated from outside Lombok and visited Lombok Island during the days of the survey visit; and a survey of captains of local Lombok boats.

For the second survey, only captains from households belonging to Balinese and Sasakese ethnic groups that either had dogs in their household, or had no dogs but had experience sailing to rabies-infected islands (the latter consideration was added after preliminary visit and questionnaire trialing), were interviewed. As explained in Chapter 3, these ethnic groups have different preferences toward dogs. Therefore, households with no dogs but had experienced sailing to rabies-infected islands were included to capture information on whether they brought dogs from rabies-infected islands to Lombok.

4.2.3 Questionnaire design

For the survey of boat captains that originated from outside Lombok, the questionnaire comprised five sections: respondent data; respondent background, to capture information on sailing trips to Lombok and whether they sailed with dogs, including details on dog/s in the boat (if present); dog management; dog health; and knowledge of rabies.

For the survey of boat captains from local Lombok households, the questionnaire consisted of seven sections: respondent data; respondent background, such as number of dogs owned, dog source and dog function; sailing practices of respondents that owned dogs; sailing practices for respondents that did not own dogs but sailed to rabies-infected island/s; dog management, including questions regarding previous dog bites in the household; dog health; and knowledge of rabies.

These two structured questionnaires were developed in English and translated into Bahasa Indonesia; each contained mainly closed ended questions. Questionnaires were modified after trialling with three captains of boats in each survey group. The modifications included the addition of answer options for the type of boat (tourist and cargo boats were added to the outside-Lombok questionnaire) and for methods of weather prediction and navigation (nature signs were added to both questionnaires). The questionnaires are presented in Appendix 2 and 3.

4.2.4 Conduct of surveys

Each survey site was visited on three consecutive days. For the survey of outside-Lombok boat captains, the target number of interviews was 12 captains of boats at each port, due to uncertainty of the number of captains of boats present at the port. For the survey of local Lombok boat captains, the target number of interviews was 100 at the one survey site: 50 with Sasakese households and 50 with Balinese households.

The surveys were conducted from January to April 2012 by the author and a team consisting of eight staff at the Research Centre for Rural Development, University of Mataram, West Nusa Tenggara Province. Each questionnaire was administered by face-to-face interviews with the captain of the outside boat or the local boat. The interviews were usually completed in 30 to 35 minutes and a rabies brochure and incentive of 20,000 IDR were given to participants on completion of the interview. The rabies brochure was given to the respondent after the interview, to prevent the interviewees from reading the brochure while being interviewed and being influenced by the brochure information.

Interviews with captains of outside boats were conducted in the boat landing area, at small food stalls and fish selling areas at each port. It was not difficult to find the captains of outside boats. Boat crew members were helpful; they pointed out or called their captains when the interviewer asked. If the captain was not present, a senior crew member was interviewed; however, this occurred once only. During the survey, all respondents were enthusiastic about the interview process, and indicated they were eager to be involved in university-supported research.

Interviews for the survey of local boat captains were conducted either at the household residence or at the boat landing area of Bangko-bangko port.

A convenient boat docking arrangement (for the purposes of this study) is seen at fishing ports in Lombok. The boats are clustered in groups according to their origin. Also, the origin of a boat is indicated by the boat shape and build. The local boats appear to be smaller than the outside boats, and local boats usually have a wing/s (Figure 4.2). Further, local boats from the southern part of Lombok have two wings, whereas boats from the western part of Lombok usually have one wing (Figure 4.3). These differences were used to distinguish between outside boats and local boats, and, at Bangko-bangko port, to distinguish local boats owned by Bangko-bangko households and those from other parts of Lombok. Furthermore, people nearby the boats were helpful; they willing helped to identify a boat's origin and the person/s associated with the boat. For local boats, usually one boat is only driven by one person.

Figure 4.2: Local boat (left) and outside boat (right) at informal port on Lombok. All boats in this figure are fishing boats.

Figure 4.3: Local boat with two wings and one wing at informal port on Lombok. All boats in this figure are fishing boats.

4.2.5 DOG OBSERVATION

During the three consecutive days of interviews conducted at each port, dog observation was also performed to document the presence of dogs on boats, the presence of dogs roaming, and the interactions of people at the port with dogs. On each of the interview days, the team was present at the port from 8 am to 6 pm. The interview team took the opportunity to observe all docked boats for dog presence while interviewing and while walking between boats at the parking area. A simple dog observation form was built for this purpose (Appendix 9).

Ethics approval for this work was obtained from the Ethics Committee at the University of Mataram, since the data collection was conducted in Lombok, Indonesia. Informed consent was obtained from the survey participants.

4.2.6 DATA MANAGEMENT AND ANALYSIS

Data were entered into Microsoft Excel and subsequently checked for missing and extreme values against the hardcopy questionnaires. Standard descriptive analyses were conducted using Genstat 14th edition (PC/Windows, 2007, VSN International Ltd., Hemel Hempsted, UK). Categorical data were described using frequency tables and continuous variables using mean, median and range.

4.3 RESULTS

4.3.1 BOATS FROM OTHER PARTS OF INDONESIA VISITING LOMBOK ISLAND

A total of 117 captains of boats that originated from outside Lombok were interviewed (Table 4.3).

Table 4.2: Number of interviews with captains of outside boats and type of boats visiting the 7 informal ports on Lombok in 2012.

No	Name of port	Location	Number of interviews	Type of boat visiting
1.	Tanjung Luar	Eastern Lombok	15.4% (18)	Fishing
2.	Labuhan Lombok	Eastern Lombok	17.9% (21)	Fishing
3.	Labuhan Haji	Eastern Lombok	6.8% (8)	Fishing
4.	Kayangan Lama	Eastern Lombok	6% (7)	Cargo and fishing
5.	Bangko-bangko	Western Lombok	42.7% (50)	Fishing
6.	Teluk Nara	Northern Lombok	6.8% (8)	Cargo and tourists (passengers)
7.	Bangsal	Northern Lombok	4.3% (5)	Tourists (passengers)
	Total number of interviews		117	

Although the target number of interviews for outside boats was 12 interviews at each port (Section 4.2.4), at some ports fewer than 12 outside boats were present during the three consecutive days: this was mainly at non-fishing ports. Meanwhile, at the three fishing ports where more than 12 outside boats were present, more than 12 captains of outside boats were interviewed (Table 4.3).

For the fishing port of Bangko-bangko, 50 captains of outside boats were interviewed. At this port, fishing boats from Bali Island are the only boats from another island that visit the port, and all of them belong to Balinese fishermen. This is due to the close proximity of Bangko-bangko port to the southeastern coast of Bali, only 45 minutes travel by boat with a small engine. A notably higher number of outside-boat interviews were conducted at this port for two reasons: to permit a thorough investigation of dog presence on Balinese fishing boats, and to compensate for the low number of Balinese captains of local fishing boats interviewed in the local boat survey conducted at this port (only two of 52 interviews in the local boat survey).

4.3.1.1 Origin of boats

Information was obtained about 117 boats based on interviews with 117 boat captains. Of these, 43.6% (51/117) of the boats originated from Bali Island, 31.6% (37/117) from South Sulawesi (a part of Sulawesi Island), 12.8% (15/117) from Java Island, 4.3% (5/117) from Flores Island and the remaining 7.7% (9/117) were from rabies-free islands (Sumbawa and Papua Island).

4.3.1.2 Gender and age data

All of the boat captains were male with a reported mean age of 30.9 years (median 30, range 19–61). Fishing boat captains start as young as 19 years old. This is not abnormal, as being a fisherman is an inherited occupation. The majority of the fishermen had been fishing as long as they could remember, having accompanied their grandfather and father during fishing trips from a young age.

4.3.1.3 Frequency of visits to Lombok

The frequency of visits to Lombok varied depending on boat type. Fishing boats visit Lombok every year and then stay for several months (two to seven months). The fishermen who visit informal ports in East Lombok are mostly from South Sulawesi, coming to Lombok during certain seasons when fish move to various fishing grounds offshore from Lombok. They come by invitation (sent to the leader of the fishing groups) from two major fish companies in Lombok, to catch fish for these companies. These fishermen were compensated based on the total weight of fish caught and they were given accommodation, a living allowance and other expenses by the two companies as payment. They were hired because these fishermen already had boats that satisfied certain requirements to sail offshore, and were thus able to spend several days offshore. These requirements related to features such as boat size, engine size and the captain's experience. This type of arrangement had been in place for many years.

A similar practice was also evident from interviews at Bangko-bangko port in West Lombok. Fishing boats from Bali always come to this port during the fishing season in Lombok (April to October); they stay for two weeks in the port (building a humble hut as shelter or sleeping in the boat), return to Bali to visit their family and sell their fish catch, and then return again to Lombok for another two weeks to catch more fish. However, unlike fishing boats from South Sulawesi, the fishermen from Bali are working for themselves. As an exception, one boat (a fishing boat from Bali) reported visiting Lombok unintentionally to seek shelter from strong wind; this boat was anchored approximately 200 meters away from Tanjung Luar port in East Lombok to take refuge from the weather.

For cargo and tourist boats surveyed, the frequency of visits to Lombok depended on demand. Boats from Flores carrying tourists usually stay for two weeks at Lombok port. Based on the captains' estimation, the number of trips to Lombok per year is between four and six. Captains of the tourist boats mentioned that the frequency of their visits is highly influenced by the presence of tourists, and that the number of the tourists had to reach eight people in order to cover expenses for fuel and other materials needed to sail, as the sailing trips could take more than two weeks. This is similar to the cargo boats: demand influences their frequency of visits.

4.3.1.4 Presence of dogs on boats

No respondents reported ever taking dogs while sailing, except one fishing boat from Bali which was anchored at Tanjung Luar and had unintentionally visited Lombok due to strong winds. At the time of interview, this fishing boat was reported to have a caged pet dog on board, and was anchored approximately 200 metres away from the port. The interviewee from this boat was interviewed when he had landed at the port to purchase supplies. An opinion held by a number of Indonesian animal health experts is that dogs in boats are used as weather predictors and for navigation (expert opinions were sought during the process of research preparation), and similar opinions were also mentioned at a 2011 IAQA meeting in Sumbawa (Badan Karantina Pertanian, 2011a); however, none of the respondents reported ever having used dogs (or other animals) to predict weather or to navigate. On the contrary, respondents said they use modern technology (such as Geographical Positioning Systems (GPS)), a compass and nature signs (cloud shape, wind direction and water surface condition) to predict weather. Stars were also mentioned as a method to predict incoming rain. Some respondents stated that some constellations of stars can be used to tell north from south. Other reasons preventing the respondents taking dogs on board their vessels included: conflict with Muslim beliefs; difficulties with feeding and faeces disposal (due to the long duration of the sailing trip); and the potential risk that dogs may eat the fishermen’s valued catch.

4.3.1.5 Knowledge of rabies

More than half of the respondents had a good knowledge of rabies: 61.5% (72/117) of respondents were aware that rabies is transmitted to humans through dog bites. However, 36.8% (43/117) of respondents were not sure about how rabies is transmitted, and two respondents believed that rabies is transmitted by keeping a dog.

4.3.2 LOCAL LOMBOK HOUSEHOLDS WITH BOATING ACTIVITY

4.3.2.1 Boat activity to rabies-infected island

Interviews were conducted with 52 captains of local boats that were all involved in fishing: no other boating activities were reported. All captains interviewed had experience travelling to Bali, a rabies-infected island. Of those, 96.2% (50/52) belonged to the Sasakese ethnic group (indigenous ethnic group of Lombok Island) and 3.8% (2/52) belonged to the Balinese ethnic group (living in Lombok). Fishing as a job is not popular amongst Balinese people living on Lombok. It is difficult to market their fish catch at traditional markets because the Balinese ethnic group is often associated with owning pigs, so that their fish are not easily accepted by the majority of ethnic groups living on Lombok (Local Lombok fisherman, name not available, personal communication).

4.3.2.2 Gender and Age data

All of the respondents were male; the mean reported age was 27.9 years (median 27, range 17–50).

4.3.2.3 Presence of dogs in boats

The results regarding taking dogs on vessels were similar to those from boats from outside Lombok: no respondent reported ever having taken a dog while sailing. This group also uses technology such as a compass to navigate, and a mobile phone to receive text messages from other fishermen about incoming weather. Similar reasons for not taking dogs on board were cited by this group. In addition, respondents in this group said it is not possible for them to bring animals because their boats are small, fitting only one person, with the remaining space for their catch.

4.3.2.4 Dog management practices

Of 52 interviewed local boat captains, only 4 had dogs in their households, with a total of 8 dogs. These dogs were either homebred or given to the owner by a neighbour from the same village.

4.3.2.5 Knowledge of dog health

All 4 households with dogs showed a lack of dog health knowledge. Only 1 household mentioned inappetence as a symptom of a sick dog, while the other 3 households were not able to list any symptoms of a sick dog.

4.3.2.6 Knowledge of rabies

Almost all of the respondents were not aware of rabies: only 7.7% (4/52) of respondents mentioned that rabies is transmitted to humans through dog bites. The remaining 92.3% (48/52) of respondents were not sure about how rabies is transmitted.

4.3.2.7 Dog bite victim

No respondents said they had been bitten by a dog, nor had their family members reported experience of dog bites.

4.3.3 OBSERVATIONS OF DOGS AT PORT

4.3.3.1 At fishing ports

At the four fishing ports, no dogs were seen on boats. A total of 79 dogs were seen at these fishing ports around the fish cleaning area, fish selling area and near garbage. Interaction of people at these ports with dogs was limited; while the people were not disturbed by the presence of the dogs, they were not seen to feed the dogs or play with or touch the dogs.

4.3.3.2 At passenger/cargo port

Similar to the fishing ports, at the three passenger/cargo ports, no dogs were seen on boats. One port where fishing and cargo boats were present was included in the passenger/cargo port category for dog observation due to the dominance of cargo boats at this port. A total of 18 dogs at the three ports were seen near garbage. People at these ports did not like dogs around; they hit the dogs with stones when the dogs came close to them.

4.4 DISCUSSION

This survey was conducted to obtain data on the likelihood that boat captains arriving in Lombok from other parts of Indonesia, and boat captains from local Lombok households, bring dogs on their boats. The results of this survey will be used to inform the pathway for rabies introduction to Lombok via fishermen and other boating activity (non-ferry).

Of the 8 informal ports, 6 are regulated by government agencies. The fishing ports in eastern and southern Lombok are regulated by the Marine and Fisheries Agency; the cargo port in eastern Lombok is regulated by a Syahbandar (port management) office; and Bangsal port (used mainly for small boats carrying tourists to and from the Gili Islands) is regulated by a port management office. However, two ports, Bangko-bangko, a fishing port in West Lombok (mainly servicing fishing boats from Bali), and Teluk Nara in North Lombok (for small boats from Bali and Flores, transporting tourists) have no government office on site. There is no quarantine post at any of these informal ports.

This survey showed that the majority of the outside boats visiting informal ports on Lombok were from rabies-infected islands. These islands are as follows: Sulawesi Island, rabies-infected since 1957; Flores Island, infected since 1997; and Bali, infected since late 2008. Considering this finding, is clear that informal ports on Lombok are visited by a high number of boats from other islands, and this should increase awareness of the potential for smuggling, if not of animals, of dangerous drugs, plant materials, food products or humans. Thus, it appears necessary to place a quarantine post at all of these informal ports, as these ports act as entry points from other islands to Lombok. If this is not possible due to resource limitations, another approach that can be implemented to guard these ports is to increase the working relationship between the quarantine agency and the government agencies that are already present at a port, such that these agencies will inform quarantine about suspected occurrences of smuggling. Another option is to place a few quarantine officers at the offices located at the informal ports. For the informal ports without an agency office, quarantine could work with the port manager or the village leader associated with the port, to observe any indication of smuggling and to report regularly.

Furthermore, this survey showed that knowledge of rabies was greater among the respondents from other parts of Indonesia (outside Lombok) than the local respondents (knowledge of transmission by dog bite was 61.5% and 7.7%, respectively, $X = 42.18$, $p < 0.001$). This may be due to the majority of the outside-Lombok respondents being from rabies-infected islands, and thus having better information about rabies than the local respondents.

In the questionnaires for both groups, questioning regarding dog presence began with a question about whether the respondent had ever brought any animals during sailing. A list of animals was provided as answer options, such as chicken, cat, dog, and others. If the respondent answered that they had previously taken a dog sailing, further questions were then asked, including what was the main purpose of having a dog while sailing. If the answer was no, the next question was about previous experience transporting dogs to Lombok from the respondent's place of origin (for outside boats), or previous experience transporting dogs to Lombok from the island most recently visited (for local boats). There were further questions about practices and behaviours during sailing; for example, about navigation methods and weather prediction while at sea. Thus, various approaches were used during each interview to gather information about dog movement by boat, and practices for navigation and weather prediction.

This survey found only one respondent (a fishing boat from Bali) that had a dog (caged pet dog) on board. The interviewee from this boat said that the dog came with them as a pet, not as a weather predictor or as a navigation tool. All other respondents, with outside boats and with local boats, reported never having a dog (or other animal) on their vessel. Whilst it is possible that a captain may lie about his history of dog transportation due to concern about not adhering to the quarantine regulation, we consider it unlikely that many captains would actively conceal this information fearful of repercussions by the quarantine services. Thus, this survey found that dogs are not commonly carried on boats. This finding is in contrast to animal health experts' opinion that dogs are common on boats as aids for weather prediction or navigation. The survey finding that dogs are not common on boats was supported by the dog observation data: no dogs were observed on boats. Further the reasons for never bringing a dog that were reported by the respondents from both groups (from outside and local Lombok) were substantial and strengthen this finding.

A study of the rabies epidemic on Flores island mentioned briefly that rabies was first introduced into this island by fishermen who imported three dogs from rabies-endemic Butung Island of South-East Sulawesi (Windiyaningsih et al., 2004). Dogs in Flores have an important cultural role; for example, they are used for wedding dowry, celebrating a new home and other similar roles (Hutabarat et al., 2003). Also, dogs are commonly consumed in Flores (Windiyaningsih et al., 2004). Thus, dogs have high cultural and economic value. Dog consumption is also documented in Manado, in North Sulawesi (Adiani and Tangkere, 2009). This suggests that it is likely that the rabies-infected dogs transported by fishing boat to Flores were transported for trade purposes because of the abovementioned dog value on Flores, rather than for navigation or weather prediction. On Bali Island, dog introduction by fishing or cargo boat is implied as the most likely route for rabies spread in 2008 (Putra et al., 2013; Scott-Orr and Putra, 2009). Given that the role and functions of dogs on Bali Island are similar to Flores Island, the purpose for dog movement by boat to Bali may also relate to trade or cultural practices.

This survey documented seasonal variation in the frequency of visitation of fishing boats from other parts of Indonesia to Lombok. This is an advantage for the quarantine agency if they want to conduct education programs to increase the knowledge of their laws and regulations among the people involved with boat activity from outside Lombok, as well as among the local Lombok people. However, educating the people that come from outside Lombok about rabies may not be greatly needed, if there is a resource constraint issue, because this survey showed that these people already have a fairly good knowledge of rabies. Rather, the rabies education budget could be better spent to educate the local fishing households, as they showed a poor understanding of the disease.

This survey has found that the likelihood of fishing and or other boats bringing dogs to Lombok is not as high as experts and the literature implied. These results will be used to inform input values for a quantitative release assessment via the boat pathway, which will be described in Chapter 8.

In summary, this survey showed that the presence of dogs on fishing and other boats that travel to Lombok is unlikely. Given the documented role of fishing and cargo boats in rabies introduction to Flores and Bali, it is likely that the presence of dogs on boats going to these islands is due to the higher value of dogs for the major ethnic groups living on these islands. The fishing or other boat (non-ferry) pathway should remain an important pathway when assessing rabies introduction into islands with communities that value dogs highly, and islands that are relatively remote and use boats (fishing or other small boats) as the main transportation method.

CHAPTER 5: SURVEY AT PADANG BAI BALI HARBOUR

5.1 INTRODUCTION

As Indonesia is an archipelago country, the main risk of rabies introduction to the remaining non-infected regions in the country is through illegal dog importation by boat: people moving dogs from rabies-endemic areas to rabies-free areas. There have been studies of the rabies epidemics on the islands of Flores (Scott-Orr H, 2009; Windiyaningsih et al., 2004) and Bali (Putra et al., 2013; Scott-Orr and Putra, 2009), that suggest rabies may have entered those islands via fishing or cargo boat. However, there have been no studies in Indonesia that have focused on the practices of moving dogs via the ferry route: that is, to investigate ferry transportation as a possible pathway of dog movement between islands. Travel by ferry is a major means of inter-island transportation of passengers and goods in Indonesia; there are multiple commercial ferry operations available, and high numbers of vehicles are moved between islands on ferries (PT ASDP Indonesia Ferry, 2013). Ferry services dock at formal harbours in Indonesia, where there are usually staff from four agencies performing different duties. Staff from the police department check people coming in and out of the harbour; and for vehicles, they check vehicle documents (driving licence of the driver, vehicle certificate, letter from the freight company stating type of goods carried and destination, transport goods permit) and ensure there are no dangerous or suspicious items in any vehicle. Staff from the harbour authority office ensure that the number of vehicles that go on to the ferry does not exceed the ferry capacity, and are responsible for checking weather conditions and providing advice to ensure the safe passage of ferries (in bad weather, the harbour authority will not provide approval for ferries to sail). Staff from the ferry companies are responsible for ticketing and for safe boarding/offloading of passengers and vehicles. Agriculture and animal health quarantine officers are responsible for checking vehicles carrying animals: they check the health statement of the animals, the numbers of animals carried and the destination of the animals. However, the numbers of animal health quarantine officers guarding these harbours on some islands are inadequate (drh. Sutedja personal communication, 2012). This may further increase the likelihood of inter-island movement of dogs.

This survey was carried out at Padang Bai, the one formal harbour in Bali providing ferry transport from Bali to Lombok, to obtain data on the practices of transporting dogs to Lombok; the management of the transported dogs; the number, origin and breed of the transported dogs; and the time/s of the year when dogs are most frequently transported. The aim was to collect data that would contribute to evaluation of the ferry route as a potential pathway for rabies introduction to Lombok Island.

5.2 METHODS

5.2.1 SURVEY SITES

This survey was carried out at Padang Bai harbour. This harbour was chosen because it is the one formal harbour that provides ferry transportation from Bali to Lombok Island. It connects with Lembar harbour on Lombok, one of only two formal harbours on Lombok island, with the second being Kayangan harbour on the west coast, which provides passenger transport only to Sumbawa island (the other major island of West Nusa Tenggara Province).

For those wanting to travel by road and sea from Western Indonesia to Lombok (e.g., from Java) overland transportation across Bali island is necessary before crossing the Lombok Strait by ferry from Padang Bai harbour to Lembar harbour on the west coast of Lombok. Further, results from the survey of dog-owning households showed that dogs were transported from islands in Western Indonesia to Lombok in vehicles by ferry from Padang Bai harbour (details listed in Chapter 3).

5.2.2 SOURCE POPULATION

The source population for this survey was people driving in vehicles (trucks, cars, buses, minibuses and motorbikes) that were going to Lombok by ferry.

5.2.3 QUESTIONNAIRE DESIGN

One structured questionnaire consisting of three parts (respondent demographics, experience with transport of dogs to Lombok, management of dogs transported to

Lombok) was developed in English and then translated into Bahasa Indonesia (Appendix 4). The questions were limited to dogs, as this species is considered the principle reservoir for rabies in Indonesia; no other susceptible species such as cats or monkeys were considered. The questionnaire was trialled with 21 people in vehicles going to Lombok by ferry during an initial visit to Padang Bai harbour, and modification of the questionnaire was not necessary.

5.2.4 CONDUCT OF SURVEY

The survey was conducted from December 2012 to February 2013 by the author and a team of eight people at the Research Centre for Rural Development at the University of Mataram, West Nusa Tenggara Province. Prior to commencement, a formal letter signed by the head of the Research Centre for Rural Development, University of Mataram was sent to the Harbour Authority to inform and obtain permission to conduct the survey. The questionnaire was administered by face-to-face interviews with people waiting to travel in a vehicle to Lombok by ferry on the day of the interview. The interviews were conducted in the parking areas of the harbour and at small food stalls inside the harbour area. The interview was usually completed in 15 to 20 minutes per respondent. The survey interviews were conducted over a total of ten days, consisting of three periods: two days for the initial visit; four days for survey round one; and four days for survey round two. The interviewers were divided into four teams, with each team focusing on a separate location in the ferry terminal area: one at the heavy vehicle (truck and bus) parking area; one at a food stall near this parking area; one at the light vehicle (cars and motorbikes) parking area; and one at a food stall close to the light vehicle parking area. All teams observed vehicles arrive and park and then approached the drivers that appeared to have spare time while waiting for their turn to enter the ferry. This convenience sampling approach was used in this survey due to the fact that vehicles can be moved quickly onto the ferries, and thus the time spent by vehicle drivers waiting for loading is variable and unpredictable. During the survey period, interviews were conducted in three sessions per day, which were morning, afternoon and night, with two to three hours spent per session at the harbour. The aim was to interview at least 15 drivers present at the harbour each day.

Ethics approval for this survey was obtained from the Ethics Committee at the University of Mataram.

5.2.5 DATA MANAGEMENT AND ANALYSIS

Data were entered into a Microsoft Excel spreadsheet and checked for missing values against the hardcopy questionnaires. Standard descriptive analyses were conducted using Genstat 14th edition (PC/Windows, 2007, VSN International Ltd., Hemel Hempsted, UK). Descriptive analyses were used to describe the demography of the people interviewed and to describe the number and origin of dogs they transported. Categorical data were described using frequency tables and continuous variables using mean, median and range. The chi-square test was used to determine statistical difference between categories for categorical variables of interest.

5.3 RESULTS

5.3.1 PEOPLE IN VEHICLES INTERVIEWED DURING SURVEY VISITS.

A total of 158 people driving in a vehicle by ferry to Lombok were interviewed during this survey, of which 89.2% (141/158) reported never bringing dogs and 10.8% (17/158) reported personal experience transporting dogs to Lombok from Bali and Java in the last two years. No one reported transporting dogs in their vehicle at the time of the survey visit. Six drivers approached for interview were not willing to talk.

Among those interviewed, the mean age was 35.5 years (median 35, range 21–60) and 96.8% (153/158) were male. Vehicles being driven were trucks 83.5% (132/158), cars 12.02% (19/158), motorbikes 3.8% (6/158) and buses 0.6% (1/158). The demographics of the interviewees are shown in Table 5.1: 51.3% (81/158) were Lombok residents and 48.7% (77/158) were non-Lombok residents. Among these, the proportion of people stating that their purpose for travel to Lombok was transportation of goods and people to Lombok was significantly higher for non-residents at 100% (77/77) than residents at 77.8% (63/81) ($X = 19.31$, d.f. = 1, $p < 0.001$).

Table 5.1: Demographics of 158 people driving in a vehicle by ferry to Lombok interviewed at Padang Bai harbour, Bali in 2012–2013

Demographic	Number (%)
Resident status	
Lombok resident	81 (51.3%)
Non-Lombok resident	77 (48.7%)
Ethnic group	
Balinese	43 (27.2%)
Sasakese	58 (36.7%)
Chinese	2 (1.3%)
Javanese	39 (24.7%)
Timorese (Flores)	4 (2.5%)
Sumbawa	12 (7.6%)
Purpose for ferry travel to Lombok	
Residents	
Transporting goods to Lombok	63 (39.9%)
Returning home	18 (11.4%)
Non-residents	
Transporting goods to Lombok	69 (43.7%)
Transporting people to Lombok	8 (5%)

5.3.2 People who transported dogs in vehicles by ferry to Lombok

Seventeen people reported that they had transported dogs in vehicles by ferry to Lombok in the last two years. The collection of details about transported dogs was limited to the last two years to aid recall. These 17 people reported transporting a total of 21 dogs during the last two years, with a mean number of 1.2 dogs each (median 1, range 1–3). Only one of the 17 people reported multiple trips transporting dogs, a bus driver who reported carrying dogs on the bus on two separate occasions. The reason for bringing dogs stated by the bus driver and 11 truck drivers was good incentive because they were being paid by dog owners to transport the dogs, and a good trading price for dogs was mentioned by another two people. The demographics of these people are shown in Table 5.2.

Table 5.2: Demographics of 17 people interviewed at Padang Bai harbour, Bali in 2012–2013 who reported transporting dogs in vehicles by ferry to Lombok in the last 2 years

Demographic	Number (%)
Resident status	
Lombok resident	7 (41.2%)
Non-Lombok resident	10 (58.8%)
Ethnic group	
Balinese	5 (29.4%)
Sasakese	4 (23.5%)
Chinese	1 (5.9%)
Javanese	6 (35.3%)
Sumbawanese	1 (5.9%)

5.3.3 Dogs transported in vehicles by ferry to Lombok

The age of the 21 dogs ranged from 3–24 months old, with 81.0% (17/21) in the three- to eight-month-old age category and 19.0% (4/21) in the 12–24 month age category; however, as age was not definitely known for some dogs, age data were not further analysed. There were 15 male and six female dogs, and the island of origin reported was Bali for 71.4% (15/21) and Java for 28.6% (6/21) of the dogs. Specific places of origin mentioned in Java were Jakarta, for four dogs (capital city of Indonesia), and West Java for two dogs. All dogs were reported to be pedigree dogs.

The reported functions of these dogs when known by respondent were pet/companion animal (one dog), guard duty (one), pet trade (two), animal to breed for puppy trade (two) and a gift (one). The remaining dogs were transported to Lombok by order of dog owners living in Lombok, and thus the function of these dogs was not known by the respondent. Payment was provided by the dog owners to the person interviewed, who transported the dogs.

Among the 21 dogs, two (9.5%) were reported to have had rabies vaccination, 6 (28.6%) had not received rabies vaccination, and vaccination status was not known for the other 13 (61.9%). Only two dogs were reported to have had documents to travel; however, these documents were limited to vaccination and pedigree records.

Of the 21 dogs, eight were known to have been purchased. One was purchased at a Kintamani dog breeder in a village on Bali, and the remainder were purchased from live animal markets and street dog traders on Bali. The source of the other 13 dogs was not known by the respondent, as the dog was handed to the respondent by people in a vehicle at the bypass or at the village next to Padang Bai harbour, without any information on the source of the dogs.

5.3.4 TIME OF YEAR AND TRANSPORTATION MODE

The results from this survey showed that dogs were moved to Lombok in almost every month of the year (Table 5.3). The transportation methods recorded were motorbikes, cars, trucks and a bus. Of the 21 dogs, 14.3% (3/21) were transported in cars; 61.9% (13/21) in trucks; 14.3% (3/21) on motorbikes and 9.5% (2/21) in a bus (Table 5.3). It is important to note that the majority of motorbikes in Indonesia are a scooter type model, so it is possible to put a box in front of the driver or tie a box on the seat behind the driver. Moreover, it is not clear if in Indonesia, there is any rule to regulate such activities. It is probable that any type of cargo could be loaded on a motorbike (e.g., boxes or bags), as long as it does not affect movement and stability of the motorbike.

Table 5.3: Month of the year the 21 dogs were transported to Lombok in the last two years, and the type of vehicles used.

Month of year	Number (%)
January	0
February	2 (9.5%)
March	1 (4.8%)
April	1 (4.8%)
June	1 (4.8%)
July	4 (19%)
August	4 (19%)
September	1 (4.8%)
October	4 (19%)
November	3 (14.3%)
December	0
Vehicles used	
Car	3 (14.3%)
Truck	13 (61.9%)
Motorbike	3 (14.3%)
Bus	2 (9.5%)

5.3.5 DOG MANAGEMENT AND INSPECTION DURING TRANSPORTATION

For the 21 dogs transported, no inspection of these animals occurred at either Padang Bai harbour in Bali or at Lembar harbour in Lombok, according to the 17 respondents who transported them in vehicles. Of the 17 people, three motorbikes riders, one bus driver, two car drivers and eight truck drivers described that dogs were placed in a carton box, handbag or sack, when the interviewer asked an open question about the need to sedate the dog/s during transportation to Lombok (further details listed in Table 5.4). Three truck drivers were not willing to answer this question.

Table 5.4: Dog management of the transported dogs during transportation to Lombok in the last two years.

Dog management while in transportation			
Motorbike	**Car**	**Bus**	**Truck**
1. Dogs inside carton box or in a sack. 2. Food provided and given at dog's meal time. 3. No sedation needed. Dogs quiet if they had enough food.	1. Dogs placed in box or if small dog put inside handbag then placed at the rear seat. 2. Food provided. 3. No sedation needed.	1. Dogs placed in a carton box covered by blanket, coffee powder poured on top of blanket to reduce smell of dogs. Then placed in bus luggage compartment. 2. Food provided. 3. No sedation needed	1. Dog put in a box and placed behind driver's seat (at driver's resting area) or the void area under driver seat. 2. Food provided for the dog. 3. No sedation needed.

5.4 DISCUSSION

This survey was undertaken to document the practices of transporting dogs to Lombok by ferry. The results of this survey can be used for documenting the ferry pathway as a possible pathway for rabies incursion from rabies-infected islands to Lombok Island.

The majority of people interviewed in this survey were truck drivers; their purpose for going to Lombok was transporting goods. At Padang Bai ferry harbour, the majority of vehicles going on the ferry to Lombok are trucks (NTB Bureau Statistic, 2011). Due to Lombok being a small island, no large companies exist on Lombok, and thus white goods, furniture, clothing and a wide range of daily household products are mainly supplied from bigger islands such as Java and Bali Island. Hence, trucks transporting goods are the major vehicle type on ferries, and the drivers have busy schedules for travel to and from Lombok. At the ferry harbour, trucks spend a relatively longer period queuing to get on the ferry compared to the other vehicle types. Ferry company procedure requires trucks to be weighed and the order for vehicle entry is based on size/weight, with smaller/lighter vehicles usually boarded first and trucks last. The length of the waiting period drivers had from arrival to boarding did influence availability to participate in this survey, with truck drivers in general having longer wait periods. For these reasons, a high number of interviews in this survey were conducted with truck drivers.

Of the total of 158 people interviewed, the proportion of Lombok residents and non-residents was almost equal; thus, the survey provides information about the practices of both groups. The interview team found that across the three time periods on the day of visit when the interviews were conducted, truck drivers were consistently the main type of people with vehicles encountered. Further, of the 17 people who reported transporting dogs into Lombok, 64.7% (11) were truck drivers, and ten of these drivers were interviewed at night. If more interviews had been conducted at night then it is possible that more data on transported dogs may have been collected. However, there were substantial safety and logistic concerns about conducting interviews at night, and for the night session the interview team was restricted to only male interviewers.

This survey documented the movement of 21 dogs from other islands to Lombok. All of the dogs were pedigree dogs and the majority had originated from a rabies-infected island or region. This finding is consistent with the result of the dog-owning household survey (Chapter 3), and indicates that owning pedigree dogs is becoming a trend on Lombok and that these dogs are being sourced from rabies-infected islands. This suggests that the movement of dogs from other islands to Lombok is likely to continue. Similar to the survey reported in Chapter 3, this survey found there was uncertainty about the rabies vaccination status of the imported dogs, and dogs were imported illegally without the proper documents required by quarantine. The uncertainty about the rabies vaccination status of imported dogs suggests that it is possible for a dog to be introduced that is incubating rabies. Further, the confinement of the 21 dogs at their place of origin was not known, and the place of purchase was only documented for eight dogs, with none reported to be from a pet shop. Thus, it is possible that some dogs imported from a rabies-infected island or region were allowed to roam at their place of origin, and if bitten by a rabid dog when unvaccinated or only recently vaccinated, could be incubating rabies when moved. These types of dogs are a risk for rabies-free areas if imported without quarantine inspection to ensure that only dogs with a sustained vaccination history are permitted entry. If people are able to successfully transport dogs to Lombok, there is a possibility that other animals are also being transported, such as chickens with Highly Pathogenic Avian Influenza (HPAI). Illegal movement of chickens from Bali to Lombok in late 2011 has been reported as the cause of the substantial HPAI outbreak on Lombok from 2011 into 2012 (drh. Nengah Dwiana personal communication, 2012).

This survey found that dogs are moved to Lombok using a number of types of vehicles, and that for most people who reported involvement in this illegal activity, a contributor to involvement was the income gained. All truck drivers involved in this activity transported dogs at the request of dog owners in Lombok, and received a good payment for their services. Good trading prices also attracted people to import dogs to Lombok. This survey found that the service of transporting dogs was likely to be a common practice, since 12 people in vehicles (11 truck drivers and one bus driver) that reported bringing 13 dogs to Lombok mentioned that the dogs were handed to them at a similar place, either the bypass or the village near the harbour. This indicates that dog transportation from Bali Island to Lombok is a well-established practice that has probably occurred for some period of time. The 13 dogs brought to Lombok on request were then given by the respondents to their owners on Lombok Island.

Fourteen of the 17 people reported hiding the imported dogs in the same manner, indicating that all were aware of the importance of hiding the dogs during transportation. Minimizing the dog’s smell also appeared to be important, with one respondent mentioning placing the dog inside a box covered by a blanket with coffee poured on top of it to reduce the smell. One motorbike rider mentioned that when transporting dogs on the ferry, it is important to come to the harbour during the police officers’ break time, such as lunch time. During this time, there is usually a transition between police staff, so there is a gap when guarding is less strict and motorbikes with dogs can enter the harbour without inspection of what is inside the sack or boxes on the motorbike. Eight truck drivers revealed similar practices to the motorbike rider, emphasizing the importance of avoiding contact with police officers when transporting dogs. Further, the fact that police officers are mentioned as the officials at the harbour that need to be avoided, not quarantine staff, suggests that the role of quarantine is not fully understood by the general public and/or the quarantine officials are not observed frequently inspecting vehicles at this harbour. The awareness of avoiding inspection of the dogs by officials showed that these people travelling to Lombok by ferry understood that there are proper procedures to follow when bringing a dog to Lombok. Thus there could be more people among the respondents that had experience transporting dogs to Lombok, but did not report it during the interview.

According to the respondents in this survey, 21 dogs were moved to Lombok Island between February 2011 and November 2012. The frequency of dog movement by month suggests that the transport of dogs is not influenced by season. This finding is different from the study of Napp et al. (2010), which reported a seasonal pattern for the movement of pets to the European Union from Morocco. Dogs were moved to the European Union accompanying their owners during summer (July/August), possibly when these people were on holidays. If dog movement by people was influenced by season in Indonesia, the quarantine authorities would benefit by increasing their inspections during the months of the season. However, this Padang Bai survey found no seasonal movement pattern; thus, there is no such recommendation for management strategies in Indonesia.

Another important result obtained from this survey was the permeability of Padang Bai ferry harbour and Lembar harbour. All 17 respondents with experience transporting dogs reported no inspection of the dogs they transported, either at the Padang Bai harbour of Bali or at Lembar harbour in Lombok. The fact that Lombok is an island with entry only by sea or air should be advantageous for quarantine and border disease control, allowing the application of strict import quarantine measures at known points of entry, as has been effectively implemented in Japan (Kamakawa et al., 2009). Border control is crucial as a prevention measure to protect rabies-free areas from rabies incursion (Weng et al., 2010).

This survey has identified the ferry route as an important pathway of dog movement between islands. Other researchers have also reported dog movement via the ferry pathway as well as the airplane route in a quantitative risk assessment model for rabies introduction into the European Union from Morocco (Napp et al., 2010).

This survey conducted at Padang Bai harbour highlighted the permeability of sea borders that enables illegal movement of dogs, and that people working for cargo companies should also be a target for rabies education.

CHAPTER 6: UNOWNED DOG POPULATION ESTIMATION

6.1 INTRODUCTION

Free-roaming dogs are a problem in all countries, especially in developing countries where dog bites/attacks and the role of these in the transmission of rabies to people are reported to be the main problems associated with these dogs (Dalla Villa et al., 2010). In India, where 20,000 humans die from rabies each year, rabid free-roaming dogs are considered the main cause of this problem (Sudarshan et al., 2007). In Indonesia, the spread of rabies through the dog population following the movement of an infected dog to a rabies-free island is intensified by the presence of free-roaming dogs. As in other countries in Africa and Asia, the presence of poorly supervised dogs and ownerless dogs is not unusual in Indonesia. For instance, rabies spread across Bali following human introduction of one rabid owned dog in 2008, was notably rapid due to the high level of dog ownership with many owned dogs being free-roaming and to human-mediated movement of dogs over the island, some of which occurred to avoid dog culling or to replace dogs that had been culled (Putra et al., 2013; Townsend et al., 2013). Similarly, dog bites are often reported in Bhutan due to the existence of large numbers of free-roaming dogs (Tenzin et al., 2011b). Therefore, programs to vaccinate and to reduce the size of free-roaming dog populations are seen as components of rabies prevention and control (Reece, 2007), with increasing evidence of greater benefit from vaccination than from population control (Townsend et al., 2013). Though fertility control through immunocontraception and surgical sterilisation has certainly been documented to reduce free-roaming dog populations (Carroll et al., 2010; Cleaveland et al., 2006; Totton et al., 2011). Population control and vaccination programs require data on the numbers of free-roaming dogs; thus, estimation of the free-roaming dog population size is a necessary first step in planning rabies control programs (Serafini et al., 2008; Totton et al., 2010). An understanding of dog demography in rural and urban environments is also necessary to inform development of management strategies (Kitala et al., 2001) because differences in terms of free-roaming dog numbers and dog bite cases are seen between urban and rural areas in

Bangladesh, Chile, Tanzania and India (Acosta-Jamett et al., 2010; Belsare and Gompper, 2013; Gsell et al., 2012; Hossain et al., 2013).

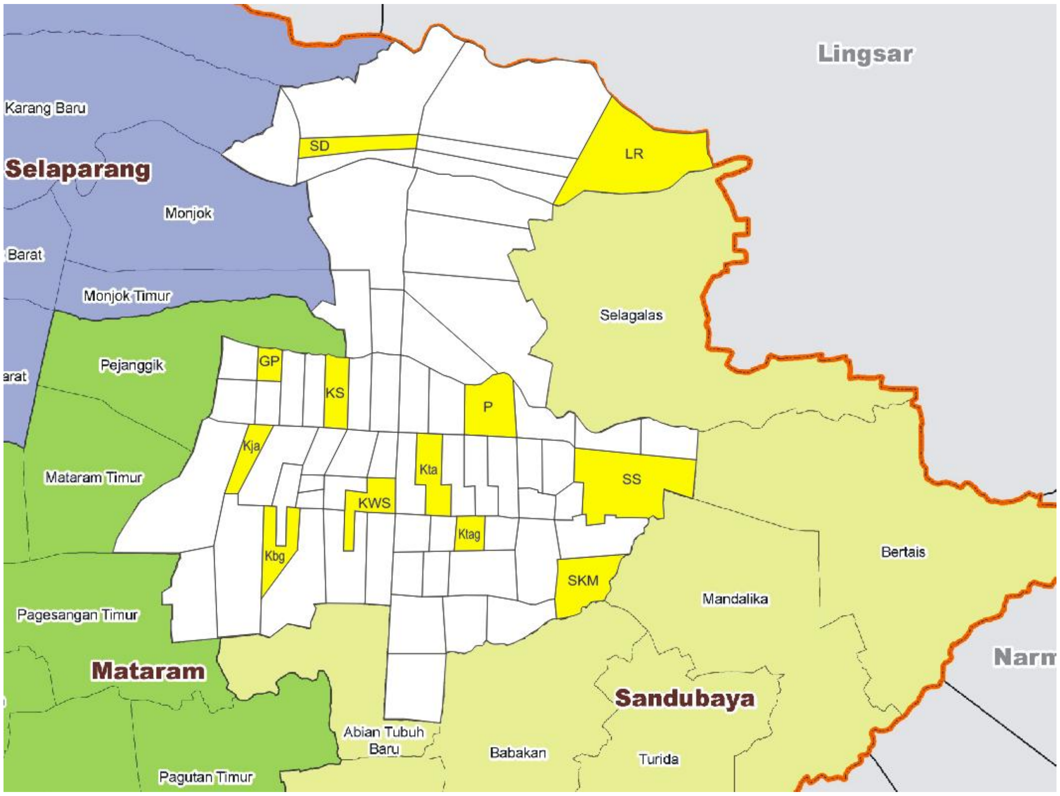
In Indonesia, lack of certainty about the size of the dog population is seen on rabies-infected islands, such as Sulawesi. Thus, it is difficult to implement an appropriate strategy (vaccination program) to manage rabies in the free-roaming dogs on these islands (Utami et al., 2008). Culling, although not an effective method to control rabies (Cleaveland et al., 2006), is still conducted in regions of Indonesia as a way to manage rabies, especially during the early stages of rabies outbreaks (Clifton, 2010). For rabies-free Lombok Island, it is important to understand the numbers of dogs, including ownerless dogs, when considering rabies prevention strategies. On Lombok, the number of ownerless dogs has never been measured. Dog counting through dog registration has only been attempted for owned dogs (drh. Aminurrahman personal communication, 2011). Thus, this survey aimed to estimate the numbers of ownerless dogs at an urban site and a rural site on Lombok Island. As the survey of dog owning households provided information on owned dogs at these sites, the data from this activity were used specifically to inform the proportion of unowned dog category of the dog type category nodes in exposure assessments for urban/rural sites and the port presented in Chapter 8.

6.2 METHODS

6.2.1 STUDY SITES

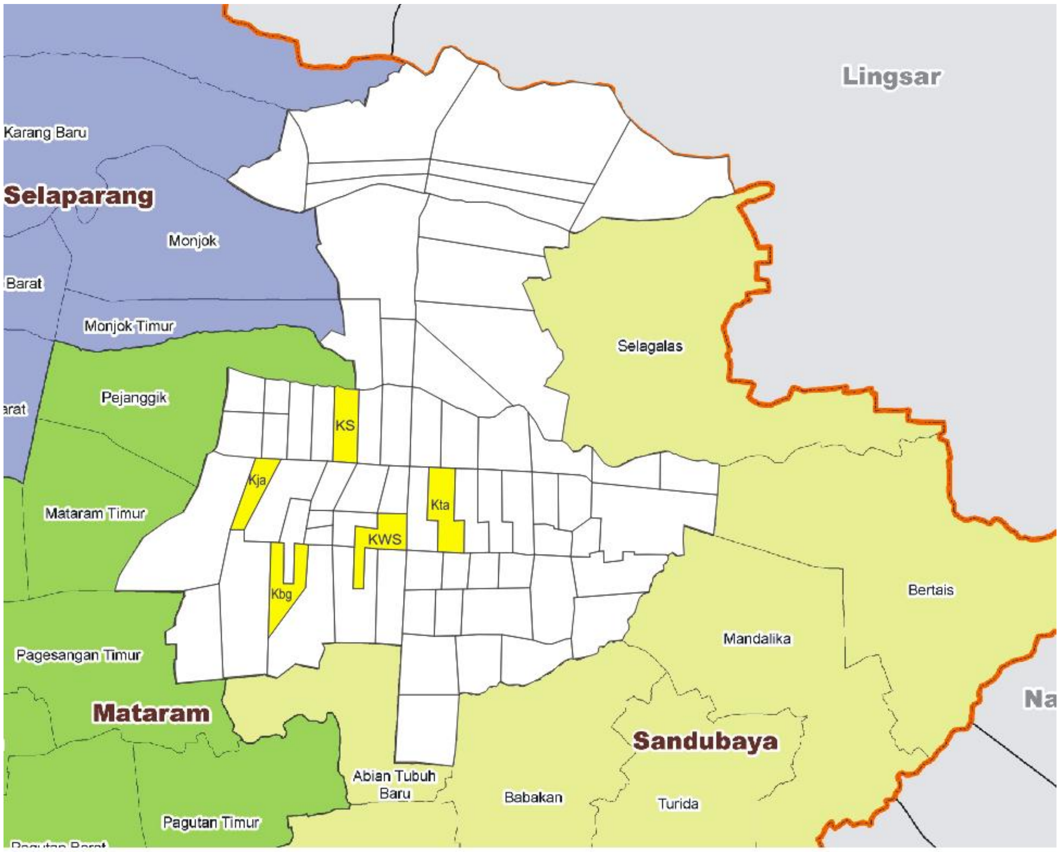
This study was conducted at two sites which were the same as the sites for the dog-owning household survey (Chapter 3). The urban site was Kota Mataram, Cakranegara District, and the rural site was Batu Putih village of Lombok Barat District. At Cakranegara District, further selection was made for the sites implementing the World Society for the Protection of Animals approach to selection of blocks/sites for dog counting (World Society for the Protection of Animals, 2008). In brief, this approach aims to achieve a random selection of blocks/sites for sampling that are well distributed across the chosen location, with ideally each block/site having a known and equal probability of selection. For Cakranegara District, this site is subdivided by municipal designation into 51 Lingkungan (term for village in an urban setting), and these constituted the blocks/sites for the selection process. First, every Lingkungan was assigned one of four colours in sequence starting from the Lingkungan located in the centre of the district and working outwards in a spiral clock-wise direction such that no two adjacent Lingkungan were assigned the same colour. Second, one of the four colours was randomly selected; this reduced the blocks/sites for selection to 18 yellow Lingkungan that were numbered from 1 to 18. Due to logistic considerations, the total number of sites that could be managed by the research team was 12. To select these 12, a form of systematic sampling method was applied with random selection of one from those numbered 1 to 3; then deletion of every third Lingkungan working down the full list of 18 to obtain 12 selected Lingkungan. The locations of the 12 Lingkungan selected are shown in Figure 7.1; of these, seven were mainly inhabited by Non-Balinese and five were mainly inhabited by the Balinese ethnic group (data regarding the main ethnic group residing in each one was obtained from the District Office Cakranegara). These 12 locations are listed in Table 3.1.

During conduct of the dog-owning household survey, it was realized that there were very few dog-owning households in the seven predominantly Non-Balinese Lingkungan. Thus, of the 12 Lingkungan, it was decided to conduct the unowned dog counting activity at only the five Lingkungan inhabited by the Balinese ethnic group, because for these sites adequate data could be obtained on owned dog numbers via the household survey and unowned dog numbers from the dog counting activity, thus providing the proportions for dog type categories required for the exposure assessment. The five locations in Cakranegara District (urban) and the site of Desa Batu village (rural) are illustrated in Figures 7.2 and 7.3.



SD: Sayang Daye; LR: Lendang Re; GP: Gubug Panaraga; KS: Karang Sampalan; P: Pamotan; SS: Sweta Selatan; SKM: Seganteng Karang Monjok; Ktag: Karang Tageban; Kta: Karang Tulamben; KWS: Karang Wana Sara; Kbg: Karang Bungkulan; Kja: Karang Jasi

Figure 6.1: The 12 locations selected at the urban site using the WSPA approach.



KS: Lingkungan Karang Sampalan; Kja: Lingkungan Karang Jasi; Kbg: Lingkungan Karang Bungkulan; KWS: Lingkungan Karang Wana Sara; Kta: Lingkungan Karang Tageban

Figure 6.2: The five locations at the urban site selected for the unowned dog counting activity of this survey.

Figure 6.3: The rural site for the unowned dog counting activity of this survey.

6.2.2 Conduct of unowned dog counting

The dog counting form was developed in English and translated into Bahasa Indonesia (Appendix 8). Data recorded on the form were village name, date and time of counting, weather at the time of counting, traffic condition (light or not) and visibility (good or not). The age, sex, body size and fur colour of each dog seen during counting were also recorded. Further the location where the dog was seen, the amount of garbage in the village (on a scale of 1 to 5) and the 'sighting status' (seen on day one, re-seen or not re-seen on day 2) were recorded.

6.2.3 Estimation of unowned dog population

6.2.3.1 Time of dog counting activity

The dog counting activity was conducted using the photographic recapture method by the author and two personnel from the Animal Health Care Centre of the Agriculture, Marine and Fisheries Office in Mataram. It was undertaken during April 2012, toward the end of rainy season (November to May in Lombok) when rain was starting to become less frequent. A preliminary visit was made to the two sites to find the most appropriate time of day to conduct the unowned dog counting. At Cakranegara District Kota Mataram, the most feasible time was at night from 12:00 am to 02:00 am because there was less traffic during that time and the presence of street lighting was adequate. In contrast, for Batu Putih village in West Lombok district, the most feasible time was early morning between 6:00 am and 8:00 am when traffic was minimal and natural light sufficient for observations. The lack of street lighting at this site prohibited dog counting at night-time. The counting was carried out at each location on two consecutive days.

The target dogs for these activities were unowned dogs defined as being free to roam and having no identifiable owner. Distinguishing owned, free-roaming dogs from unowned dogs is challenging; therefore, good support and coordination with dog owners at these sites was essential for successful dog population counts. Dog owners (through village leaders) were told to tether or collar their dogs during the dog counting activity. Village leaders notified dog owners to tether or collar their dogs through the banjar and mosque. Banjar is a community meeting usually held once or twice a week in villages of the Balinese ethnic group, for the purpose of providing information to the community as well as acting as a forum to address problems that arise between neighbours in the village. Announcing information through the mosque loudspeaker system is a common method for communication to the community on Lombok, and this practice has been in place for a long time.

6.2.4 PHOTOGRAPHIC RECAPTURE

The photographic recapture method was used to estimate the population of unowned dogs, implementing a modification of Schnabel's variation of the Petersen-Lincoln Index using multiple recaptures (Beck, 1973). As Beck stated, the individual differences between dogs made it possible to recognize individuals and to determine whether or not a dog had been previously photographed, i.e., "recaptured". For this work, a motorbike was utilized to carry out the counting activity along pre-defined routes. At each site, the route comprised of main roads and by-roads; all of these roads were visited once. When an unowned dog –that is, a dog with no collar or other identification – was encountered, the observer photographed it, and recorded the location as well as the other information on the dog counting form (Section 7.2.2).

In order to be thorough and not miss any dogs, the movement of the motorbike was kept at a reasonably low speed. Stopping and pushing the motorbike was sometimes required when searching for dogs in places with potential for hiding, such as in drains, under cars and behind garbage containers. In order to move quietly and not scare off dogs, four cylinder motorbikes were used because they produce relatively little noise.

6.2.5 OBSERVATION OF GARBAGE

Observation of presence of garbage was conducted in both urban and rural sites. Number of garbage containers or piles and type of garbage at each site were noted.

6.2.6 DATA MANAGEMENT AND ANALYSIS

Data were entered into Microsoft Excel and subsequently checked for missing and extreme values against the hardcopy questionnaires. Standard descriptive analyses were conducted using Genstat 14th edition (PC/Windows, 2007, VSN International Ltd., Hemel Hempsted, UK). Categorical data were described using frequency tables and continuous variables using mean, median and range.

The estimated number of the unowned dogs was calculated using a formula called Chapman estimate from Beck (1973; Equation 2.1 and Equation 2.2); the formula is as follows:

$$Nc = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \quad \text{.......... Equation 2.1}$$

with its approximate variance estimate (Equation 2.2)

$$var\ Nc = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)}$$

where Nc = The estimated number of unowned dogs

n_1 = Number of dogs seen on day 1

n_2 = Number of dogs seen on day 2

m_2 = Number of dogs seen on day 1 and re-seen on day 2

var Nc = Variance estimate of Nc

An approximate 95% confidence interval assuming normality for $\hat{N}c$ is given by $\hat{N}c \pm 1.96(\hat{var}\ \hat{N}c)^{0.5}$

This simple formula is commonly used to estimate the size of a dog population, and it allows a dog population estimate using survey data for just two days' observations (Beck, 1973).

6.3 RESULTS

6.3.1 ESTIMATION OF UNOWNED DOG POPULATION

During dog counting, it was assumed that all dogs present on the counting days were ownerless dogs, given that the dog owners were asked to confine or give collars to their dogs. Only one dog with a collar was viewed during that time. The majority of houses at the two sites were fenced. Only dogs present outside residences' fences and thus on the street were counted. Unowned dogs were seen near garbage piles, on the streets, and sleeping in front of closed shops, around unfinished buildings and in empty water drainage. Table 6.1 shows the estimated number of unowned dogs at the urban and rural sites. Table 6.2 shows the number of unowned dogs that were observed during the counting activity at the urban and rural sites.

Table 6.1: Estimated number of unowned dogs at the urban and rural sites in Lombok in 2012.

Site	N[a]
Urban	180 ± 14.2
Rural	65 ± 7.6

[a], Number of unowned dogs estimated within the survey areas by means of Chapman's estimation.

Table 6.2: Demographics of the unowned dogs observed during counting at the urban and rural sites in Lombok in 2012.

	Urban site	Rural site
Number	158	58
Demographics		
Age		
Puppy	7.6% (12/158)	24.1% (14/58)
Young	8.2% (13/158)	8.6% (5/58)
Adult	84.2% (133/158)	67.2% (39/58)
Sex		
Male	81.6% (129/158)	69% (40/58)
Female	11.4% (18/158)	10.3% (6/58)
Sex not seen	7% (11/158)	20.7% (12/58)
Seen on both days	47.5% (75/158)	46.6% (27/58)

Ages of the dogs were distinguished by the body size.

6.3.2 PRESENCE OF GARBAGE

In the survey areas at the urban site, one large garbage container is located in a central position for each cluster of houses. The container is provided and weekly garbage collection service is conducted by the Dinas Kebersihan (an agency at municipal level that is responsible for waste management). In addition, there was one wet market present at the urban site with piles of market garbage in a large container. The tops of the garbage containers are not secure and easily flap open. Often the containers were overloaded and some also had garbage placed outside the containers. Dogs were seen climbing on the garbage containers and feeding themselves. The garbage dumps included leftover meals and other household kitchen garbage; some were in plastic bags, some were not. The garbage observed at the wet market was fish waste and leftover meals, presumably from the sellers' lunches.

In survey areas at the rural site, no garbage containers were provided for the community. Piles of loose garbage, not in plastic bags, were seen in two areas. Garbage types were leftover meals, plastic bags and containers, and leaves from trees. During the time of visit, a few dogs were seen to feed themselves at these garbage piles.

6.4 DISCUSSION

This survey was conducted to obtain data on the size of the unowned dog population at sites that represent a high risk of rabies introduction and exposure (details on what constitutes a high risk site are provided in Chapter 3). The results of this survey will be used to parameterise the dog type category nodes for quantitative assessment to estimate the probability of rabies virus exposure from a rabid dog to a susceptible dog at the selected sites.

This survey has used the WSPA approach to select the dog survey locations at the urban site. Of the 12 locations selected, only five Lingkungan that were inhabited mainly by the Balinese ethnic group were actually used. However, given that dogs are more tolerated and appreciated in these communities, focusing on the Balinese villages potentially provides a focus on the communities with the highest numbers of dogs. This was appropriate, given the purpose was to obtain data to inform the exposure assessment; thus, the exposure assessment considers exposure for the highest risk urban communities on Lombok.

The decision to conduct dog counting during the night at the urban site (Cakranegara District) was based on observations during the preliminary visits to each site by the research team. High traffic mobilisation in Cakranegara District was observed during the day as this district serves as Lombok's business centre; thus, trading activities and movement of vehicles slows down only in the late evening, such as from 10 pm. During the high activity period, it is challenging to do proper dog counting, because often free-roaming dogs are scared away by the busy traffic and are likely to hide themselves. Further, during the preliminary visit, numbers of free-roaming dogs were seen scavenging at trash bins near the market and premises and on streets at night-time. Thus, night-time was considered appropriate for the dog counting activity in this district. Similarly, night-time was utilised to count dogs in a survey of roaming dogs conducted in central Cairo (World Society for the Protection of Animals, 2008).

During the conduct of this survey, all roaming dogs without a collar seen at the sites were recorded. Because of the great effort taken to inform dog owners in the area to tether or collar their dogs during the counting activity, it was assumed that all of the dogs seen (untethered or uncollared) were unowned. Only one dog with a collar was observed during the counting activity. During the days of counting activity, the weather was clear with no rain, thus enabling the team to record the dogs easily. Although the majority of the dogs observed tried to keep a distance from the team, they did not run too far and were seen standing alert with eyes directed to the counting team. This was also observed in a study of the stray dog population in Sao Paulo, Brazil (Dias et al., 2013).

According to our survey, the estimated number of unowned dogs at the urban site is higher than at the rural site, with 180 dogs (95% CI 166–194) at the urban site and 65 dogs (95% CI 57–73) at the rural site. It appears that the type of garbage, such as fish waste, leftover meals and other household kitchen garbage, seen at the urban site provided food for the unowned dogs at this site. The study conducted at Sao Paulo also showed the importance of garbage for free-roaming dogs; thus, this study attempted to observe dogs around areas with trash bins and places with leftover food, such as restaurants and food stalls (Dias et al., 2013).

In a study to compare the number of free-roaming dogs in Kathmandu, Nepal and Shimotsui, Japan, it was found that one of the causes for the higher number of free-roaming dogs observed in Kathmandu is the lack of effort to control the dog population (Kato et al., 2003). Another study in Brazil outlined how attempts at free-roaming dog population control consisted of reduction and sterilisation programs for street dogs (Amaku et al., 2010). In India, stray dog population reduction is mainly through sterilisation programs (castration and spaying) (Totton et al., 2010). On Lombok Island, attempts to reduce the free-roaming dog population have been implemented through a dog culling program (two to three times a year) and intermittent sterilisation programs (however, this costly exercise is limited by budgetary constraints). The culling program is limited to unowned dogs while the sterilisation program is for both catchable unowned dogs and owned dogs, with permission from the owners. These programs started in 2009, after rabies spread on neighbouring Bali Island in late 2008. However, there has been no evaluation to measure the impact of these programs on the free-roaming dog population on Lombok, due to budgetary issues. Also, the sterilised dogs are not identified in any way (e.g., collar or tag) and the culling program is not targeted (drh. Aminurrahman personal communication, 2011); thus, it is possible that the sterilised dogs may be culled as well. Capturing ownerless and unwanted owned dogs and housing them in animal shelters, as occurs in Ireland, UK, Australia and New Zealand (Downes et al., 2009; Elliott et al., 2010; Stavisky et al., 2012), seems far beyond the financial capacity of Lombok as an island in a developing country.

Feasible methods of unowned dog population reduction on Lombok may include reducing dog access to garbage disposal areas: for example, fencing the dump area. This will require collaboration with the Dinas Kebersihan (an agency at municipal level that responsible for waste management). Further, regular sterilisation of male free-roaming dogs (unowned and owned dogs) will also assist population reduction, and is less expensive than spaying. Inexpensive identification should be provided for the sterilised dogs. Education of dog owners to promote responsible dog ownership is also necessary, as many semi-free roaming and free-roaming owned dogs are seen on Lombok (Chapter 3). Owned dogs that are allowed to roam freely will likely contribute to the unowned dog population (through breeding) and, through fighting, could acquire disease from unowned dogs or could spread disease to the unowned dogs.

This survey conducted at the urban and rural sites has provided initial data about the unowned dog population in urban and rural Lombok. The main limitation of this survey was its utilisation of a simple dog population estimation method to estimate the unowned dog population. This method is not the best way to estimate the number of dogs (Belsare and Gompper, 2013). Other methods, such as the Bayesian method used in Chad (Durr et al., 2009), may also improve the accuracy of survey results. However, the simple method used in this survey was adequate to provide an initial estimate of the ownerless dog population at urban and rural sites on Lombok, and was appropriate given the limited time period for dog counting (of two days at each location) that could be completed within the context of a Masters research project. Further, the initial data was adequate to inform parameters for the exposure assessment reported in Chapter 8.

CHAPTER 7: QUANTITATIVE RISK ASSESSMENT FOR RABIES VIRUS INTRODUCTION INTO LOMBOK AND TRANSMISSION FROM A RABIES-INFECTED DOG TO A SUSCEPTIBLE DOG ON LOMBOK

7.1 INTRODUCTION

The importation of rabies-infected dogs is the principle means by which urban rabies can enter a rabies-free country or region. Implementation of strict border control is used by some countries to prevent rabies entry via infected dogs. For example, Japan requires imported dogs to be microchip identified, vaccinated against rabies with satisfactory titre antibody level, and held for at least 180 days after titre testing before travel to Japan (Kamakawa et al., 2009). In the United Kingdom, dogs and cats must go through the Pet Travel Scheme to ensure disease status, including rabies, prior to entering this country (Jones et al., 2005).

In Indonesia, movement of rabies-infected dogs on fishing or cargo boats has been documented as a route of rabies spread to previously rabies-free areas (Putra et al., 2009; Scott-Orr H, 2009). Research reported in Chapter 5 demonstrates that movement of dogs on passenger ferries is another possible route for entry of a rabies-infected dog to rabies-free islands. However, no research to date has attempted to quantitatively evaluate the probability of rabies entry through a rabid dog to a rabies-free island/region in Indonesia. Thus, the aims of the risk assessment presented in this chapter were to assess the probability of rabies virus entering Lombok Island through a rabies-infected dog, via boat and ferry pathways and to assess the probability of the rabid dog transmitting infection to the susceptible Lombok dog population.

7.2 METHODS

7.2.1 RISK ASSESSMENT MODEL

This study consisted of release and exposure assessments, following the World Organisation for Animal Health (OIE) methodology for risk analysis (OIE, 2010). The single hazard of interest is the rabies virus and as rabies in Indonesia is limited to the urban cycle, the pathways investigated were limited to the movement of infected dogs. Risk assessment consists of four steps including the release, exposure, consequence assessments and risk estimation (OIE, 2010). The current work was limited to a release and exposure assessments due to the lack of Lombok dog population data required to assess the spread of the virus (consequence assessment). Given the consequence assessment was not conducted, estimation of the overall risk of an incursion of rabies virus into Lombok was not conducted, as risk estimation is an integration of the release, exposure and consequence assessments.

The release assessment evaluated the probability of a rabies-infected dog from rabies-infected islands entering Lombok via boat and ferry pathways. Further, the exposure assessment described the probability of a rabies-infected dog exposing the susceptible dog population on Lombok Island.

Scenario trees were developed for the release and exposure pathways using Microsoft Excel (PC/Windows 2007) and probabilities were estimated using Monte Carlo stochastic simulation modelling with @Risk 6.0 (Palisade Corporation, USA). Each simulation consisted of 5,000 iterations sampled using the Latin hypercube method with a fixed random seed of one.

7.2.2 DATA SOURCES

Data from Chapters 3, 4, 5 and 7 of this thesis were used to parameterize the input values used for these assessments. Literature and expert opinion were also used for a number of parameters which were not covered by activities described in these chapters. Expert opinion was also used to refine and prioritize pathways.

7.2.2.1 Boat survey

Chapter 4 reports the results of the questionnaire survey administered to captains of boats arriving at Lombok ports from other parts of Indonesia (outside Lombok), and to local Lombok households with boat activity. A total of 169 respondents (117 captains of boats visiting Lombok Island and 52 local Lombok households with boat activity) were interviewed. The boats included fishing boats, tourist boats and cargo boats. The information on the origin of the boats, the presence of dogs on fishing and other boats, the management of dogs transported on these boats to Lombok and the frequency of this type of dog transport to Lombok, were collected. Data on the origin of dogs owned by local Lombok households with boat activity was also obtained. This information was used in the release assessment for the boat pathway (Figure 1).

7.2.2.2 Household survey

Chapter 3 reports the results of the questionnaire survey conducted with dog owning households at urban and rural sites on Lombok Island. The results of the questionnaire identified the rabies-infected island of Bali as one source of dogs owned by the interviewed households. Information on ethnic group of dog owners, whether they travel with their dogs to other islands as well as dog management were also obtained. This information was used in the release assessment for the ferry pathway (Figure 2). Dog management data was used in the exposure assessment.

7.2.2.3 Interviews at Padang Bai ferry harbour

Chapter 5 reports the results of the questionnaire survey conducted at Padang Bai ferry harbour. The survey investigated practices used to transport dogs from rabies-infected areas/islands to Lombok Island. Information about the ethnic group of people who transported dogs and the origin of transported dogs were obtained and used in the release assessment for the ferry pathway.

7.2.2.4 Dog population estimation

Chapter 6 reports the results of the study estimating the dog population of unowned dogs at an urban site and a rural site on Lombok Island. Information on dog categories (full restriction, semi-free roaming owned dogs, free-roaming owned dogs and unowned dogs) living at both sites was based on Chapters 3 and 6. These data were used in the exposure assessment to estimate the probability of exposure of the Lombok dog population to the rabies virus from a rabies-infected dog.

7.2.2.5 Literature and expert opinion

Data obtained from published literature were used to describe the pathways of virus release, and to parameterize the input values when the data needed were not available from the data gathering exercises presented in this thesis. Expert opinion to refine and prioritize the pathways of release was sought from provincial experts in the Indonesia Agriculture Quarantine Agency, Marine and Fisheries Office and Animal Health Agency.

7.2.2.6 Pathways and scenario trees

7.2.2.6.1 Release pathways:

Initially, release pathways were described based on the literature. Accordingly, the most likely pathways were:

- Local Lombok fishermen who travel to rabies-infected islands with a dog on the boat – belief that sailing with a dog ensures a safer journey
- Lombok fishermen adopting a dog from rabies-infected islands and returning to Lombok with an infected dog
- Fishermen originating from another island travelling to Lombok with an infected dog on the boat – belief that sailing with a dog ensures a safer journey
- Lombok resident adopting an infected dog from outside Lombok and returning to Lombok by ferry or plane
- Trade of infected dogs from a rabies-infected island by ferry or plane
- Infected dogs imported from a rabies-infected island for use as police sniffer dogs, transported by ferry or plane.

These proposed pathways were reviewed by experts at the West Nusa Tenggara Province offices of the Indonesia Agriculture Quarantine Agency, Marine and Fisheries Office and Animal Health Agency. All experts were based at the provincial level (West Nusa Tenggara Province). These experts were asked to refine the pathways and prioritize in order of importance. This consultation was conducted during face-to-face individual meetings, using open-ended questions regarding the list of pathways, followed by email communication when required.

As a result of the expert consultation process, the following three pathways were used to assess the likelihood of rabies entering Lombok:

1. People with boat activity from outside Lombok that dock at informal ports, carrying an infected dog – ports with no quarantine post

2. Local people with boat activity who travel to rabies-infected islands and return to Lombok with an infected dog

3. Local people who travel to rabies-infected islands by ferry (formal port) and return to Lombok with an infected dog.

7.2.2.6.1.1 Release assessment via boat pathway (Release Scenario Tree)

The scenario tree shown in Figure 7.1 was used to describe the release of a rabies-infected dog to Lombok via the boat pathway. Two pathways of release of a rabies-infected dog were identified: Boats that originated from outside Lombok (outside boats) and boats that originated from Lombok (local boats). The pathways and nodes of this scenario tree are represented in Figure 7.1, and nodes, branches for each node and input values used are described in Table 7.1.

The following nodes are used for both, local and outside boat pathways:

7.2.2.6.1.1.1 Boat origin

Boats were categorised into two groups based on their origin, thus defining the two branches of this category node: outside boats and local boats. The proportions of outside and local boats were identified in Chapter 4. Of a total of 169 captains of boats interviewed, 117 were from outside Lombok Island and 52 local Lombok boats. The 117 captain of outside boats interviewed were from South Sulawesi, Java Island, Sumbawa Island, Flores, Bali and Papua Island. The proportion of boats according to their origin (outside or local) was incorporated into the model using a Beta distribution to add uncertainty around this proportion.

7.2.2.6.1.1.2 Ethnic group

A category node with two branches (Low risk and High risk) was included to represent differences between ethnic groups in Indonesia in relation to dog ownership and management. In this study, people interviewed were categorised into two different types of ethnic groups: low risk ethnicity type and high risk ethnicity type. Ethnicity types that are known to not commonly have dogs in their households and are therefore considered to be less likely to take dogs from another island to Lombok, were included in the low risk ethnicity type. Ethnicity types which commonly have dogs in their households are considered to be more likely to take dogs from another island to Lombok and were therefore included in the high risk ethnicity type. For boat captains from outside Lombok, categorisation was based on their island (or part of the island) of origin, the main religion on this island and knowledge about the majority of people's attitude towards dogs on this island. For boat captains from Lombok, categorisation was based on ethnic group. Thus, the low risk ethnicity type for the boat captains interviewed from outside Lombok included those from South Sulawesi, Java Island and Sumbawa Island. The high risk ethnicity type included boat captains interviewed who came from Flores, Bali and Papua. For the local Lombok boat captains, the low risk category included the Sasakese ethnic group, whereas the Balinese ethnic group was included in the high risk category. For the 117 outside boat captains interviewed, 53 were included in the low risk ethnicity group and 64 in the high risk ethnicity group. For the 52 local boat captains, 50 were the low risk ethnicity group and 2 were the high risk ethnicity group.

7.2.2.6.1.1.3 Do they have a dog in the boat?

Dog presence is essential for virus release to be able to occur. Results from Chapter 4 showed that of 117 outside boat captains interviewed, only 1 boat had a dog on board. From interviews with 52 captains of local Lombok boats, none reported ever having a dog on their boat. To account for uncertainty around these proportions, these values were incorporated into the model using Beta distribution.

7.2.2.6.1.1.4 The island is infected

The island of origin of a dog in a boat that originated from outside Lombok and the island visited by a local Lombok boat must be rabies-infected in order for a rabies-infected dog to be released into Lombok. As mentioned in Section 7.2.2.6.1.1.1, the outside boats that visited Lombok were from six different islands or regions; three of which are rabies-infected (Flores, Bali and South Sulawesi). Local Lombok boat captains reported visits only to Bali Island with the short distance between Western

Lombok and Eastern Bali meaning the journey is feasible for small sized boats (Chapter 4). Accordingly, rabies prevalence in Bali, Flores and South Sulawesi was used in the model.

Data on rabies prevalence for Bali was obtained from an ACIAR report of Indonesia Rabies Risk Assessment Workshop held in October 2012. The report stated that following the success of the island-wide dog vaccination campaign in Bali, the rabies incidence decreased in 2012, with only 37 rabid dogs among a total of 96,582 susceptible dogs reported in the period from March 2012 to July 2012. From this rabies prevalence on Bali was estimated to be 0.04%, and incorporated into the model using a Beta distribution.

Rabies prevalence on Flores was obtained from a Master thesis reporting a study of the dog population and oral bait trial in district of Flores Timur on Flores Island in 2009 (Nani, 2010). These prevalence estimates were subsequently sent to two Indonesian animal health experts to confirm accuracy of available data from Flores as well as to obtain estimates for the current rabies prevalence in South Sulawesi. Rabies prevalence in Flores was estimated as 0.5% and South Sulawesi 1%. To incorporate these values into the model a Pert distribution was used, using estimated prevalence as the most likely value of the distribution, with minus and plus 10% for the minimum and maximum values, respectively.

The following nodes are used for the local boat pathway only:

7.2.2.6.1.1.5 Origin of the dog

Among the 52 local Lombok captains interviewed, all of whom were fishermen; there were four that owned dogs. These four fishermen owned a total of eight dogs that had all been born in Lombok (three owned by low risk, five owned by high risk). None of the fishermen interviewed owned dogs that originated from outside Lombok Island. Data on the origin of dogs owned by the four fishermen were used to parameterize the required input values for this node. A Beta distribution was used to add uncertainty around this proportion.

7.2.2.6.1.1.6 The local dog has contact with dogs in another island

This node accounts for the probability that a dog on the boat of a local fisherman from Lombok will contact another dog when the boat is visiting another island. Dogs are likely to be present around the ports due to food availability. According to Chapter 3 results, the level of dog confinement varied depending on ethnicity type. The low risk ethnicity type was more likely to allow their dogs to roam freely than the high risk ethnicity type. Since specific data on dog contact was not available, a qualitative estimate was used, with a *Low* probability of contact used for the high risk ethnicity type and a *High* probability of contact used for the low risk ethnicity type fishermen. Qualitative estimates were transformed to quantitative values using uniform distributions following the semi-quantitative methodology used for import risk analysis (DAFF, 2004).

7.2.2.6.1.1.7 The local dog is bitten by dog on infected island

This node account for the probability of a dog from Lombok being bitten by a rabies-infected dog when visiting the rabies-infected island. The proportion of furious and paralytic types of rabid dogs obtained from literature was used to estimate the required probability of this node. Dogs affected with the furious type of rabies are aggressive and as such likely to bite any object. This is in contrast to the paralytic type, in which case biting is not common. According to Banyard and Fooks (2011) the proportion of rabid dogs having furious and paralytic rabies is 25% and 75%, respectively.

7.2.2.6.1.1.8 The dog gets infected

Information on how likely it is that a dog gets infected with rabies from a bite of an infected dog was obtained from literature. Hampson et al. (2009) identified that the probability of non-rabies vaccinated dogs to become infected after been bitten by a rabid dog is 0.49 with a 95% confidence interval of 0.45 - 0.52.

7.2.2.6.1.1.9 The dog returns to Lombok

For this node, an assumption was made that if an owned dog became rabies-infected while travelling, the dog would most likely return to Lombok if it was during the incubation period and thus with no clinical signs. As in Section 8.2.2.6.1.1.6, the probability of a dog returning home to Lombok is also influenced by the ethnicity type. Dogs owned by the high risk ethnicity type would have higher probability to return to

Lombok than dogs owned by the low risk ethnicity type. For the high risk ethnicity, 0.95 was used as the most likely value of a Pert distribution, with a minimum value is 0.9 and a maximum of 1. For the low risk ethnicity type, the probability was assumed to be 20% lower than the probability for the high risk ethnicity type.

The following nodes are used for the outside boat pathway only:

7.2.2.6.1.1.10 Island of origin

This node is needed because the probability of a dog being infected differs depending on the rabies prevalence on the island of origin. Chapter 4 reports that outside boats originated from 6 different islands - 3 rabies-infected islands (South Sulawesi, Bali and Flores) and 3 rabies-free islands or island regions (Sumbawa, Papua Island and East Java). As the islands of origin differed between the low and high risk ethnicity types, South Sulawesi, Sumbawa and East Java were branches for the low risk ethnicity type; while Bali, Flores and Papua were included in the high risk ethnicity type. Proportions of boats from outside Lombok originating from each island were incorporated into the model using a Beta distribution.

7.2.2.6.1.1.11 Dog confinement in the boat

As explained in Section 7.2.2.6.1.1.6, the probability of the dog being able to roam freely will differ according to the ethnicity type. The high risk ethnicity type has higher probability to confine their dogs than the low risk ethnicity type. This higher estimate is supported by results in Chapter 4, which report that the Balinese fishing boat captain interviewed with a dog on his boat, had the dog confined in a cage on the boat. As such, for high risk ethnicity type a uniform distribution from 0.9 to 1.0 was used; while a uniform distribution from 0.7 to 0.9 was used for the low risk ethnicity type.

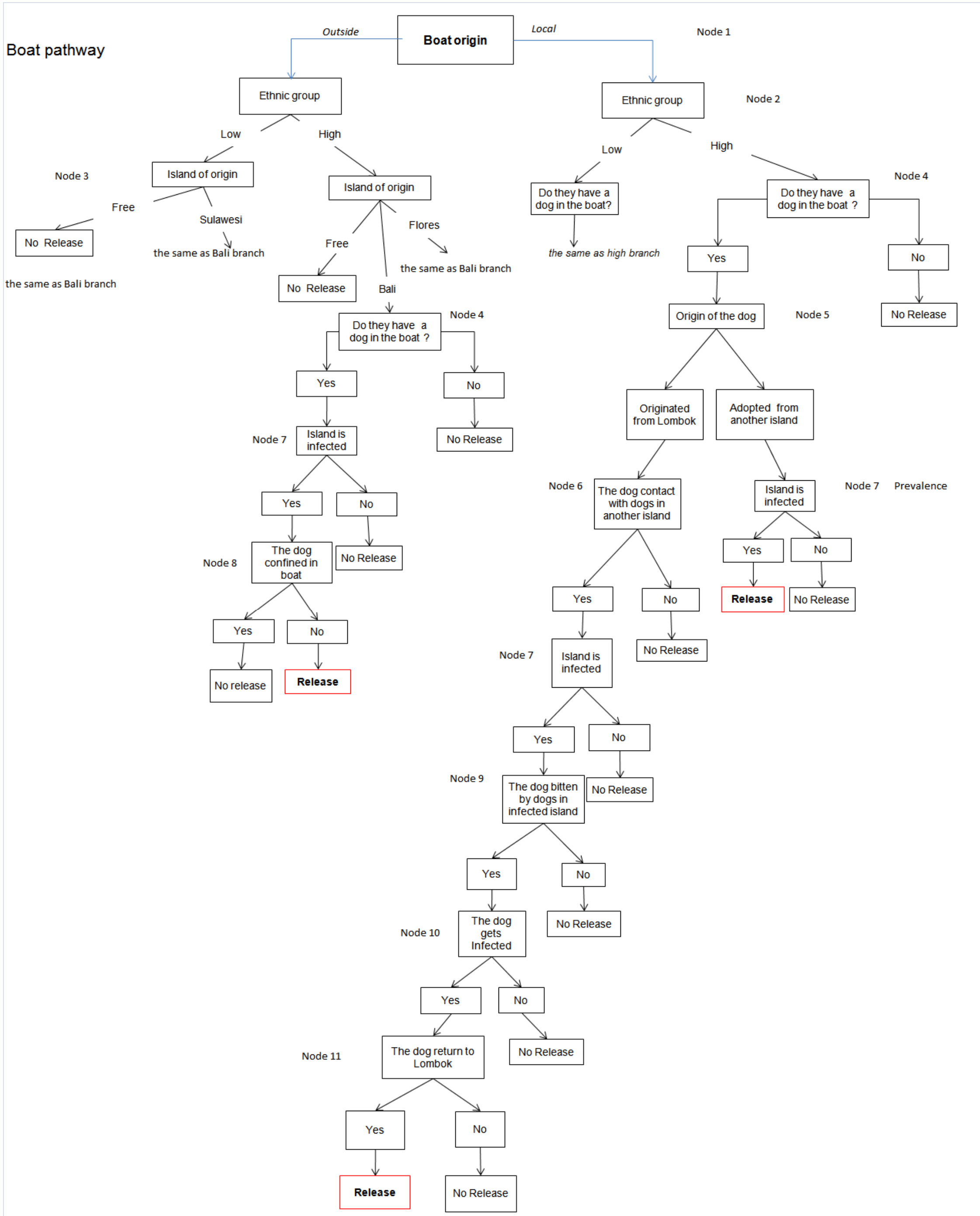


Figure 7.1: Scenario tree representing the release assessment evaluating the probability of a rabies-infected dog being released to Lombok Island from boat.

Table 7.1: Nodes, parameter estimates and input values used for the release assessment evaluating the probability of a rabies-infected dog entering Lombok Island via boat

Node	Branch of node	Parameter estimates	Input values[a]	Data sources
1. Boat origin	Local Outside	Proportion of the origin of people with boat activity interviewed	Beta (53, 51)	Chapter 4
2. Ethnic group	Low High	Among interviewed people, the proportion of each type of this people	Local Low risk : Beta (51, 3) High risk : Beta (3, 51) Outside Low risk : Beta (54, 65) High risk : Beta (65, 54)	Chapter 4
3. Island of origin (Only for boat originated from outside Lombok)	Rabies-free island Rabies-infected island	Proportion of people interviewed coming from each island	Low risk Rabies-free Sumbawa and East Java: Beta (24, 38) Rabies-infected Sulawesi : Beta (38, 24) High risk Rabies-free Papua : Beta (2, 57) Rabies-infected Bali : Beta (52, 7) Rabies-infected Flores : Beta (6, 53)	Chapter 4
4. Do they have a dog in the boat?	Yes	Proportion of people interviewed with dog in the boat	Local Low risk : Beta (1, 51)	Chapter 4

	No		High risk : Beta (1, 3) Outside Low risk : Beta (1, 54) High risk : Beta (2, 64)	
5. Origin of the dog (only for boat local Lombok)	Originated from Lombok Adopted from another island	Proportion of people interviewed that only have local dogs (dogs originated from Lombok) Proportion of people interviewed that adopt a dog from another island sometimes	Low risk Originated from Lombok : Beta (4, 1) Adopted from other island : Beta (1, 4) High risk Originated from Lombok : Beta (6, 1) Adopted from other island : Beta (1, 6)	Chapter 4
6. The local dog has contact with dogs in another island (only for boat local Lombok)	Yes No	The proportion of people interviewed in relation to the confinement for their dogs	Low risk : Uniform(0.9, 1) High risk : Uniform(0.7, 0.9)	Chapter 3
7. The island is infected	Yes No	Rabies prevalence on each specific island	Bali : Beta(38, 96546) Sulawesi : Pert(0.009,0.01,0.011) Flores : Pert(0.0045,0.005,0.0055)	ACIAR report of Indonesia Rabies Risk Assessment Workshop 2012 and Expert opinion
8. Dog confinement in the boat (only	Yes No	Probability of dogs present in the boat being confined	Low risk : Uniform(0.7, 0.9) High risk : Uniform(0.9, 1.0)	Chapter 4

for boat originated from outside Lombok)				
9. The local dog is bitten by dog in infected island (only for boat local Lombok)	Yes No	Probability of local dog being bitten by a rabid dog in Bali (proportion of furious and paralytic of rabid dogs)	Output discrete (0.25, 0.75)	Literature : proportion of furious and paralytic from (Banyard and Fooks, 2011)
10. The dog gets infected (only for boat local Lombok)	Yes No	Probability of a healthy dog gets infected with rabies from a bite of an infected dog	Output discrete (0.49, 0.51)	Literature : Hampson et al. (2009)
11. The dog return to Lombok (only for boat local Lombok)	Yes No	Probability that a local dog in a boat from Lombok returning to Lombok after being in a rabies-infected island	Low risk ethnicity type: Pert (0.9, 0.95, 1) – 20% High risk ethnicity type Pert (0.9, 0.95, 1)	For the high risk ethnicity type: Assumption that owned dog infected with rabies virus is in the incubation period and as such, not yet shows clinical signs and likely to return home For the low risk ethnicity type: The probability for the dog to return home is 20% lower than the high risk ethnicity type.

[a] Beta = Beta distribution (*successes + 1, total number – successes + 1*); Pert = Pert distribution (*minimum, most likely, maximum*); Uniform = Uniform distribution (*minimum, maximum*)

7.2.2.6.1.2 Release assessment via ferry (Release Scenario tree)

The scenario tree shown in Figure 7.2 was used to describe the release of a rabies-infected dog into Lombok from people travelling to this island by ferry. The nodes and branches for each node and parameters estimates are described below and summarised in Table 7.2.

7.2.2.6.1.2.1 Residential status

People interviewed at Padang Bai ferry harbour were categorized into two groups based on their residential status, whether they were Lombok resident or non-resident. These were the two categories used in this node. The proportions of resident and non-resident were identified in Chapter 5. Of the total 158 people driving in vehicles present in ferries interviewed, 81 were residents and 77 were non-residents. A Beta distribution was used to incorporate uncertainty around these proportions.

The following sections are branches for Lombok resident pathway:

7.2.2.6.1.2.2 Ethnicity group of Lombok residents interviewed at the ferry harbour

Similar to the scenario tree for people with boat activity (Section 7.2.2.6.1.1.2), as dog function, purpose and management varies among different ethnic groups, this node was needed to provide a more accurate representation of the overall population - separated in subsets (low risk ethnicity type and high risk ethnicity type) which have different practices with dog management. Similar as for people with boat activity scenario tree, this node reflects a difference in taking dogs from another island into Lombok or travelling with their dog to another island. The proportion of residents in each group was identified in Chapter 5. Of 81 residents interviewed, 66 were belonging to low risk ethnicity type and 15 were high risk ethnicity type. To account for uncertainty around these proportions, Beta distributions were used.

7.2.2.6.1.2.3 Lombok residents travelling with their dog to another island

Dogs travelling with their owner to a rabies-infected island is a potential pathway of rabies introduction into Lombok, if the Lombok dog gets infected while on the island and returns to Lombok. However, results from Chapter 3 showed that among people interviewed, none reported having ever travelled with their dogs to another island. Consequently, this pathway was considered negligible and a quantitative assessment was not further conducted. However, this pathway poses a potential risk for rabies introduction, and further research might support quantification of its corresponding probabilities. The nodes that this assessment has not quantified (although shown in Figure 2) are: 1. The probability of the dog travelling with the Lombok resident contacting local dogs on another island; 2. The probability that this island is infected; 3. The probability of the dog travelling with the Lombok resident being bitten by local dogs on infected island; 4. The probability that the dog travelling with the Lombok resident gets infected; and, 5. The probability that the dog travelling with the Lombok resident returns to Lombok.

7.2.2.6.1.2.4 Lombok residents adopting a dog from another island

This is a probability node representing the probability of a Lombok resident adopting a dog from another island. The proportion of people interviewed adopting dogs from another island was identified in Chapters 3 and 5. Of the total 481 people interviewed, 22 reported adopting dogs from another island (Bali and Java). Of the 22, seven people were from the low risk ethnicity type and 15 from high risk ethnicity type. A Beta distribution was used to incorporate uncertainty around the proportion of people from the two ethnicity types adopting dogs from another island.

7.2.2.6.1.2.5 Island of origin of the adopted dog

Data from Chapter 3 and Chapter 5 was used to parameterize this category node, which represents the different origins of the dogs adopted by Lombok residents. A total of 32 dogs were brought to Lombok by the residents. Of those, ten dogs were adopted by low risk ethnicity type; these dogs were from Jakarta, a rabies-free area (five dogs) and Bali (five dogs). The remaining 22 dogs were adopted by high risk ethnicity type; these dogs were acquired from rabies-infected West Java (two dogs) and Bali (17 dogs) and the remaining three dogs were adopted from Jakarta. The proportion of dogs originating in each specific area was calculated for each ethnicity group, and incorporated into the model using a Beta distribution (Table 2). The origin of the dog was considered as the rabies prevalence among the local dog population is different according to the region or island considered.

The following sections are branches for the non-resident pathway:

7.2.2.6.1.2.6 Non-resident people visiting Lombok bringing a dog to Lombok

Bringing dogs to Lombok from a rabies-infected island could be a pathway of introduction of rabies virus into Lombok. Data from Chapter 5 was used to parameterize this probability node. Among 77 non-residents interviewed, ten people reported having brought dogs to Lombok in the last two years. Data at Chapter 5 showed that these ten people reported to have brought dogs to Lombok as a request from dog owners from Lombok. As such, this practice of moving dogs conducted by the ten people was not depend on the ethnicity of the interviewed but more on who asked them to bring the dog. Therefore, the ethnicity type of the non-residents was not considered in the model. This proportion was incorporated in the model using a Beta distribution.

7.2.2.6.1.3.7 Island of origin of dogs brought to Lombok by non-residents

This category node accounts for the proportion of dogs originating from different islands. The islands considered were rabies-infected islands (Bali, West Java) and non-infected islands (Jakarta). Result from Chapter 5 showed that non-residents interviewed reported having brought 11 dogs to Lombok from other island and all these dogs were from Bali. To account for uncertainty around these proportions (Bali, 11/11; West Java, 0/11; Jakarta 0/11), Beta distributions were used.

The following node applies for both, resident and non-resident pathways:

7.2.2.6.1.3.8 Prevalence of rabies in the island of origin of the dogs

This node accounts for the rabies status of the island of origin of the dogs being brought into Lombok by the residents and non-residents. Prevalence of rabies at each area/island of the dogs' origin was obtained from published literature and expert opinion. Rabies prevalence in Bali was calculated as in Section 7.2.2.6.1.1.4. Using the same expert consultation process as in Section 7.2.2.6.1.1.4 rabies prevalence in West Java was estimated as 0.04%. These values were used as the most likely probability of rabies prevalence in a Pert distribution, and minus and plus 10% around this value were used as the minimum and maximum values of the distribution, respectively.

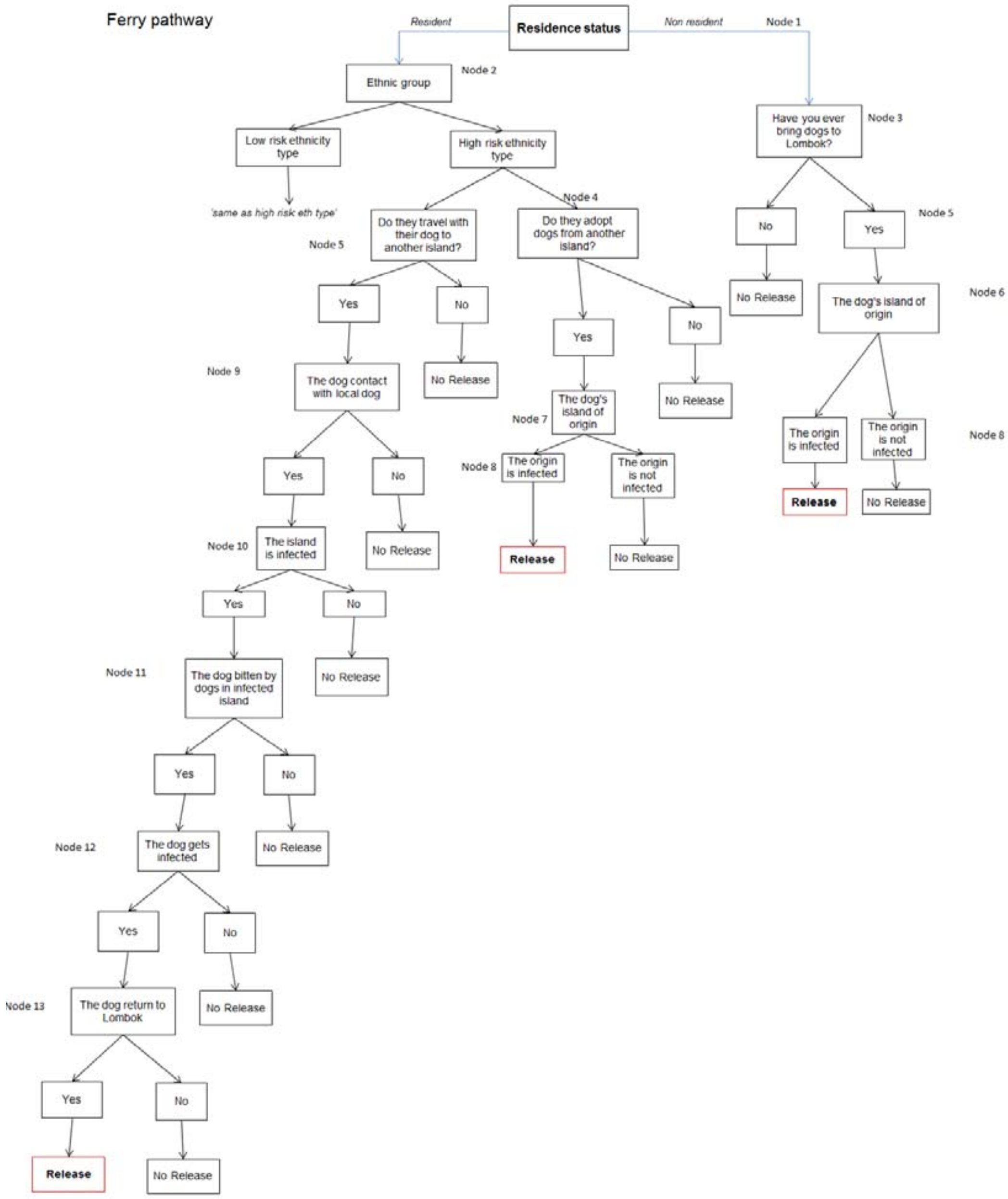


Figure 7.2: Scenario tree representing the release assessment evaluating the probability of a rabies-infected dog being released to Lombok Island from people travelling to Lombok by ferry.

Table 7.2: Nodes, parameter estimates and input values used for the release assessment evaluating the probability of a rabies-infected dog being released to Lombok Island from people travelling to Lombok by ferry.

Node	Branch of node	Parameter estimates	Input values[a]	Data source
1. Residential status	Resident Non resident	Among all interviewed people travelling to Lombok in vehicle by ferry, the proportion of each type of this people	Resident: Beta(82, 78) Nonresident: Beta(78, 82)	Chapter 5
2. Ethnicity group of Lombok residents interviewed at the ferry harbour	Low risk ethnicity type High risk ethnicity type	Among the residents, the proportion of each ethnicity type	Low risk ethnicity type: Beta(67, 16) High risk ethnicity type: Beta (16, 67)	Chapter 5
3. Non-resident people visiting Lombok bringing a dog to Lombok	Yes No	Among the non-residents, the proportion of people that brought dogs to Lombok	Beta (11, 68)	Chapter 5
4. Lombok residents adopting a dog another island?	Yes No	Proportion of local people who adopt a dog from another island	Low risk ethnicity type: Beta(8, 132) High risk ethnicity type: Beta(16, 329)	Chapter 3 and Chapter 5
5. Lombok residents travelling with their dog to another island?	Yes No	Proportion of local people that travel only with their dog	None of the people interviewed reporting travel with dog to other island	Chapter 3
6. Island of origin of dogs brought to Lombok by the non-residents	Non rabies-infected area West Java Bali	Of the dogs brought by the non-residents, the number of dogs' according to their island of origin	Non rabies-infected area: Beta(1,12) West Java : Beta(1, 12) Bali: Beta(12,1)	Chapter 5
7. Island of origin of the adopted dogs (resident)	Non rabies-infected area West Java Bali	Of the dogs brought by the residents, the proportion of dogs' according to their island of origin	Low risk ethnicity type: Non rabies-infected area: Beta(6, 6) West Java: Beta (1, 11) Bali : Beta (6, 6) High risk ethnicity type: Non-infected area:	Chapter 3 and Chapter 5

			Beta(4, 20) West Java: Beta(3, 21) Bali: Beta(18,6)	
8. Prevalence of rabies in dogs in the island of origin of the dogs	Infected Not Infected	Rabies prevalence on each specific island	Non rabies-infected area: Output discrete(0,1) West Java: Pert(0.00036, 0.0004, 0.00044) Bali: Beta(38, 96546)	ACIAR report of Indonesia Rabies Risk Assessment Workshop 2012 and Expert opinion
9. The dog (that travelling with owner) contact with local dog in another island	Yes No	Not assessed because no residents interviewed reported ever travelling with dogs to another island thus there was no input available for nodes 9 to 13.		
10. The island is infected	Yes No			
11. The dog (that travelling with owner) bitten by dogs in infected island	Yes No			
12. The dog gets infected	Yes No			
13. The dog return to Lombok	Yes No			

[a] Beta = Beta distribution (*successes + 1, total number – successes + 1*); Pert = Pert distribution (*minimum, most likely, maximum*)

7.2.2.6.2 Exposure scenario trees

The exposure assessment estimates the probability of a susceptible dog from Lombok becoming infected with rabies virus after the release of a rabies-infected dog via the boat and ferry pathways previously described. Three scenario trees were built to assess the probability of exposure, according to three different areas in Lombok (informal port, urban area and rural area).

7.2.2.6.2.1 Exposure assessment at informal Lombok port (Exposure Scenario tree)

This exposure scenario tree estimates the probability of one susceptible dog from Lombok becoming rabies infected after release of a rabies-infected dog from a boat (boat from outside Lombok or boat from local Lombok) at informal Lombok port. Figure 7.3 represents a scenario tree of this exposure pathway and Table 7.3 presents a summary of the scenario tree nodes, parameters and input values used in this assessment. A detailed description of the nodes follows.

7.2.2.6.2.1.1 Origin of the boat travelling with a dog

This node represents the proportion of local and outside boats among those boats travelling with a dog and arriving at Lombok. This node is required as the management of the dog will differ depending on the boat being a local (returning to Lombok) or an outside boat. According to results from Chapter 4, only one of 169 boat captains interviewed reported having a dog on board and this boat originated from outside Lombok. No local boats reported travelling with a dog. This data was used to parameterize the input for this node using Beta distributions.

7.2.2.6.2.1.2 Ethnic group

As in Sections 7.2.2.6.1.1.2 and 7.2.2.6.1.2.2, this node is needed because it provides a more accurate representation of the overall population which has different practices with dog management. The proportion of low risk and high risk ethnicity type within local and outside boats was identified in Chapter 4. Of the 117 captains from outside boats, 53 belonged to the low risk ethnicity type and 64 were high risk ethnicity type. Of the 52 captains from local boats, 50 were low risk ethnicity type and 2 were high risk ethnicity type. To account for uncertainty around these proportions, Beta distributions were used.

7.2.2.6.2.1.3 Dog confinement

For virus transmission to occur, a rabies-infected dog must contact susceptible dogs. This node only applies to infected dogs being introduced by local boats. These dogs are assumed to be returning to Lombok and as such, a Lombok household will be their final destination. Among the fishermen households interviewed, (Chapter 4) only four households owned dogs, two of these were considered low risk ethnicity type and two were high risk ethnicity type. Information on dog confinement (yes/no) was used in this node. Among the low risk ethnicity type, both dogs were not confined; while, among the high risk ethnicity type, one dog was kept confined and one unconfined. A Beta distribution was used to incorporate these proportions.

7.2.2.6.2.1.4 Is the dog confined with other dogs?

Similarly to the previous node, this node only applies to infected dogs being introduced by local boats. This node represents the probability that the recently introduced infected dog, which is kept confined at the household, is kept in confinement with another dog. If the rabies-infected dog is confined with other dogs, virus transmission could occur. Data from Chapter 4 showed that among the 4 households with dogs, only 1 household, of the high risk ethnicity type, reported keeping the dog under confinement (at night-time only). In addition, this dog was confined with other dogs (a Beta distribution was used around the probability of 1). Since none of the dogs kept by the low risk ethnicity type were kept confined as explained in the previous node, no information was available to estimate the probability of confinement with other dogs. However, a Beta distribution around a probability of 0 was used.

7.2.2.6.2.1.5 Infected dog contact local dog at the port?

This node only applies to the exposure pathway following release of an infected dog from an outside boat and represents the probability of this infected dog contacting a local dog at informal Lombok port. If the rabies-infected dog does contact a local dog at informal Lombok port, virus transmission could occur. Data on confinement of dogs on boats from outside Lombok was obtained from Chapter 4. Among the 117 outside boats, only one captain of boat, of the high risk ethnicity type reported having a dog on board and the dog was confined in a cage on the boat. This data was incorporated into the model using a Beta distribution to account for uncertainty. Since none of the low risk ethnicity type had dog on boat, a uniform distribution around a probability of 0 was used.

7.2.2.6.2.1.6 Dog category

This node is used in the exposure assessment following the release of an infected dog from an outside boat and a local boat, which are not kept under confinement. This assessment assumes that both of these infected dogs can contact Lombok dogs once they are released and this node represents the proportion of dogs in three different dog categories. The categories considered are: 1. Semi-free roaming owned dog; 2. Free-roaming owned dog; 3. Unowned dog. The proportion of dogs for semi-free roaming and free-roaming owned dogs at a rural site associated with a port is estimated from information presented in Chapter 3. For the semi-roaming owned dogs, the number of dogs was 51 dogs and the free-roaming owned dogs was 119 dogs. For the unowned dogs, the number of dogs was estimated from dog counting described in Chapter 7, which reported an estimate of 65 dogs (s.d. 7.6). A normal distribution was used around the mean and s.d. The proportions of the three types of dogs were then calculated and incorporated into the model using a Beta distribution.

7.2.2.6.2.1.7 Local dog bitten by infected dog

This node represents the probability that a local dog from Lombok is bitten by an infected dog released from an outside boat and a local boat. This node accounts for the probability of the released infected dog developing clinical signs while in Lombok. For outside boats, the length of stay depends on the origin of the boat. Boats originating from South Sulawesi are likely to spend six months at the port (Chapter 4), thus given the dog is infected, it is likely to become clinical during this time period. Boats from Flores and Bali carrying tourists usually stay for two weeks at Lombok port (Chapter 4). The proportion of boats originating from these locations (South Sulawesi, 37%; Bali, 51%; Flores, 12%; Chapter 4) was considered in this assessment, which assumed that at least all dogs travelling in boats coming from South Sulawesi will develop clinical signs during their stay in Lombok. A Pert distribution was used to estimate the probability of an infected dog developing clinical signs, with a minimum of 0.37, and 5 and 10% were added to this value to estimate the most likely and maximum values of this distribution, respectively. For infected dogs released by a local boat a value of 1 was used to estimate the probability of this dog developing clinical signs, as this dog is assumed to be kept in Lombok for its lifespan.

The probability of a local Lombok dog being bitten by a rabies-infected dog was parameterised using data from literature similar to Section 7.2.2.6.1.1.7, and multiplied by the probability of the infected dog developing clinical signs, to obtain the overall probability of a local dog being bitten by an infected dog released by an outside or a local boat.

7.2.2.6.2.1.8 Dog gets infected

The parameter for this node was determined from literature similar to Section 7.2.2.6.1.1.8 of this chapter.

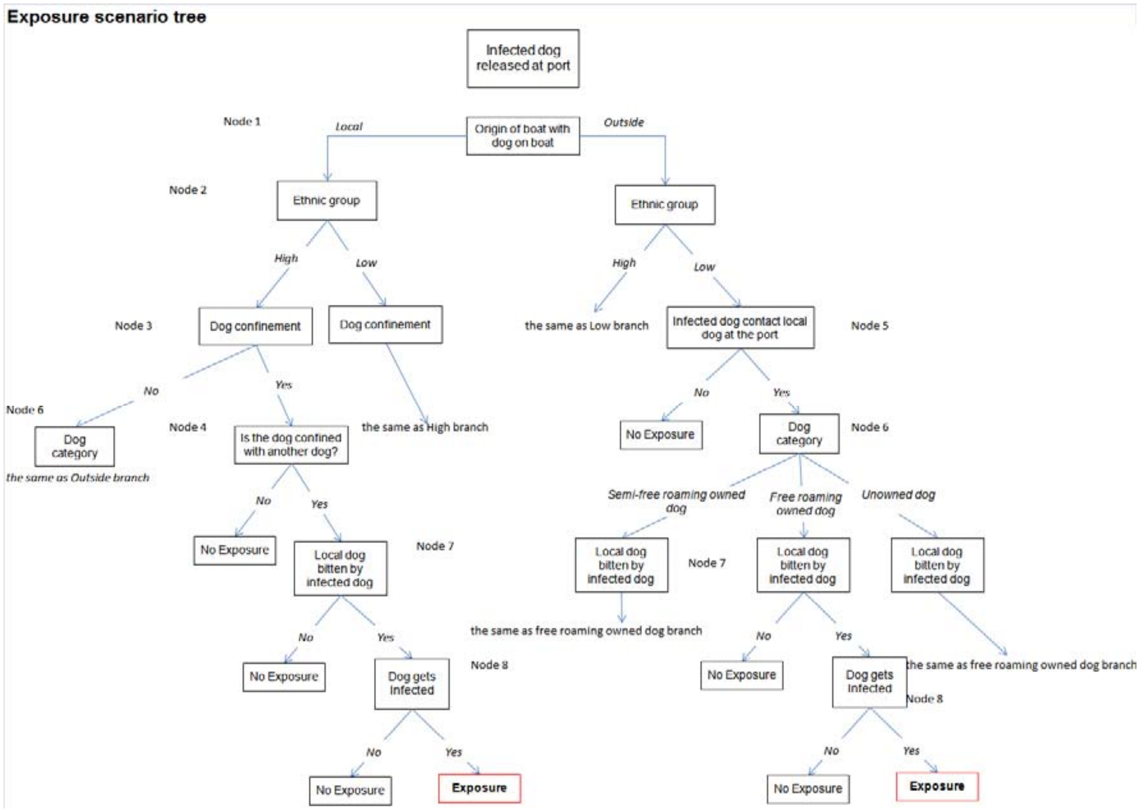


Figure 7.3: Scenario tree representing the exposure assessment evaluating the probability of a susceptible dog become infected with rabies virus following the release of a rabies-infected dog at Lombok port via boat pathway.

Table 7.3: Nodes, parameter estimates and input values used for the exposure assessment evaluating the probability of a susceptible dog in Lombok being infected with rabies virus after the release of a rabies-infected dog from a boat at Lombok port.

Node	Branch of node	Parameter estimates	Input values[a]	Data source
1. Origin of the boat travelling with a dog	Local Outside	Proportion of boat originated from outside Lombok and boat local Lombok that have dogs in the boat	Local : Beta (1, 2) Outside : Beta (2, 1)	Chapter 4
2. Ethnic group	Low risk ethnicity type High risk ethnicity type	Among the boats, the proportion of each ethnicity type	Local : Low risk ethnicity type: Beta(51, 3) High risk ethnicity type: Beta(3, 51) Outside : Low risk ethnicity type: Beta(54, 65) High risk ethnicity type: Beta(65, 54)	Chapter 4
3. Dog confinement (only for boat local Lombok)	Yes No	The proportion of the people interviewed that confined their dogs	Low risk ethnicity type : Beta(1, 3) High risk ethnicity type : Beta(2, 2)	Chapter 4
4. Is dog confined with other dog? (only for boat local Lombok)	Yes No	Among the people interviewed that confined their dogs, the proportion of those confined and not confined their dogs with other dog	Low risk ethnicity type : Beta (1, 1) High risk ethnicity type : Beta (2, 1)	Chapter 4
5. Infected dog contact local dog at the port?	Yes No	The proportion of people interviewed with dog in the boat	Low risk ethnicity type : Uniform(0.9, 1)	Chapter 4

(only for boat originated from outside Lombok)		that confined dog in the boat	High risk ethnicity type : Beta(1, 1)	
6. Dog category	Semi-free roaming owned dogs Free roaming owned dogs Unowned dogs	Proportion of each dog type in a village associated with a port in Lombok	Semi-free roaming owned dogs: Beta(52, 186.3) Free roaming owned dogs: Beta(120, 118.3) Unowned dogs: Beta(67.3, 171)	Chapter 3 and Chapter 7
7. Local dog bitten by infected dog	Yes No	Probability of local dog being bitten by a rabid dog (proportion of furious and paralytic of rabid dogs)	Boat local: Output discrete (0.25, 0.75) Boat outside : Output discrete (Outcome Pert*proportion of furious, paralytic)	Literature : proportion of furious and paralytic from Banyard and Fooks (2011)
8. Dog gets infected	Yes No	Probability of a healthy dog getting infected with rabies from a bite of an infected dog	Output discrete (0.49, 0.51)	Literature: Hampson et al. (2009)

[a] Beta = Beta distribution (*successes + 1, total number – successes + 1*)

7.2.2.6.2.2 Exposure assessment at an urban area in Lombok (Exposure Scenario tree)

This exposure assessment estimates the probability of a susceptible dog from Lombok becoming infected with rabies virus after release of a rabies-infected dog transported with people travelling by ferry and arriving in an urban area in Lombok. Figure 8.4 represents a scenario tree of this exposure pathway and Table 8.4 presents a summary of the scenario tree nodes, parameters and input values used in this assessment. A detailed description of the nodes is as follows.

7.2.2.6.2.2.1 Ethnicity group

As mentioned in Section 7.2.2.6.1.1.2, this node represents the different dog management practices by the overall population. In Chapter 3 a total of 300 households living in an urban area were interviewed. Of those, 22 households belonged to low risk ethnicity type and 278 households to high risk ethnicity type. A Beta distribution was used for each of these proportions to account for uncertainty.

7.2.2.6.2.2.2 Dog confinement

Similarly to Section 7.2.2.6.2.1.3 a rabies-infected dog must contact susceptible dogs. Input for this node was estimated from data on dog confinement by the 300 households presented in Chapter 3. This node has two branches, confined and not confined. Among the 22 households of low risk ethnicity type, eight households confined their dogs and 14 households allowed their dogs to roam freely. Of the 278 households belonging to high risk ethnicity type, 103 households confined their dogs and 175 households did not confine their dogs. This proportion was incorporated into the model after uncertainty was accounted using a Beta distribution.

7.2.2.6.2.2.3 Is the dog confined with other dogs?

As in the previous node, this node represents the probability of the recently introduced infected dog, which is kept confined at the household, being kept confined with another dog. If the rabies-infected dog is confined with other dogs, virus transmission could occur. Data for this node was provided from Chapter 3. Among the eight households at low risk ethnicity type that confined their dogs, only one household reported keeping the dog confined with other dogs. Of the 103 households of the high risk ethnicity type that confined their dogs, 13 households reported keeping the dog confined with other dog/s. These proportions were incorporated using Beta distributions.

7.2.2.6.2.2.4 Dog category

Similarly to Section 7.2.2.6.2.1.6, this node is used in this assessment following a release of an infected dog from a rabies-infected dog arriving with people by ferry to an urban area, which is allowed to roam. This dog then contacts Lombok dogs. In this node, three dog categories were included which were semi-free roaming owned dogs, free roaming owned dogs and unowned dogs. The proportion of dogs for the semi-free roaming and free-roaming categories was estimated from data presented in Chapter 3, which were 121 and 216 dogs respectively. For the unowned dogs, the proportion of dogs was estimated from dog counting in urban area described in Chapter 6, which reported an estimate of 180 (s.d. 14.2). A normal distribution was used around the mean and s.d. The proportion of the three dog categories were calculated and incorporated into the model using a Beta distribution.

7.2.2.6.2.2.5 Local dog bitten by infected dog

As in Section 7.2.2.6.1.1.7, the probability of a local Lombok dog being bitten by a rabies-infected dog was obtained from literature. The proportion of rabid dogs having furious (25%) was used to estimate the probability of a local dog bitten by the infected dog.

7.2.2.6.2.2.6 Dog gets infected

The parameter for the probability of a susceptible dog being infected after bitten by a rabies-infected dog was determined from literature as in Section 7.2.2.6.1.1.8 of this chapter.

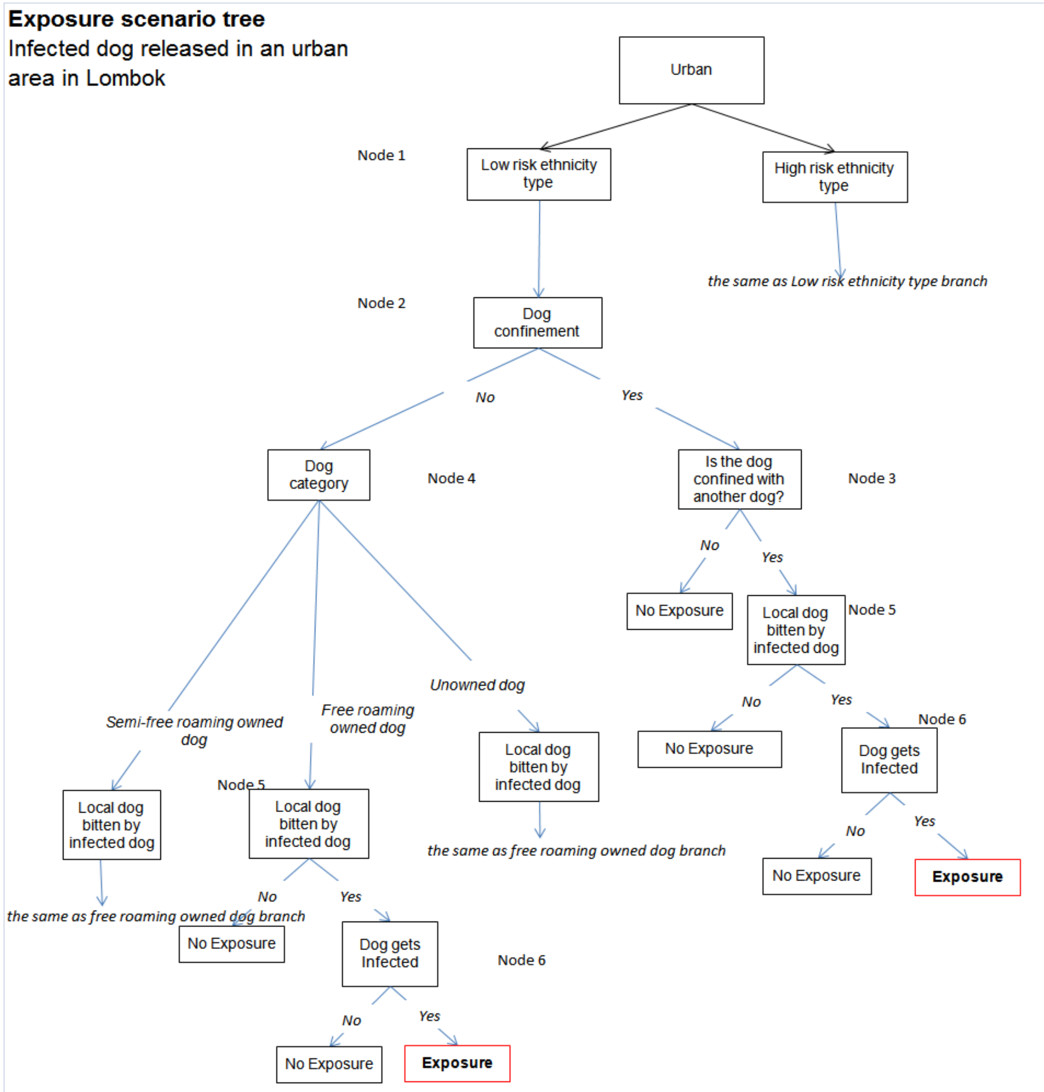


Figure 7.4: Scenario tree representing the exposure assessment evaluating the probability of a susceptible dog becoming infected with rabies virus following the release of a rabies-infected dog at an urban area via ferry pathway.

Table 7.4: Nodes, parameter estimates and input values used for the exposure assessment evaluating the probability of a susceptible dog in Lombok becoming infected with rabies virus after the release of a rabies-infected dog at an urban area in Lombok from people in ferry

Node	Branch of node	Parameter estimates	Input values[a]	Data source
1. Ethnicity group	Low risk ethnicity type High risk ethnicity type	Among the interviewed people living in urban, the proportion of each type of this people	Low risk ethnicity type: Beta(23, 279) High risk ethnicity type: Beta(279, 23)	Chapter 3 and Chapter 5
2. Dog confinement	Yes No	The proportion of the people interviewed that confined their dogs	Low risk ethnicity type: Beta(9, 15) High risk ethnicity type: Beta(104, 176)	Chapter 3
3. Is the dog confined with other dog?	Yes No	Proportion of the adopted dogs confined with local dogs	Low risk ethnicity type: Beta(2, 8) High risk ethnicity type: Beta(14, 91)	Chapter 3
4. Dog category	Semi-free roaming owned dog Free roaming owned dog Unowned dog	Proportion of each dog type at urban site in Lombok	Semi-free roaming owned dogs: Beta(122, 378.7) Free roaming owned dogs: Beta(217, 283.7) Unowned dogs: Beta(162.7, 338)	Chapter 3 and Chapter 6
5. Local dog bitten by infected dog	Yes No	Probability of local dog being bitten by a rabid dog (proportion of furious and paralytic of rabid dogs)	Output discrete (0.25, 0.75)	Literature : proportion of furious and paralytic from Banyard and Fooks (2011)
6. Dog gets infected	Yes No	Probability of a healthy dog getting infected with rabies from a bite of an infected dog	Output discrete (0.49, 0.51)	Literature: Hampson et al. (2009)

[a] Beta = Beta distribution (*successes + 1, total number – successes + 1*)

7.2.2.6.2.3 Exposure assessment at a rural area in Lombok (Exposure Scenario tree)

The exposure assessment estimates the probability of a susceptible dog becoming rabies infected after release of a rabies-infected dog transported with people travelling by ferry arriving in a rural area in Lombok. The pathways and nodes of this scenario tree are represented in Figure 7.5, and nodes, branches for each node and input values used are described below and summarized in Table 7.5.

7.2.2.6.2.3.1 Ethnicity group

Data from Chapter 3 reported on 100 households living in a rural area. Of those, 50 households were belonging to low risk ethnicity type and 50 households to high risk ethnicity type. A Beta distribution was used for each of these proportions to account for uncertainty.

7.2.2.6.2.3.2 Dog confinement

Input for this node was estimated by data on dog confinement by the 100 households presented in Chapter 3, none of which confined their dogs. A beta distribution around a probability of 0 was used for this node.

7.2.2.6.2.3.3 Is the dog confined with another dog?

There is no input for this node due to none of the 100 households confined their dogs. Thus this node was not calculated.

7.2.2.6.2.3.4 Dog category

Similar to the dog category node for exposure assessment at the port and urban area previously described. This node also considered three dog categories. Further as in Section 7.2.2.6.2.1.6 the proportions of dogs for the semi-free and free-roaming owned dogs were also obtained from number of dogs at the rural site associated with port. The number of semi-free roaming dogs was 51 dogs and the free-roaming dog was 119 dogs (Chapter 3). For the unowned dogs, the number of dogs was estimated from dog counting described in Chapter 6, which reported an estimate of 65 dogs (s.d. 7.6). A normal distribution was used around the median and s.d. The proportions of the three dog categories were calculated and incorporated into the model using a Beta distribution.

7.2.2.6.2.3.5 Local dog bitten by infected dog

This node was calculated as for Section 7.2.2.6.1.1.7 with the probability of a local dog bitten by a rabies-infected dog was obtained from literature.

7.2.2.6.2.3.6 Dog gets infected

The parameter for the probability of a dog being infected after bitten by a rabies-infected dog was determined from literature as in Section 7.2.2.6.1.1.8 of this chapter.

The probability of exposure in the urban and rural areas were then combined to estimate the overall probability of exposure after a rabies-infected dog is released via the ferry pathway. The proportions of dogs brought by Lombok residents to an urban and to a rural area were used to combine these probabilities. Of the total 32 dogs brought by residents to Lombok, 31 dogs were brought to an urban area and one dog brought to a rural area. A Beta distribution was used to incorporate uncertainty around these proportions into the model.

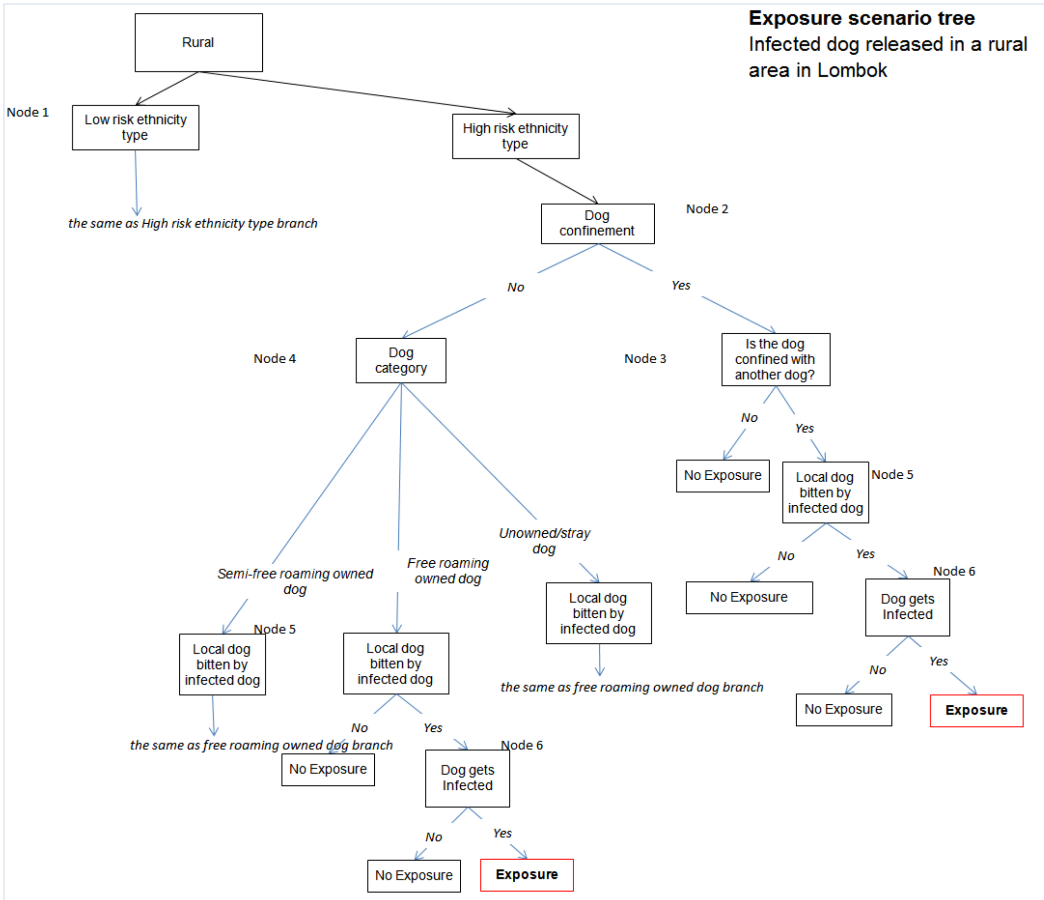


Figure 7.5: Scenario tree representing the exposure assessment evaluating the probability of a susceptible dog become infected with rabies virus following the release of a rabies-infected dog at a rural area via ferry pathway.

Table 7.5: Nodes, parameter estimates and input values used for the exposure assessment evaluating the probability of a susceptible dog in Lombok become infected with rabies virus after the release of a rabies-infected dog at a rural area in Lombok from people in ferry

Node	Branch of node	Parameter estimates	Input values[a]	Data source
1. Ethnicity group	Low risk ethnicity type High risk ethnicity type	Among the interviewed people living in rural, the proportion of each type of this people	Low risk ethnicity type: Beta(51,51) High risk ethnicity type: Beta(51, 51)	Chapter 3
2. Dog confinement	Yes No	The proportion of the people interviewed that confined their dogs	Low risk ethnicity type: Beta(1, 51) High risk ethnicity type: Beta(1, 51)	Chapter 3
3. Is the dog confined with another dog?	Yes No	Proportion of the adopted dogs confined with local dogs	Among the interviewed people living in rural, no people reported confining their dogs thus no input for this node	Chapter 3
4. Dog category	Semi-free roaming owned dog Free roaming owned dog Unowned dog	Proportion of each dog type in a village associated with a port in Lombok	Semi-free roaming owned dogs: Beta(52, 186.3) Free roaming owned dogs: Beta(120, 118.3) Unowned dogs: Beta(67.3, 171)	Chapter 3 and Chapter 7
5. Local dog bitten by infected dog	Yes No	Probability of local dog being bitten by a rabid dog (proportion of furious and paralytic of rabid dogs)	Output discrete (0.25, 0.75)	Literature : proportion of furious and paralytic from Banyard and Fooks (2011)
6. Dog gets infected	Yes No	Probability of a healthy dog getting infected with rabies from a bite of an infected dog	Output discrete (0.49, 0.51)	Literature : Hampson et al. (2009)

[a] Beta = Beta distribution (*successes + 1, total number – successes + 1*)

7.2.2.7 Sensitivity analysis

The sensitivity of the outputs of the model to some of the input parameters was evaluated using the @Risk 6.0 Advanced Sensitivity Analysis (Palisade Corporation, USA). Sensitivity analyses were conducted separately for the overall outputs of the release assessment models and the exposure models to identify which input parameters were the most influential to the output probabilities. This was evaluated by simulating the outputs for a series of fixed values for a given input variable. Probability input parameters were allowed to vary from 0 to 1 in tenths (0.1, 0.2, 0.3…) or a specific table of values covering a biological feasible probability range was used. Each of the values for the input parameters was evaluated in a simulation of 1,000 iterations, while values for the rest of the input parameters were fixed to their base value.

7.3 RESULTS

The release assessment conducted identified the most likely pathways of rabies virus introduction into Lombok Island and the corresponding probability of these pathways to occur. The two pathways of introduction investigated were via boats and ferries. The exposure assessment conducted identified the pathways through which the released rabies-infected dog contacts and transmits the virus to a dog from the Lombok dog population.

7.3.1 RELEASE ASSESSMENT

7.3.1.1 Release assessment via boat pathway

According to this assessment, the median probability of a rabies-infected dog being introduced into Lombok via a boat originating from outside Lombok was slightly higher than the probability of release via a local Lombok boat, as shown in Table 8.6. The most likely reason being the higher probability of presence of dogs on fishing boats from outside Lombok (Chapter 4).

The overall probability of release for each boat travelling to Lombok, considering both types of boats, was estimated to be extremely low [2.6×10^{-5} ($7 \times 10^{-6} - 7.5 \times 10^{-5}$)].

Table 7.6: Predicted median (5 and 95 percentiles) probability that one rabies-infected dog is released at Lombok for each boat arriving to the island according to the type of boat[a]

Boat pathway	Probability (median, 5% - 95%)
Boat originated from outside Lombok	4.3×10^{-5} (8.1×10^{-6} – 1×10^{-4})
Local Lombok boat	6×10^{-6} (7.9×10^{-7} – 3.2×10^{-5})
Overall probability	2.6×10^{-5} (7×10^{-6} – 7.5×10^{-5})

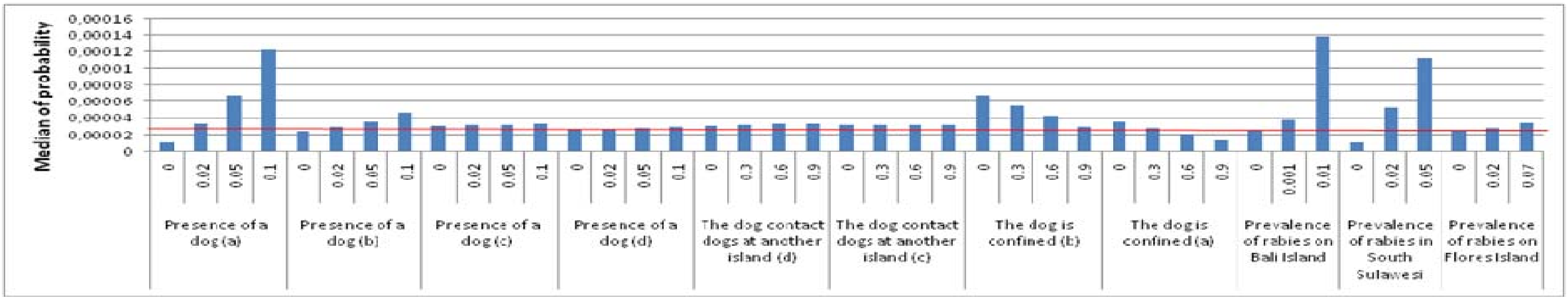
[a] Output distribution of a simulation stochastic model with 5,000 iterations.

Results of the sensitivity analysis for the overall probability of release via boat are shown in Figure 7.6. The greatest influence on the overall probability of release of a rabies-infected dog into Lombok via the boat pathway was the prevalence of rabies in Bali, followed by presence of a dog on a boat from outside Lombok (especially for those boats owned by a person within the low risk ethnicity group). The prevalence of rabies in South Sulawesi as well as the probability of the dog travelling in an outside boat being confined while the boat is in Lombok are also shown to be influential parameters.

The median probability of release increased 5.3-fold when the prevalence estimate of rabies in Bali was set to 0.01 (compared to the base value of 0.0004). Similarly, the release probability increased 4.3-fold when the prevalence of rabies in South Sulawesi was set to 0.05 (compared to the base value of 0.0002). The influence of the prevalence of rabies in Flores was less as there is a low proportion of outside boats originating from Flores compared to Bali, and local boats were not reported to travel to Flores.

The probability of the presence of a dog on a boat from outside Lombok and owned by a low risk ethnicity group person, was more influential on the release probability than the presence of a dog on a boat from outside Lombok and owned by a high risk ethnicity group person. This is likely due to the fact that low risk ethnicity group people are considered less likely to keep their dog under confinement while they are at Lombok port, increasing the probability of virus release.

Another influential input parameter on the output of the release via the boat pathway was the confinement of the dog on a boat from outside Lombok and owned by a high risk ethnicity group person. As expected, if the dog is not confined, the release probability significantly increases. When the probability of the dog being confined was set to 0.0 (compared to the base value of 0.0000013), the probability of release increased 2.6-fold. Confinement of the dog among high risk ethnicity group boats is more influential than among low risk ethnicity group boats, as in the latter group, dogs are not likely to be confined.



(a) on low risk ethnicity type boat from outside Lombok
(b) on high risk ethnicity type boat from outside Lombok
(c) on low risk ethnicity type boat from local Lombok
(d) on high risk ethnicity type boat from local Lombok

Figure 7.6: Results of the sensitivity analysis representing the influence of input variables on the median (red horizontal line) probability of release of one rabies-infected dog at Lombok via boat pathway. Results were obtained from a simulation of 1,000 iterations using @Risk's Advanced Sensitivity Analysis

7.3.1.2 Release assessment via ferry pathway

The median overall probability of a rabies-infected dog being introduced into Lombok via one person travelling to Lombok in a ferry was estimated to be extremely low, as shown in Table 7.7. This probability was similar for residents and non-residents travelling to Lombok in this type of transport, although slightly higher for non-residents.

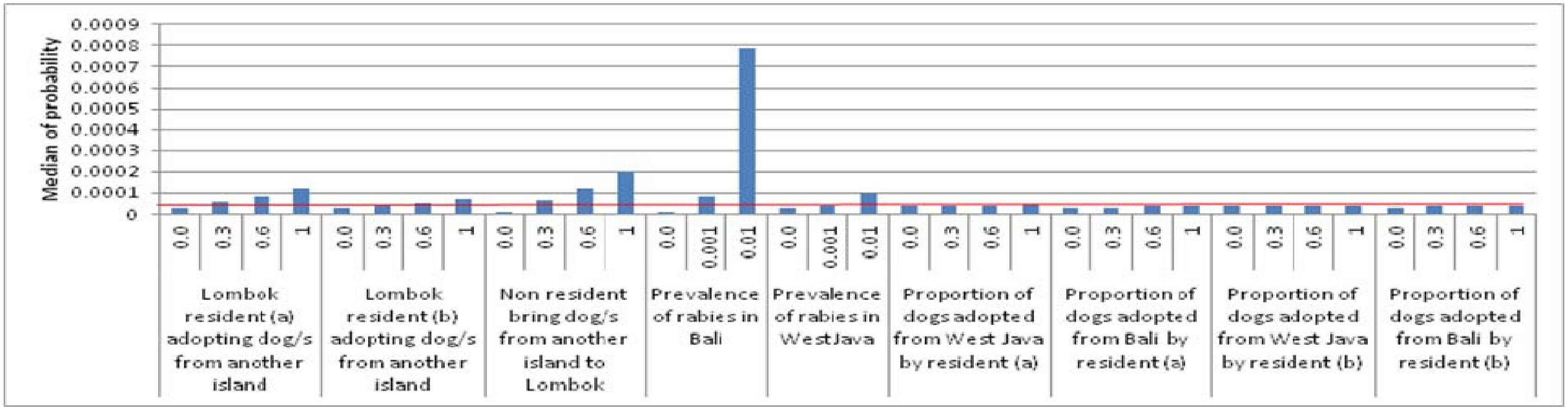
Table 7.7: Predicted median (5 and 95 percentiles) probability of one rabies-infected dog is released at Lombok via a person travelling in a ferry according to the residency status. [a]

Ferry pathway	Probability (median, 5% - 95%)
Resident	1×10^{-5} ($6 \times 10^{-6} – 2 \times 10^{-5}$)
Non resident	5×10^{-5} ($2 \times 10^{-5} – 8 \times 10^{-5}$)
Overall probability	3.2×10^{-5} ($1.9 \times 10^{-5} – 5.1 \times 10^{-5}$)

[a] Output distribution of a simulation stochastic model with 5,000 iterations.

Results of the sensitivity analysis for the overall probability of release via ferry pathway are shown in Figure 7.7. The prevalence of rabies in Bali was the most influential parameter on the on the probability of release of a rabies-infected dog at Lombok via the ferry pathway. The median probability of release increased to 7×10^{-4}, representing 24-fold increase, when the rabies prevalence in Bali was set to 0.01 (compared to the base value of 0.0004). The second most influential input parameter was the probability of a non-resident bringing a dog from another island into Lombok. When this probability was set to 0.6 (compared to the base value of 0.13), the probability of a rabid dog released at Lombok increased approximately 4-fold.

The rest of the input parameters had minimal influence on the release probability via this pathway.



(a) low risk ethnicity type
(b) high risk ethnicity type

Figure 7.7: Results of the sensitivity analysis representing the influence of input variables on the median (red horizontal line) probability of release of one rabies-infected dog at Lombok via the ferry pathway. Results were obtained from a simulation of 1,000 iterations using @Risk's Advanced Sensitivity Analysis.

7.3.2 EXPOSURE ASSESSMENT

7.3.2.1 Exposure assessment at informal Lombok port

According to this assessment, the median probability of exposure from a rabid dog arriving at informal Lombok port with a boat that originated from outside Lombok was lower than the probability of exposure from a rabid dog arriving with a local Lombok boat (Table 7.8). The most likely reason being, that the dog arriving with a local boat would return with the owner to their household and be more likely to be allowed to roam freely and to develop clinical signs while in Lombok.

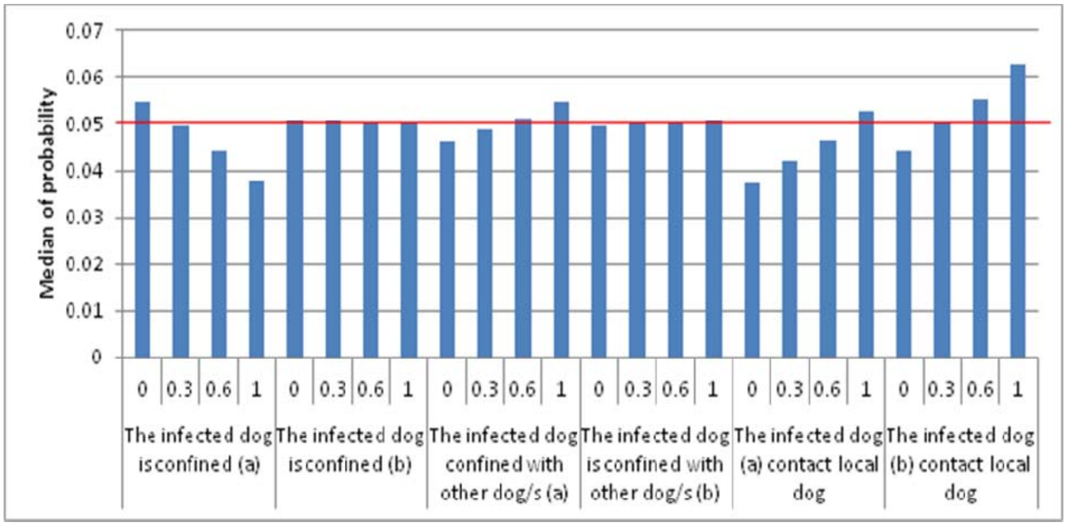
The overall probability of exposure of a local Lombok dog from a rabid dog arriving with a boat to the island, considering the proportion of both types of boats, was estimated to be low [0.050 (0.026 – 0.091)].

Table 7.8: Predicted median (5 and 95 percentiles) probability of a local dog from Lombok is exposed and infected with the rabies virus from a rabid dog released at informal Lombok port. [a]

Rabid dog present on	Probability (median, 5% - 95%)
Boat originated from outside Lombok	0.026 (0.018 – 0.039)
Boat local Lombok	0.112 (0.074 – 0.121)
Overall probability	0.050 (0.026 – 0.091)

[a] Output distribution of a simulation stochastic model with 5,000 iterations.

Results of the sensitivity analysis for the overall probability of a rabid dog exposing and infecting a susceptible dog at informal Lombok port are shown in Figure 7.8. The confinement of the infected dog introduced by a local boat from Lombok and among the low risk ethnicity group household was the input most influential for the probability of exposure. Increasing this confinement probability to 1 (compared to the base value of 0.20) resulted in a 1.3-fold decrease of the probability of exposure. The second most influential parameter was the probability of the infected dog being confined with other dogs among low ethnicity group households. However, the influence of this parameter was limited.



(a) at local Lombok low risk ethnicity type household
(b) at local Lombok high risk ethnicity type household

Figure 7.8: Results of the sensitivity analysis representing the influence of some input variables on the median (red horizontal line) probability of a susceptible dog from Lombok being exposed and infected by a rabid dog being released at informal Lombok port. Results were obtained from a simulation of 1,000 iterations using @Risk's Advanced Sensitivity Analysis.

7.3.2.2 Exposure assessment at an urban and a rural site on Lombok

Given one rabies-infected dog has been released by a person travelling in a ferry at an urban and a rural site at Lombok, the probability of exposure was estimated to be higher at the rural site than at the urban site (Table 7.9). The higher probability of exposure was most likely due to rural dogs being allowed to roam freely.

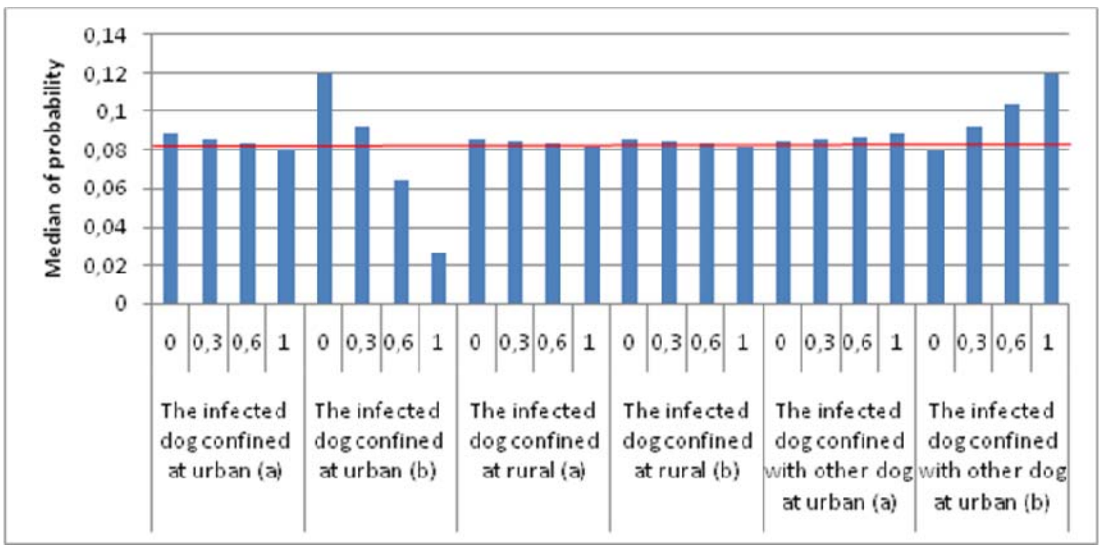
The overall probability of exposure of a local Lombok dog from a rabid dog arriving with a person travelling by ferry, considering the location of the rabid dog arrived, was estimated to be low [0.085 (0.079 – 0.091)].

Table 7.9: Predicted median (5 and 95 percentiles) probability of a rabid dog transmitting infection to one susceptible dog at an urban and a rural site on Lombok. [a]

Rabid dog present at	Probability (median, 5% - 95%)
Urban site	0.083 (0.077 – 0.089)
Rural site	0.120 (0.106 – 0.134)
Overall probability	0.085 (0.079 – 0.091)

[a] Output distribution of a simulation stochastic model with 5,000 iterations.

Results of the sensitivity analysis for the overall probability of a local dog in Lombok (considering rural and urban areas) being exposed and infected with the rabies virus from a rabid dog introduced in a ferry are shown in Figure 7.9. The probability of the infected dog being confined at an urban high risk ethnicity group household was the most influential input parameter for the probability of exposure. When this confinement probability increased to 1 (compared to the base value of 0.4), the probability of exposure decreased to 0.026, representing approximately 3-fold decrease. In addition, increasing the probability of the infected dog being confined with other dogs among the same type of households to 1 increased (compared to the base value of 0.13) the probability of exposure to 0.119, representing approximately 1.4-fold increase.



(a) low risk ethnicity type
(b) high risk ethnicity type

Figure 7.9: Results of the sensitivity analysis representing the influence of some input variables on the median (red horizontal line) probability of a probability of a susceptible dog from Lombok (rural and urban sites considered) being exposed and infected by a rabid dog introduced in a ferry. Results were obtained from a simulation of 1,000 iterations using @Risk's Advanced Sensitivity Analysis.

7.4 DISCUSSION

The introduction of a rabies-infected dog through the boat pathway is believed to be the most likely route for rabies spread to Bali and Flores from infected islands (Hutabarat et al., 2003; Putra et al., 2013). This study quantitatively investigates the probability of release of rabies virus through the introduction of a rabies-infected dog to Lombok Island through a boat and a ferry, as well as the probability of exposure of a susceptible dog on Lombok following the virus release.

The ferry pathway is not documented as a likely pathway of introduction of rabies virus to free islands in Indonesia; however, this pathway could be possible. Data to inform input parameters in the release and exposure models were mainly obtained from fieldwork conducted for the purpose of this study. Literature and expert opinion were used to estimate those input parameters were data was not available. Two experts were consulted regarding rabies prevalence on infected islands, after being provided with available prevalence data from literature, with the aim of reducing the potential uncertainty around experts' estimates (Vose, 2008). Island prevalences used were estimates of current prevalence considering the current rabies control programs underway in Bali, Sulawesi and Flores. This provided estimates on the probability of imported dogs from these islands incubating rabies.

To account for the uncertainty of parameter estimates, a stochastic model was used incorporating these parameters as probability distributions. This study investigated rabies introduction to Lombok via dog smuggling thus intervention from quarantine was not included in the release models. Furthermore, findings from the surveys described in Chapters 3 and 5 showed that among those respondents who had previously transported dogs to Lombok from Bali harbour, none reported their dogs having quarantine inspections. Risk of rabies introduction through smuggling of dogs and cats is also mentioned in other research conducted in the United Kingdom and Taiwan (Jones et al., 2005; Weng et al., 2010). Although this study found low probabilities for boat and ferry pathway, the low probability for the boat pathway was for one boar arriving at an informal port on Lombok and the low probability for ferry pathway was for one person travelling to Lombok by ferry. When consideration is given to the volume of boat arrivals and of ferry passenger arrivals on Lombok then the results of this research suggest that animal smuggling poses a real risk of rabies introduction and that enforcing border control is a necessary measure to minimize animal smuggling as well as to promote the legal importation of animals. The release assessment conducted in this study does not account for the rabies vaccination status of dogs brought into Lombok, as this information was not available. Among the 33 people interviewed who previously brought dogs to Lombok, 12 mentioned that these dogs had been vaccinated; however, 11 people did not know the type of disease the dogs were vaccinated against. Only one person had mentioned his two dogs were vaccinated against rabies; however, these dogs were from Jakarta which is a rabies-free province.

The ferry pathway considered the possibility of Lombok residents and non-residents bringing an infected dog into Lombok Island. For Lombok resident passengers, the assessment considered two potential pathways, the residents adopting an infected dog from another island and the residents travelling with their own dog to another island, where this dog would become infected. However, results from Chapter 3 reported no Lombok residents travelling with their dog to another island and this pathway was not quantitatively assessed in this study. This pathway could be further investigated if additional data becomes available.

Since Lombok Island has similar conditions to other islands in Indonesia, in relation to the transportation by the sea between islands and therefore for the potential pathways of rabies-infected dog introduction by boat and ferry, the framework used for this assessment could be used for assessing the introduction of rabies virus to other rabies-free islands in this country. Also for Lombok itself, the models can be revised and re-run when additional data is available to inform parameter inputs.

Based on the results of this study, the probability of rabies being introduced into Lombok via both boat and ferry pathways was very low. However, these estimates are not negligible. In addition, these estimates refer to the probability of rabies virus being introduced by one boat or by one person travelling in a ferry. As such, to interpret the overall risk of virus introduction into Lombok for a specific period of time, the total number of boats, ferries and passengers in each ferry coming into Lombok should be considered. The number of ferries travelling to Lembar harbour Lombok from Padang Bai harbour Bali is mentioned to be 24 ferries per day and could reach 26 to 28 ferries per day during public holiday (Idul Fitri, Muslims' festive after Ramadan) (Badan

Pusat Statistik, 2012). Whereas the number of local Lombok fishing boats is 1,574, however this number only represents the fishing boats in North Lombok District and does not inform about the total number of local boats docking on return to Lombok per year (Dinas Kelautan dan Perikanan Kabupaten Lombok Utara, 2010). The number of boats from other parts of Indonesia docking at Lombok informal ports was 4,355 in 2010; however this number is limited to fishing boats from Sulawesi (Dinas Kelautan dan Perikanan Provinsi NTB, 2011). Therefore, credible data needs to be gathered from relevant agencies in Lombok however cannot be obtained at this time.

The sensitivity analyses for the release assessments indicate that the prevalence of rabies in Bali has a significant influence on the probability of rabies virus being introduced into Lombok. Prevalence of rabies in South Sulawesi was also found influential for the probability of release via boat, although the influence of this parameter was not as significant as the prevalence in Bali. The input values used for the prevalence parameters were estimated from available prevalence data supported by expert opinion as previously explained. A similar result was reported in a study investigating the probability of rabies introduction to Taiwan, with the prevalence of rabies in exporting countries being as the most influential parameter (Weng et al., 2010). The recommendations of this study to prevent rabies virus introduction into Taiwan were to strengthen border control and increase the control of illegal smuggling by identifying the smuggled animals. Interestingly, this study suggested that the total prohibition of animal introduction from rabies prevalent countries was not recommended as it would likely increase animal smuggling (Weng et al., 2010). In Lombok, controlling illegal smuggling to prevent rabies introduction poses significant challenges, such as the limited number of quarantine personnel present at Lembar harbour, Lombok to conduct control inspections of all vehicles travelling to Lombok from Bali Island (drh. Sutedja personal communication, 2012). Hence, education on quarantine regulations to the general public and dog owners is important to promote legal procedures for dog or other animal importation. In addition, in order to prevent rabies spread within Indonesia and potentially to other countries, it is crucial for rabies-infected island/region in Indonesia to apply rabies control programs through mass dog vaccination, improve education on responsible dog ownership and have reliable information on rabies cases through laboratory-based surveillance (Durr et al., 2009; Kaare et al., 2009; Lembo et al., 2010; Rupprecht et al., 2006; Zinsstag et al., 2009).

As expected, the presence of dogs in boats travelling to Lombok and the probability of ferry passengers bringing dogs to Lombok were influential parameters on the probability of rabies virus being introduced into Lombok. However, survey results presented in Chapter 4 reported no boats (from Lombok and outside Lombok) carrying dogs, except for one boat originating from Bali Island bringing a pet dog confined in a cage. The parameter used for estimating the probability of a dog being present on a boat was based on these survey results as there is no previous study conducted in Indonesia investigating the presence of dogs on boats. Further research is needed to confirm the low probability of the presence of dogs on boats reported in the current study.

The probability of a Lombok resident adopting dog/s from another island was also an influential parameter, especially among the low risk ethnicity type. The purpose of dog ownership and the dog function depend on the ethnicity type (such as Balinese, Sasakese and other non-Balinese ethnic groups) as reported in Chapter 3. Among Lombok residents belonging to the low risk ethnicity type (Sasakese, Javanese and Bimanese ethnic groups), dogs are not commonly kept by these households, being allowed to roam freely, and being only used for the purpose of guarding property. Among Lombok residents belonging to the high risk ethnicity type (Balinese, Chinese and Timorese (Flores) ethnic groups), dogs are commonly kept, are better confined than dogs owned by other ethnic groups, and kept as property guards, pets and used for additional income (dogs bred then puppies traded). For the Balinese and Timorese (Flores) groups, dogs are also included in ceremonial events. As the low risk ethnicity type provides less confinement to their dogs than the high risk ethnicity type, the probability of the former group among Lombok residents adopting a dog from another island has more influence on the probability of release for a rabies-infected dog than among high risk ethnicity groups. This indicates that Lombok residents of low risk ethnicity type should be targeted in education programs about responsible dog ownership, including the need for dog confinement, as a useful rabies prevention strategy. Similarly, confinement of the rabies-infected dog present on outside boats is an appropriate method to prevent the dog being released into Lombok.

The proportion of dogs adopted from each of the potential islands of origin was not seen influencing the probability of release via ferry pathway as the probability of a dog being infected in the infected island or region was estimated to be very similar (Bali, 0.00037; and, West Java, 0.0004).

Some of the influential parameters for the probability of release via boat and ferry pathways, including the probability of non-resident bringing dogs from another island to Lombok, the presence of dogs on boats and the probability of a Lombok resident adopting dogs from another island; could be targeted to mitigate the risk of rabies virus introduction, through for example the implementation of education awareness and intensifying the quarantine measures at the border.

Results from the exposure assessments suggest that the overall median probability of a rabid dog released in Lombok exposing and infecting a susceptible dog in Lombok was low. This probability was similar after a rabid dog being released at informal Lombok port or by a person travelling in a ferry to rural/urban Lombok. These results suggest that the probability of exposure is not negligible. In addition, given the high number of non-supervised and unowned dogs present in Lombok (drh. Aminurrahman personal communication, 2011), further rabies spread is likely to occur after exposure. Although the number of owned dogs obtained from the household survey only represents the number of dogs owned by interviewed households, this was considered adequate to inform the proportion of dog types among roaming dogs for the purpose of quantifying the probability of exposure at informal port, urban and rural sites on Lombok. Certainly for the high risk rural site, a high proportion of total dog owning households were captured including all Balinese households and approximately 80% of Sasakese households.

Confinement of dogs after being introduced into Lombok (at port or rural/urban locations) was an influential parameter on the probability of susceptible dogs in Lombok being exposed. Following release of the rabid dog at Lombok port, the probability of confinement of the infected dog among Lombok residents of the low risk ethnicity type was the most influential parameter for the probability of exposure at Lombok port as this ethnicity type (Sasakese ethnic group) are more likely to allow dogs to roam freely than the high risk ethnicity type (Balinese ethnic group).

Following release of a rabid dog at an urban and rural site (via a passenger travelling in a ferry), the probability of the infected dog being confined at an urban high risk ethnicity type household was the most influential parameter for the exposure probability. The main reasons being the fact that most dogs brought into Lombok via ferry are going to an urban setting. Similarly, the probability of the infected dog being confined with other dog/s in urban high risk ethnicity type households had a significant influence on the probability of exposure. Since the influence of dog confinement on the probability of exposure is significant, implementation of education strategies to increase awareness of dog owners of the importance of providing better confinement would minimise susceptible dogs being exposed. In addition, rabies vaccination among the dog population in Lombok should also be considered as a potential prevention strategy to minimise this probability of exposure. Currently, no rabies vaccination program is implemented in Lombok, since it is not considered to be required due to the rabies-free status (drh. Nengah Dwiana personal communication, 2011).

This study is the first study to quantitatively assess the probability of rabies introduction to a rabies-free island/region in Indonesia, especially in the West Nusa Tenggara region, and the probability of susceptible dogs being exposed. The results of this study provide an insight on which parameters should be considered and targeted for the implementation of mitigation strategies in order to minimise the risk of a rabies incursion in Lombok. Thus these findings are useful to support decision making about rabies prevention strategies for Lombok Island. The framework of this study could be used to assess risk of rabies introduction to other rabies-free island via boat or ferry pathway.

CHAPTER 8: DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

In Indonesia, cycling of rabies in the dog population remains an animal and public health issue in 24 of the total 33 provinces. Vaccination of dogs as the principle means of control of rabies has achieved eradication in only four provinces in Java, and rabies has spread to previously rabies-free islands of eastern Indonesia in the last five years. This heightens concern about the introduction of rabies to the remaining rabies-free islands of Indonesia and to the neighbouring countries of Timor Leste, Papua New Guinea and Australia. Such spread results from people moving dogs incubating rabies from rabies-infected to rabies-free areas. There is, however, limited information in the literature about pathways for rabies entry and transmission via dogs in Indonesia. The work presented in this thesis was conducted to document pathways for entry of rabies-infected dogs to rabies-free Lombok Island in eastern Indonesia, and to estimate the probability of release and exposure for each pathway. The aim was to provide knowledge that can inform the development of quarantine and surveillance strategies to prevent rabies entry and establishment on Lombok.

This work is the first study to document the management of dogs and movement practices of dog owners on Lombok, and of people who illegally transport dogs by ferry to Lombok. It is also the first to investigate the movement of dogs on local Lombok boats and boats from other parts of Indonesia that dock at informal ports on Lombok. For Indonesia, it presents the first quantitative estimates of rabies release and exposure to a rabies-free island.

8.1 MAIN FINDINGS

8.1.1 ILLEGAL MOVEMENT OF DOGS FROM RABIES-INFECTED ISLANDS OR REGIONS TO RABIES-FREE LOMBOK HAS BEEN OCCURRING BY FERRY, A DIFFERENT MEAN OF TRANSPORTATION TO THE FISHING VESSELS AND OTHER BOATS INDICATED BY THE LITERATURE.

This study has found that illegal dog movement from rabies-infected islands or regions to rabies-free Lombok has occurred in a systematic manner for some time. Movement of dogs in vehicles travelling by ferry from Padang Bai harbour in Bali to Lembar harbour in Lombok was the common means of introduction reported. Contrary to the findings in the published literature and expert opinion, this study did not find it common practice to carry dogs on fishing boats, with only one medium size fishing boat from Bali identified with a dog on board. Furthermore, no dogs were reported or observed on other boats docking at informal ports on Lombok (such as cargo and tourist boats) in this work. Pedigree dogs were moved by residents to Lombok by ferry for various purposes, such as breeding for the pet trade, companion animals and guarding property. Non-residents of Lombok were also identified bringing dogs to Lombok by ferry; however, these non-residents brought the dogs as a paid service on request for dog owners on Lombok.

On some islands in Indonesia, dogs are highly valued. For example dogs are required for important ceremonial events and are a notable source of protein in Manado in North Sulawesi (Adiani and Tangkere, 2009), Flores (Bingham, 2001a) and Ambon. Movement of dogs from Sulawesi for the purpose of consumption is said to be the cause of rabies introduction into Ambon in 2003 (ProMED, 2003). Dogs also have an important role in Balinese culture (Putra, 2011a) and dog movement by a cargo boat is mentioned as the probable route for rabies introduction into Bali in 2008 (Scott-Orr and Putra, 2009). For these islands it is likely that dogs are imported as a trade commodity due to market demand and higher prices. Given the lesser importance of dogs for most people on Lombok, the demand for imported dogs is likely to be lower and linked more to specialised purposes, as indicated by reports in this work of only pedigreed dogs being introduced.

8.1.2 There is limited knowledge about rabies and about quarantine regulations, and limited policing of quarantine regulations.

This study found that generally people on Lombok have limited knowledge about rabies and about the quarantine regulation that prohibits dog movement from rabies-infected to rabies-free areas in Indonesia. Awareness of the procedure required to legally move dogs between islands was also lacking. Most people interviewed in this study that had transported dogs to Lombok, mentioned the ‘necessity’ of hiding dogs from the authorities, with the authorities of concern being police officers at ports, not quarantine officers. Of interest is the fact that no respondent with experience of bringing dogs by ferry into Lombok reported quarantine inspection of the dog/s at either Padang Bai harbour, Bali or Lembar harbour, Lombok. Furthermore, the majority of imported dogs did not have records, and for those that did, documentation was limited to vaccination and pedigree records; none had the required health statement. These findings indicate that the role of quarantine at border areas or the duties of quarantine officials may not be well known by the general public. It is probable that the general public are not familiar with quarantine regulations regarding dog movement, due to the limited policing of these regulations at formal ports. The spread of rabies to Bali is an illustration of the limited implementation of quarantine regulations. A rabies-incubating dog was able to leave Flores and arrive on Bali in 2008. This led to the death of its owner and transmission of the rabies virus to dogs on Bali (Clifton, 2010). The movement of dogs intentionally by people, and the additional issue of free roaming movement of free-roaming dogs, pose a similar problem for rabies control in other places. For example, the southern part of Bhutan that borders with rabies-endemic India, faces difficulties with ensuring quarantine regulations to control rabies due to movement of free-roaming dogs across the border, which has resulted in a high incidence of rabies in dogs and humans in the southern part of Bhutan (Tenzin et al., 2012a).

8.1.3 ETHNIC GROUP DIFFERENCES EXIST, PARTICULARLY IN DOG CONFINEMENT AND FOR SASAKESE, IN DOG OWNERSHIP BETWEEN RURAL AND URBAN.

The Balinese people living on Lombok have the same attitudes towards dogs as those of the Balinese living on Bali. For the Balinese, the dog is a necessity, it is a part of Balinese culture and the people always have a close relationship with dogs. Dogs in the Balinese community serve as guards, spirit alarms and companions, as a source of traditional remedies and culinary delicacies, and as sacrificial symbols at religious events. Thus to convey rabies awareness to Balinese communities these cultural perspectives must be considered (Center for Indonesian Veterinary Analytical Studies, 2013b). Dogs are also important in the culture of Timorese-Flores people (Bingham, 2001b). The majority of Lombok residents, being Muslim Sasakese, Javanese and Sumbawanese, do not respect dogs as highly as the Balinese and Timorese-Flores groups. However, this study found that on Lombok, being Sasakese, Javanese and Sumbawanese does not necessarily preclude people from owning dogs. Also among the Sasakese, dog ownership was more common at the rural site than the urban site. Nonetheless, due to their religious belief, these dog owners did not commonly handle their dogs and mostly allowed them to roam freely.

8.1.4 RISK FOR RABIES RELEASE AND EXPOSURE BASED ON SENSITIVITY ANALYSIS RESULTS

According to the release assessment in this study, the overall probability of one rabies-infected dog being released on Lombok was very low, and similar for a dog arriving at an informal port on a boat and a dog being transported by a passenger on a ferry. Although this study found the probability of release via both pathways to be very low, these results must be interpreted with caution, because each probability result represents the probability for one boat or one person travelling in a ferry. Reliable data on the number of boats arriving on Lombok and the number of people travelling by ferry to Lombok are needed to aid interpretation of these results. Factors influencing the probability of release of a rabid dog via the boat pathway were prevalence of rabies on Bali, presence of a dog on a boat from outside Lombok and dog confinement on an outside boat. Similar to the ferry pathway, the probability of a non-resident bringing a dog from another island to Lombok was the most influential factor for the probability of a rabid dog release.

For the exposure assessment, this study found that the overall probability of rabies transmission to a local dog on Lombok was low, but higher at urban and rural sites than at a Lombok port. The most influential parameter for the exposure probability was the same for urban and rural sites and the port, being confinement of the rabies-infected dog at their household on Lombok.

These findings should be taken into account when making decisions about rabies prevention strategies for Lombok.

8.2 RECOMMENDATIONS FOR CONSIDERATION

8.2.1 PREVENTION OF RABIES ENTRY TO LOMBOK

8.2.1.1 Control at source – reducing prevalence on infected islands

The most influential factor on the probability of release for both boat and ferry pathways was rabies prevalence on the island of Bali. Prevalence on other infected islands of boat origin was also influential for the boat pathway. This emphasises the importance of the concept ‘contain at source’ and the role that rabies control on infected islands has in preventing spread to new locations. It appears likely that investment to achieve eradication on Bali will also benefit West Nusa Tenggara (NTB)

Province, through avoidance of expenditure on potential rabies response and control efforts on Lombok.

8.2.1.2 Education about rabies and quarantine regulations

For the general public and dog owners on Lombok

As Lombok is a rabies-free island, the most feasible method of control to maintain the rabies-free status is through prevention strategies. This includes educating the general public about the severe consequences of rabies, the role of dogs in its transmission, the length of the incubation period (an infected dog will be asymptomatic for a long period) and the importance of not moving dogs from rabies-infected islands or regions into Lombok. Education on quarantine regulations to the general public and dog owners is also important to promote the legal procedures for dog importation. However, an education campaign may be difficult to conduct, considering the diverse ethnic groups on Lombok. To educate these ethnic groups, obtaining support from community and religious leaders is an appropriate step to be able to effectively disseminate messages about rabies to the community. The necessity of gaining community leaders' support to convey health education related to zoonotic disease is also recognised elsewhere, for example in Sierra Leone in Africa (Subramanian, 2012). To target dog owners, raising rabies awareness of staff at venues such as veterinary clinics, pet shops and kennel clubs, and providing posters and leaflets for display and distribution, are viable methods of conveying rabies education. This would be especially viable for reaching those with pedigreed dogs, who will most likely visit these venues. To target the general public, introducing basic information about rabies to children at schools is applicable as they could extend the message to their families. School children are appropriate to target, as children under 16 years of age have higher risk of rabies exposure than other age groups (Hampson et al., 2008). Mass media such as television and radio can also be an effective method of extending information about rabies to the general public on Lombok. Mass media has been found to be the most effective tool for spreading rabies information in India (Herbert et al., 2012).

A community-based approach can also provide a better way of conveying the information to the general public on Lombok, similar to that conducted in Bali. In Bali, to improve rabies control, rabies working groups have recently been established in two villages as a pilot program with the support of livestock and health service officials.

This group consists of representatives from each banjar (a traditional Balinese meeting group) within a village, and actively encourages the community members to register their dogs and to report dog bite cases. It also provides general information about rabies. The same type of group will be established in all villages in Bali (Center for Indonesian Veterinary Analytical Studies, 2013b). In the Philippines, in a program known as the Bohol Rabies Program, local communities are involved in decisions regarding rabies control programs and implementing the programs in their area in line with the national rabies program (Lembo et al., 2011).

For animal health and public health officials

Knowledge about zoonotic disease should be a priority among animal and public health officials in Lombok because these people are the most likely sources of health information for farmers, pet owners and the general public. These officials include a wide range of health professionals including veterinarians, paraveterinarians, laboratory workers, agricultural extension workers, nurses and health practitioners. Worldwide, veterinarians are respected as a reliable source of animal health and zoonotic disease information for communities. For example, in relation to anthrax in Zimbabwe, information from veterinary authorities prevents the majority of cattle farmers from consuming the meat of cattle that are found dead (Chikerema et al., 2013). In England, farmers prefer to consult their local veterinarian about animal disease and disease risk management because these veterinarians are considered to provide better advice than government animal health authorities (Garforth et al., 2013). Similarly, veterinarians are perceived as a trusted source of horse health and biosecurity information by horse owners in Australia (Schemann et al., 2012).

Strengthening the knowledge of zoonotic diseases, in this case rabies, among public health practitioners in NTB Province is critical because these professionals must be prepared and able to recognise rabies symptoms in humans. This is particularly crucial since the recognition of rabies introduction to disease-free islands to date in Indonesian has been by the diagnosis of human rabies cases (Bingham, 2001a; Clifton, 2010; Putra et al., 2009). During the initial rabies outbreak in Bali, many doctors were not experienced in rabies diagnosis, thus were unprepared to handle human rabies (Susilawathi et al., 2012). A lack of knowledge among health authorities on how to administer post-exposure prophylaxis to humans could also lead to ineffective rabies treatment (Wilde, 2007).

8.2.1.3 Improvement of performance of quarantine agency on policing of regulations

Prevention of smuggling of dogs into Lombok that could lead to rabies incursion requires strong performance of the quarantine agency to enforce their regulations. Nevertheless, it would be challenging to detect every smuggled dog entering Lombok, considering the low number of quarantine personnel. Thus, an alternative would be to provide a more accessible legal procedure for the movement of dogs into Lombok and then ensure that this is widely publicised to the general public. However, this would require extensive consideration for quarantine officials, as it would be necessary to amend existing regulations. Nevertheless, this method has been successful in preventing the entry of the rabies virus into Japan, by allowing dog importation from other rabies-infected countries or territories while at the same time implementing a strict import quarantine regimen under Japan Rabies Prevention Law (Kamakawa et al., 2009).

8.2.2 PREVENTION OF ESTABLISHMENT IN THE EVENT OF RABIES INCURSION BY EFFECTIVE RESPONSE THROUGH EARLY DISEASE DETECTION AND PREPAREDNESS PLANNING

8.2.2.1 Enhancement of surveillance for early detection

Relevant authorities on Lombok must increase awareness of the rabies threat to Lombok and the fact that it may be already present yet undetected on Lombok. Animal disease surveillance enables early detection of a disease (Sawford et al., 2013) and by providing reliable disease case reports it prompts timely responses and influences decisions for effective control efforts (Townsend et al., 2012). Surveillance is an effective tool for improving estimates of rabies incidence and distribution. It can inform animal and public health authorities as well as policy decision makers on the rabies burden and the necessity to include rabies as one of the priority diseases for government response (Kitala et al., 2000; Lembo et al., 2010). Enhancing the capacity of laboratories to provide better surveillance (Banyard et al., 2013) is necessary to make an impact on formulation of health policy. In Tanzania, a lack of accurate figures caused rabies to be a low priority for public health and veterinary agencies (Hampson et al., 2008). The ability and willingness of animal health workers to submit samples to laboratories should be improved to enhance passive surveillance (Sawford et al., 2013). It is possible to improve rabies surveillance for Lombok by providing better equipment and technical diagnostic training for staff at the provincial animal health laboratory. In addition, the process for sending samples for confirmation to the regional animal disease investigation centre on Bali could be improved.

Hospitals and public health centres across Lombok can assist with rabies surveillance by monitoring the level of human dog bite cases and informing the community about the importance of reporting dog bites to these centres. An unusual increase in the number of dog bite cases in humans can act as an early warning system to alert authorities to investigate a potential rabies incursion. In the event of an incursion, good reporting will inform decisions on areas in which to intensify rabies control efforts. This study found that most dog bite victims did not report to a hospital or public health centre. Therefore, public awareness about the benefit of reporting dog bite cases is important. Surveillance of dog bites is highly valuable in understanding the epidemiology of dog bites (Tenzin et al., 2011a). Data on dog bites in humans is also being used to estimate trends in human rabies deaths in rabies-endemic countries in Asia and Africa (Cleaveland et al., 2002; Fèvre et al., 2005; Knobel et al., 2005; Tenzin et al., 2011a). Unfortunately, currently on Lombok, hospital records monitoring dog bites are not available. This situation was the same as for Bali, in which there was no data on dog bites prior to the rabies outbreak in 2008 (Susilawathi et al., 2012).

8.2.2.2 Emergency animal disease response plan for rabies

In order to be able to effectively manage emergency animal diseases, government agencies and animal industries must be in effective consultation with each other, and the government agency develop preparedness plans outlining the actions and procedures to be enacted in the event of an incursion. Such plans are essential to ensure quick response to an animal health emergency. In Australia, the Australian Veterinary Emergency Plan (AUSVETPLAN) is constitutes the plans for conduct of disease responses. AUSVETPLAN includes a comprehensive series of manuals that outline the preferred approaches in response to outbreaks of various exotic diseases. AUSVETPLAN manuals are developed and ratified by Commonwealth and state/territory governments and industry organisations before a disease outbreak occurs, and outline the roles and responsibilities of agencies and organisations involved in a response. The prior availability of the agreed policies ensures the most timely response possible can occur. The manuals are used in training and simulation exercises to allow for relevant structures and processes to be put in place and practised (Animal Health Australia, 2008). In Indonesia, the Australian government through the ACIAR project titled 'Improving Veterinary Service Delivery in a Decentralised Indonesia' assisted the development of the Indonesia Veterinary Plan (INDOVETPLAN). INDOVETPLAN is a set of guidelines for systematic planning and preparedness for emergency animal disease outbreaks in Indonesia (Australian Centre for International Agricultural Research, 2012). Under this project, the integrated Incident Control System (ICS) has been introduced to animal health authorities in Indonesia and has been implementation for the first time for rabies in Bali.

Currently, INDOVETPLAN is under revision by the Directorate General Livestock and Animal Health Service (DGLAHS) (drh. Pebi Purwo Suseno personal communication, 2013). In regard to the preparedness plan for rabies incursion in NTB, DGLHAS held a meeting in April 2011 in Lombok. This meeting discussed strategies for prevention of rabies incursion into NTB (including Lombok) such as strict control of dog movement at NTB border areas, education of the general public to increase knowledge about rabies and management of dog populations. The DGLAHS is also suggesting NTB to conduct rabies vaccination for the dog population (drh. Pebi Purwo Suseno personal communication, 2013).

8.2.2.3 Responsible pet ownership

Confinement of dogs is known to be an effective strategy for rabies control as it prevents disease transmission between dogs. The sensitivity analyses for the release assessment of the boat pathway and for the exposure assessment of urban and rural sites and at the port identified dog confinement as an influential factor. This study also estimated the number of free-roaming dogs at urban and rural sites on Lombok, demonstrating that the number of these dogs is substantial, as seen in other islands of Indonesia and elsewhere in the developing countries of Africa and Asia (Kato et al., 2003; Ratsitorahina et al., 2009; Sudarshan et al., 2007; Totton et al., 2010). Promoting responsible dog ownership to owners on Lombok should be recognised as an important component of activities to prevent the introduction and establishment of rabies on Lombok. It incorporates dog registration and identification, dog vaccination, neutering and confinement. However, this may be a difficult concept to introduce to the people of Lombok due to the diversity of cultural and religious beliefs, and thus differences in attitudes toward desexing and keeping dogs confined. Considerable effort will need to be invested to change approaches to dog management within communities on Lombok. Dog management could be included in community-based programs on rabies and thus presented in the context of rabies prevention. Application of policy to enforce responsible dog ownership may be used on Lombok to support the adoption of new practices in dog management. For example dog registration free of charge may be introduced as well as community programs to encourage dog owners to register their dogs.

8.2.2.4 Dog population control and waste control – by government agencies

Activities to contain and reduce the dog population, whilst increasing recognised as not an essential component of a dog rabies control program, have real benefits in preventing abandonment of unwanted puppies and reducing nuisance behaviours of free-roaming dogs. Thus birth control for dogs by castration and speying should be encouraged among dog owners as part of responsible pet ownership. Government animal health centres should be utilised to provide affordable dog neutering services. This would prevent the presence of unwanted puppies that may be left in the streets to contribute to the unowned dog population. A study in India has used desexing to reduce its free-roaming dog population (Totton et al., 2010). In this study, conducted in five areas in Jodhpur, India, the free-roaming dog population was measured in 2005, prior to implementation of the desexing program, and the population re-estimated two years (2007) after the desexing program. The results show that the free-roaming dog population decreased significantly in three of the areas. Although this animal birth control program appears to be successful in managing the free-roaming dog population in these areas, it could be a challenge if applied on Lombok, since it requires a large amount of funding and time as well as a high level of commitment. According to this study, to achieve a stable 70% reduction in the free-roaming dog population, 90% of the dogs must be sterilised; if less than 40% are sterilised, the population will not be reduced. Further, this effort should be implemented for 13-18 years to achieve the 70% reduction (Totton et al., 2010). Thus, adopting this program would be financially impractical for the resources-limited Lombok government.

Culling to reduce free-roaming dog populations has long been proven to be ineffective due to the rapid population turnover. As many as 50-80% dogs a year need to be culled to maintain a stable dog population (Totton et al., 2010). On Lombok, a periodic dog culling program is conducted by the animal health authority. No evaluation has been undertaken to measure the effect of the culling program on the Lombok free-roaming dog population (drh. Aminurrahman personal communication, 2011). However, population management through a better waste collection and disposal system to reduce a source of food for roaming dogs may be more feasible to conduct on Lombok than other approaches to control free-roaming dogs in urban areas. Waste management as a method of influencing free-roaming dog population density is also suggested by studies conducted in Bhutan (Tenzin et al., 2012a), Nepal and Japan (Kato et al., 2003), and Brazil (Dias et al., 2013).

8.2.2.5 Rabies vaccination

Establishing immunity against rabies for the Lombok dog population should be seriously considered as part of the rabies prevention strategy. Dog population estimation is also important to ensure adequate information is available to underpin planning and implementation of rabies vaccination program. A lesson learned from rabies outbreaks in Bali and Flores is that rabies virus infection occurred readily among the dog population, and caused human deaths, following importation of a rabid dog into these islands (Bingham, 2001a; Putra et al., 2009). This ease of spread was due to the presence of free-roaming dogs and active movement of dogs by people was worsened by the fact that the dog population was not vaccinated against rabies during the initial outbreak (Clifton, 2010). Herd immunity, achieved by vaccination of 70% of the dog population (Coleman and Dye, 1996), is the one approach to control that will prevent rabies from being established in the dog population and will protect humans from the risk of rabies infection via dog bites. A study conducted in N’Djamena, Chad, that compared cost-effectiveness between rabies intervention in dogs through mass dog vaccination and in humans through post-exposure prophylaxis, has found that among the two, mass vaccination to 70% of the dog population is the most cost-effective measure as a rabies control strategy (Zinsstag et al., 2009).

Currently no rabies vaccination program is implemented on the islands that comprise the NTB province. Although the provincial Livestock and Animal Health officials consider rabies vaccination to be necessary, this is not supported by provincial policy-makers or by animal health officers at district level on Lombok, because Lombok or NTB is rabies-free (drh. Aminurrahman personal communication, 2011). Plans for vaccination campaigns should be designed carefully and policy-makers convinced of their value prior to commencement of vaccination. Community leaders should also be engaged to encourage dog vaccination and consideration be given to the perspectives of ethnic groups that may actively oppose vaccination of dogs, when planning community-based programs. Effective targeted communication will be required in order to convey the necessity of vaccination to protect dogs from contracting rabies and thus establish a barrier that prevents rabies transmission to people.

A systematic review of canine rabies vaccination in the developing world shows that with high commitment between authorities, dog populations can be successfully vaccinated even including those at remote locations (Davlin and VonVille, 2012). Issues that must be considered when planning a vaccination program are cost, vaccine efficacy, cold chain for vaccine storage and logistics. A study in N'Djamena, Chad, investigating the association between the cost of dog rabies vaccination and willingness of dog owners to have their dogs vaccinated, showed that cost influences the decision of dog owners to vaccinate their dogs (Dürr et al., 2008). In Bali, the cost of rabies vaccine per dog is approximately $2 US (Center for Indonesian Veterinary Analytical Studies, 2013a). The type of vaccine being used is imported vaccine that provides one year's immunity. If vaccination is implemented on Lombok, a low charge during initiation of the campaign would be required and a similar high quality vaccine must be used to ensure uptake and efficacy. A charge similar to that of Bali will likely lead to lower uptake in rural areas, as the charge is equal to one day's wage for lower income earners in the rural areas of Lombok (Dr. Muktasam personal communication, 2012). For the cold chain, the provision of equipment to maintain an adequate vaccine cold chain is reported as lacking in some areas in Bali (Russell et al., 2011), and similar deficiencies exist in the majority of rabies-infected islands in Indonesia. On Lombok, where electricity supply is unreliable or even non-existent, inadequate cold chain will be a problem; the majority of animal health centres at rural sites are unable to power an electric refrigerator. The same issues exist for vaccine storage at public health centres on Lombok, and the issue of ability to provide post-exposure treatment to dog bite victims during a rabies incursion would need consideration. Given the multiple challenges to rabies vaccine distribution outlined here, considerable thought is required to guide decisions on dog rabies vaccination for Lombok, particularly ahead of an incursion.

At present there is no information available about the presence or otherwise of wild dogs on Lombok. There is no comment in the literature about wild dogs on this island and no information has been obtained from experts on this point. Literature about dog demography elsewhere in Indonesia states dog categories according to the dogs' physical environment, listing owned dogs, semi free-ranging owned dog and unowned free-ranging dogs. Unowned free-ranging dogs live and search for food around people's premises and thus are not categorised as wild or feral dogs (Putra, 2011b). This is the same as this current study has found during a survey of households (Chapter 3) and unowned dog count (Chapter 4) at urban and rural sites, which tallied owned dogs with full restriction, semi-free roaming dogs, free-roaming owned dogs and unowned free-roaming dogs. During the dog counting activity, unowned dogs were seen scavenging around garbage near people's premises. This emphasises that the conduct of a rabies vaccination program on Lombok should be more achievable as it would involve domestic rather than wild dogs.

8.2.3 For future research

This study provides insights into potential pathways for the spread of rabies within Indonesia. These findings can also inform research on rabies spread to near neighbours Timor Leste and Papua New Guinea. Entry of rabies to these two countries would heighten the possibility of rabies entering northern Australia. The existence of free-roaming dogs in the indigenous communities of northern Australia and the northern dingo and wildlife populations mean that it would be difficult to eradicate rabies if this disease enters Australia. Therefore, it is urgent for Australia to better understand pathways for rabies spread in the region in order to inform preventive action. A current ACIAR small research activity is investigating potential pathways for the introduction and spread of rabies in eastern Indonesia, East Timor, Papua New Guinea and northern Australia, as well as assessing the risk of rabies introduction through those potential pathways. Thus, it will provide understanding for rabies surveillance approaches to prevent the spread of rabies in these regions.

To further underpin decision-making by the NTB provincial authorities, future research on Lombok should be conducted to understand dog ecology, the cost-benefit and feasibility of pre-emptive rabies vaccination, and dog owners' knowledge, perceptions and attitudes toward rabies. The baseline information obtained would facilitate the development of more targeted and cost effective rabies prevention strategies for NTB province.

7.3 CONCLUSION

This thesis has identified that there is potential for entry of the rabies virus via dogs imported from rabies-infected islands or regions into Lombok, given documented illegal movement of dogs with people travelling by ferry, and that the probability of release and exposure was not negligible. This finding suggests that extensive efforts to prevent rabies incursion and establishment are urgently required in order to maintain the rabies-free status of Lombok. The emphasis should be on strengthening quarantine control at Lombok border areas; on surveillance and preparedness planning to enable early detection and response; and on educating dog owners and the general public on Lombok about rabies itself, the quarantine regulations on dog movement and responsible dog ownership (particularly dog confinement and desexing). If the factors shown to have great influence on release and exposure are targeted, the probability of release and exposure will be reduced and subsequently Lombok maintained rabies-free. Thus the contribution of rabies eradication on Bali for the protection of Lombok is recognised. Finally, for the rabies prevention effort on Lombok to be well informed and successful, full evaluation of the role of pre-emptive dog vaccination must be undertaken and network structures for collaborative action across animal health, public health, quarantine and municipal sectors established.

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APPENDIX

Appendix 1 Questionnaire used to interview the 400 dog owning households

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

Questionnaire for dog-owning household

Introduction to project: The aim of this questionnaire is to obtain data on owned dogs and the dog management practices of community ethnics in urban and rural sites on Lombok

All information obtained from this interview will only be used for this research purpose.

Code Identification No: [ ]

Village Name : 1. Batu Putih
2. Cakranegara

Location name (for Cakranegara only): 1. Kr. Sampalan 2. Sayang Daye 3. Gubug Panaraga 4. Kr. Wana Sara 5. Kr. Bungkulan 6. Kr. Jasi 7. Lendang Re 8. Pamotan 9. Kr. Tulamben 10. Kr. Tageban 11. Sweta Selatan 12. Seganteng Kr. Monjok

Ethnic group : 1. Bali 3. Java 5. Other, please specify [ ]
2. Sasak 4. Chinese

Respondent No : three digit (00_)

Example Code Identification No : **211001** (Village 2;Location 1;Ethnic Bali(1); Respondent No 1)

Interviewer Name: [ ]

Date of interview : [ ] (dd/mm/yy)

Instructions for interviewing

1. Interviewer will interview the head of the family in the household or member of the family at age ≥ 18.
2. Interviewer should read clearly the aim of the interview as written above, before starting the interview.
3. Questions and answer options should be read clearly to the respondent to ensure consistency.The validity of the survey will depend on the truthfulness of responses, therefore interviewer should not persuade the interviewee to answer the most desirable answers.
4. To answer each questions, please circle all relevant answers for each question, multiple answers are possible. If the respondent answers other than answer options, please circle the 'Other' option box and write in the 'please specify' textbox.
5. This questionnaire is a total of 9 pages. Please check before starting the interview that all pages are present.

1

A : Respondent Data

A.1 Name [ ]

A.2 Age [ ]

A.3 Gender 1 Male 2 Female

A.4 Education – Please tick the highest year of school completed:

1 School not attended or primary not completed
2 Primary school
3 Secondary school
4 High school
5 Bachelor degree
6 Undergraduate school
7 Postgraduate school

A.5 Religion 1 Islam 2 Catholic 3 Hindu 4 Buddhist 5 Christiant

A.6 Occupation 1. Farmer 2. Trader 3. Carpenter 4. Government employee 5. Driver 6. Other [ ]

A.7 Number of living in household

Adult : [ ] persons Children: [ ] persons

B : Respondent Background

B.1 What animals do you keep on your property during last 12 months?

1 Dog
2 Cat
3 Goats
4 Poultry
5 Pigs
6 Cattle/buffalo
7 Monkey
8 Other [ ]

2

B.2 How many dogs do you have? For each dog, please record

	1	2	3	4					5
				Where did you get your dog? Tick the selected option then ask further questions in the bracket where necessary					
No	Gender 1. Male 2. Female	Age (years)	Breed 1.Local 2.Non local/Pure	1 Keep them since they were little	2 Gift (Where from and which year)	3 Purchase (Where from and which year)	4 Took it from the street (in Lombok or outside)	5 Dog came by itself	What is your reason to keep these dogs? 1.Guard dog 2.As pet 3.To consume/cultural tradition 4.For trade 5.Other,specify
1.									
2.									
3.									
4.									
5.									
6.									

B.3 Have you kept dogs for consumption/cultural tradition? 1. Yes 2. No
If yes, please specify your answer

Consumption				
When you have a dog for consumption what do you generally do				
1	2	3	4	5
Where did you get dogs for this use? 1.Took it from the street 2.Kept it since little 3.Buy it in Lombok 4.Buy it in another island	If the dog were bought from another island, which island? 1. Bali 2. Sumbawa 3. Flores 4. Jawa	If the dog were bought or you took the dog from the street, did you keep the dog for a while before slaughter it? 1. Yes 2. No	If yes, how many days did you keep the dog? ____ days	How you keep the dog: 1. Caged it 2. Chained it 3. Free to roam

Cultural tradition				
When you have a dog for cultural tradition what do you generally do				
1	2	3	4	5
Where did you get dogs for this use? 1.Took it from the street 2.Kept it since little 3.Buy it in Lombok 4.Buy it in another island	If the dog were bought from another island, which island? 1. Bali 2. Sumbawa 3. Flores 4. Jawa	If the dog were bought or you took the dog from the street, did you keep the dog for a while before slaughter it? 1. Yes 2. No	If yes, how many days did you keep the dog? ____ days	How you keep the dog: 1. Caged it 2. Chained it 3. Free to roam

B.4 House/property fence type

- 1 House fenced with gate
- 2 House fenced without gate
- 3 House without fence

C. Dog Management

C.1 How do you keep your dogs? Please circle the answer then give list for each dog the respondent have

Dog number	How do you keep your dog?	How many hours/day you let your dog roam outside your property?
1.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam	
2.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam	
3.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam	
4.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam	
5.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam	

C.2 What is the main purpose of your dogs going outside your property?

- 1 Looking for food
- 2 Play with other dog
- 5 Guard crops in the field
- 3 Mating
- 4 Guard house
- 6 Other ______

C.3 To your knowledge, when your dogs outside your property, does it have contact with other dogs?

1 Yes 2 No 3 Not sure

C.4 What do you feed your dogs?

1 Comercial dog food 2 Table scraps from home

3 Other, please specify ______

C.5 Do you provide water for your dogs?

1 Yes 2 No. If not, where do your dogs get access to water?

1 The dog get water from outside the property

2 The dog get water somewhere inside the property

3 The dog get water inside and outside the property

C.6 Do you or members of your family often interact with your dog/s? E.g. play with the dog?

1 Yes 2 No

C.7 Have you or members of household been bitten by one of your dogs in last 5 years?

1 Yes 2 No

C.8 Have you or members of household been bitten by one of your dogs in last 12 months?

1 Yes 2 No

C.9 Have you or members of household bitten by other dog in last 5 years?

1 Yes 2 No

C.10 Have you or members of household bitten by other dog in last 12 months?

1 Yes 2 No

C.11 If yes, what is the age and gender of the person bitten? Please list for each of the dog bites reported by the respondent

No.	Age of the person bitten	Gender of the person bitten 1. Male 2. Female	Bitten by 1.Own dog 2.Other people's dog 3. Unowned dog 4. Dog that you transport for other people	Part of the body bitten 1. Leg part 2. Hand 3. Stomach 4. Hip 5. Shoulder/neck
	1	2	3	4
1.				
2.				
3.				
4.				
5.				
	Please also write if the respondent reported other people in the same village who are bitten by dog			
6.				

7.				
8.				

C.12 What did you or members of family do to the wound?

1 Clean it 4 Clean it and give simple medication (e.g. Iodine)

2 Go to seek medication to the hospital 5 Do nothing

3 Give traditional medication, such as oil

C.13 Has one of your dogs ever bitten a person outside your household?

1 Yes 2 No 3 Not sure

C.14 What did you do to the dog that bit you or other people?

1 Do nothing 2 Repel the dog

3 Kill the dog

C.15 What did you do to other people's wound, if the person bitten by your dog?

1 Clean it and give simple medication (e.g. Iodine)

2 Go to seek medication to the hospital

3 Give traditional medication, such as oil, etc

4 Do nothing. Why? ______

C.16 What will you do to other people, if the person bitten by unowned dog?

1 Clean it and give simple medication (e.g. Iodine)

2 Go to seek medication to the hospital

3 Give traditional medication, such as oil, etc

4 Do nothing. Why? ______

C.17 Do you use identification with any of your dog?

1 Yes. If yes, please specify type of identification 1 Collar 2 Tattoo 3 Other,specify ______

2 No

For respondent that have female dogs

C.18 Please complete the questions below

1	2	3	4
In average, how many puppies do the female dog usually delivered?	In average, how many times /year the female dog delivering puppies?	In what month do puppies born the most?	What do you usually do with the puppies? 1.Keep the puppies 2.Throw it away, where? 3.Give it to other people

C.19 Have you or member of family travel outside Lombok with your dog by ferries/plane in the last 5 years?

1 Yes 2 No, please go to question C.24

C.20 If yes, how many times in a year you travel outside Lombok with your dog? ____ times

C.21 Please give information for the each travel

1	2	3	4	5	6
No.	When (month/year)	Where (island) 1.Bali 2.Java 3.Sumbawa 4.Sulawesi	Length of stay (days or weeks)	What did you do with your dog while in the island 1.Caged it 2.Roam within your sight 3.Free to roam anywhere	Did your dog have contact with the local dogs? 1. Yes 2. No 3. Don't know
1.					
2.					
3.					
4.					
5.					
6.					

C.22 Did you provide your dog letter of health certification or such for your dog travel?

1 Yes

2 No. If not, have you ever experience quarantine inspection to your dog? 1 Yes 2 No

C.23 Did the dog return home?

1 Yes 2 Sometimes 3 Never

C.24 Have you ever brought a new dog (either by purchase or buy or gift) back to Lombok from any place that you have visited?

1 Yes 2 No, please go to part D

C.25 If yes, how many times in a year did you brought back new dog to Lombok from any place that you visit? ___ times

C.26 If yes, please provide information on each dog you brought back to Lombok

No.	Where from (island) 1.Bali 2.Sumbawa 3.Java 4.Flores 5.Sulawesi	Year when you brought the dog or the age of the dog at that time	Was it vaccinated at that time? 1. Yes, what kind of vaccination? 2. No 3. Don't know
	1	2	3
1.			
2.			
3.			
4.			

C.27 What kind of transportation you mainly used when you brought the dog to Lombok?

1 By car through ferries

2 Put it in fast boat or fishermen's boat

3 By plane

C.28 Did you provide your dog letter of health certification or such for the dog?

1 Yes

2 No. If not, have you ever experience quarantine inspection to your dog? 1 Yes 2 No

D. Dog Health

D.1 What signs indicate to you that a dog is sick?

1 Loss of appetite 4 Diarrhea 7 Other, specify

2 Depression 5 Itch

3 Vomit 6 Don't know

D.2 What do you usually do when you realise your dog is sick?

1 Take the dog to the veterinarian 5 Other, specify

2 Call the Veterinarian/paramedics at the animal care centre

3 Give the dog medication yourself; please specify what kind of medication

Ex. Diarrhea gives guava leaf

4 Do nothing

E. Knowledge of Rabies

E.1 Have you heard about Rabies?

1 Yes 2 No, please go to question E.6

E.2 If yes, where have you heard about Rabies from? (Multiple answers are possible)

1 Leaflet/Brochure 4 Relatives 7 Other, please specify

2 Newspaper 5 Government staff

3 Television/Radio 6 School

E.3 Do you think that rabies is a dangerous disease (fatal disease)?

1 Yes 2 No 3 Don't know

E.4 How do people get rabies?

1 Bitten by dog 2 Play with dog 3 Keep dog 4 Not clean environment

5 Don't know 6 Other, specify

E.5 Do you think rabies can be transmitted to humans through dog bite? (Ask this question, if the respondent did not mentioned dog bites)

1 Yes 2 No 3 Not sure

E.6 Do you think that dogs can transmit disease to humans, other than rabies?

1 Yes, what disease? 1 Itch 2 Asthma 3 Worm 4 Other

2 No

3 Don't know

E.7 Based on your understanding, please explain what is Rabies

1 Dangerous disease

2 Mad dog

3 Disease transferred by dog

4 Disease caused by dog bites

5 Don't know

6 Other

Completion of questionnaire: Thank you very much for your participation.

Would you willing to provide additional information if we need to contact you for further inquiries?

1 Yes 2 No

Appendix 2 Questionnaire used to interview the 117 captains of boats from outside Lombok that dock at Lombok ports

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

Questionnaire for people with boat activity from outside Lombok

Introduction to project:

The aim of this questionnaire is to obtain data on

1. People with boat activity from outside Lombok who sailed to Lombok, the origin of this group and frequency of their visits to Lombok and to obtain data on the likelihood of this group bringing dogs in the boat to Lombok
2. The management of dogs by the people with boat activity from outside Lombok

All information obtained from this interview will only be used for this research purpose.

Code Identification No: ____________

Enter district name:

LT; LU; LB; LTi = LT for Lombok Tengah, LU for Lombok Utara, LB for Lombok Barat, LTi for Lombok Timur

Name of Port:

1. Teluk Awang	4. Kayangan	7. Tanjung Luar	10. Kayangan Harbour
2. Teluk Nara	5. Labuhan Haji	8. Lembar	
3. Pemenang	6. Labuhan Lombok	9. Bangko-bangko	

Respondent's origin : 1. Bali 3. Flores 5. NTT (East Nusa Tenggara)
2. Java 4. Sulawesi 6.

Responden's No : three digit (00_)

Name of interviewer: ____________

Date of interview : ____________ (dd/mm/yy)

Instructions for interviewing

1. Interviewer will interview the person in the boat or the captain of the boat (if >1 person in the boat).
2. Interviewer should only interview people in the boat that travelled from rabies infected island (Bali, Java, Flores East Nusa Tenggara, Maluku and Java) and or people with dog in the boat even though they are not coming from rabies infected island.
3. Interviewer should read clearly the aim of the interview as written above, before starting the interview.
4. Questions and answer options should be read clearly to the respondent to ensure consistency.The validity of the survey will depend on the truthfulness of responses, therefore interviewer should not persuade the interviewee to answer the most desirable answers.
5. To answer each questions, please circle all relevant answers for each question, multiple answers are possible. If the respondent answers other than answer options, please circle the 'Other' option box and write in the 'please specify' textbox.
6. This questionnaire is a total of 7 pages. Please check before starting the interview that all pages are present.

1

A: Respondent Data

A.1 Name ____________

A.2 Age ____________

A.3 Gender [1] Male [2] Female

A.4 Education – Please tick the <u>highest</u> year of school completed:

[1] School not attended or primary not completed	[5] Bachelor degree
[2] Primary school	[6] Undergraduate University degree
[3] Secondary school	[7] Postgraduate University degree
[4] High school	

A.5 Religion [1] Islam [3] Hindu [5] Christiant
[2] Catholic [4] Buddhist

A.6 Occupation 1. Fishermen 2. cargo/passenger boat 3. Other, please specify ____________

A.7 Number of persons travelling in the boat: persons

A.8 Maximum capacity of persons in the boat: persons

B: Respondent Background

B.1 Where are your boat travelled from?

[1] Bali	[4] Sulawesi
[2] Flores	[5] Maluku
[3] Java	[6] Other, please specify ____________

B.2 <u>In the</u> last 5 years, did you <u>always</u> sailed to Lombok?
[1] Yes, ____times/year [2] Sometimes, ________times/year [3] Only this time

B.3 When in a year did you sailed to Lombok?
[1] In the good weather. In what month/s? ____________
[2] In the fishing season at Lombok sea. In what month/s ____________
[3] Other reason, please specify ____________

B.4 Did you take animals while sailing?

[1] Dog	[4] Poultry	[7] Monkey
[2] Cat	[5] Pigs	[8] Other, specify ____________
[3] Goats	[6] Cattle/buffalo	[9] Never take animals

If the respondent's answer is other than option no. 1, please go to question B.12

2

B.5 How often do you sail with a dog?

[1] Every time when sailing (times/year:) [2] Sometimes (times/year:)

B.6 What is your main purpose of having a dog while you are sailing?

[1] Safety reason [3] For trade

[2] Tradition,explain [ ] [4] Other, specify [ ]

B.7 In the last 12 months, how many trips did you make to Lombok?

Trips to Lombok in the last 12 months	Average number of days spent in Lombok on each trip in last 12 months	What did you do with your dog while you were in Lombok? 1. No dog 2. Left it in the boat 3. Caged it 4. Roam within your sight 5. Free to roam 6. Other, specify	Where did you get the dog that travelled with you in this specific trip? 1. Island which the boat travelled from 2. Took it/gift/purchase it from another island (which year and which island)	Did the dog stay in Lombok or return home with you? 1. Yes 2. No
1.				
2.				
3.				
4.				
5.				

B.8 To your knowledge, during the time when staying in Lombok, did your dog have contact with other/local dog?

[1] Yes [2] No [3] Not sure

B.9 Did you have to provide letters from your place of origin for the dog sailing with you?

[1] Yes, what kind? [E.g. Health certificate]

[2] No. If not, have you ever experience quarantine inspection to your dog? Please describe

[ ]

B.10 Do you usually use identification for your dog that travel with you on the boat?

[1] Yes, what kind of identification? [1] Collar [2] Tattoo [3] Other, please specify [ ]

[2] No

3

B.11 Do you or other person in your boat often interact with your dog that travels with you on the boat? E.g. play with the dog?

[1] Yes [2] No

B.12 In the last 5 years, have you ever transport dogs to Lombok from your place of origin?

[1] Yes, go to questions B.14 [2] No

B.13 If not, are you willing to transport dogs to Lombok, if someone asked you to?

[1] Yes [2] No, why? [ ]

Go to question B. 16

B.14 If the answer of B.12 is yes, please provide information on each dog you brought to Lombok

No.	Where from (island) 1. Bali 2. Java 3. Sumatera 4. Sulawesi 5. Other, please specify	Year when you brought the dog or the age of the dog at that time	Have it vaccinated at that time? 1. Yes, what kind of vaccination? 2. No	What is the purpose of bringing these dogs? 1. An order from someone else 2. As a gift 3. To trade 4. Other, please specify	How many dogs in average that you brought in a year?
1.					
2.					
3.					
4.					
5.					
6.					

B.15 Is there any letters (e.g health certification letter) for the dogs that you transport?

[1] Yes, what kind? [ ]

[2] No. If not, have you ever experience quarantine inspection to your dog? Please describe [ ]

B.16 During sailing, what do you use as navigator or to show which way to go and as bad weather predictor while you are in the sea?

[1] Animal, specify [ ] [2] Wind blow

[3] Cloud [4] Wave [5] Stars [6] Technology, e.g GPS

[7] Other, specify [ ]

4

C. Dog Manajement

C.1 How do you keep your dogs when you are at home, including dog that you take to Lombok and/or transport to Lombok? Please circle the answer then fill in information for each dog the respondent have

Dog number	How do you keep your dog?	How many hours/day does the dog roam free outside your property?	Have your dog vaccinated? 1. Yes, what kind of vaccination? (e.g rabies) 2. No
	1	2	3
1.	1. Do not have dog at home 2. Caged 3. Tethered next to your house 4. Roam inside your property 5. Free to roam		
2.	1. Do not have dog at home 2. Caged 3. Tethered next to your house 4. Roam inside your property 5. Free to roam		
3.	1. Do not have dog at home 2. Caged 3. Tethered next to your house 4. Roam inside your property 5. Free to roam		
4.	1. Do not have dog at home 2. Caged 3. Tethered next to your house 4. Roam inside your property 5. Free to roam		
5.	1. Do not have dog at home 2. Caged 3. Tethered next to your house 4. Roam inside your property 5. Free to roam		

For respondent who answer do not have a dog at home, go to questions in part E

C.2 What is the main purpose of your dogs (or dogs that you transport) going outside your property?

1 Looking for food 2 To play/interact with other dog/s 5 To defecate

3 Mating 4 Guard house 6 Other, specify

C.3 What do you feed your dog/s(or dog/s that you transport)?

1 Commercial dog food 2 Table scraps from home 3 Other, pelase specify

C.4 Do you provide water for your dogs (or dogs you transport)?

1 Yes 2 No. If not, where do your dog/s get access to water?

1 The dog get water from outside the property

2 The dog get water somewhere inside the property

3 The dog get water inside and outside the property

C.5 Have you or other people in your boat been bitten by your dog that you take to Lombok?

1 Yes 2 No, go to question C. 7

C.6 If yes, what do you or the person who get bitten do to the wound?

1 Clean it 4 Clean it and give simple medication (e.g. Iodine)

2 Go to seek medication to the hospital 5 Do Nothing

3 Give traditional medication, such as oil or leaf

C.7 Has your dog ever bitten a person while in Lombok?

1 Yes 2 No, go to question C.9 3 Not sure

C.8 What did you do to the dog that bit you or other people?

1 Nothing, why?

2 Repel the dog 3 Kill the dog

C.9 When leaving Lombok, do your dog left behind?

1 Always 2 Sometimes 3 Never, go to questions in part D

C.10 Why your dog left behind?

1 Can not find it 2 Give/sell it to other people in Lombok

3 Other, please specify

D. Dog Health

D.1 What signs indicate to you that a dog is sick?

1 Loss of appetite 4 Diarrhea 7 Other, specify

2 Depression 5 Itch

3 Vomit 6 Fever

D.2 What do you usually do when you realise your dog (or dogs that you transport) is sick?

1 Take the dog to the veterinarian 4 Do Nothing

2 Call the Veterinarian/paramedics at the animal care centre

3 Give the dog medication yourself 5 Other, specify

Please specify what kind of medication. Diarrhea gives guava leaf

E. Knowledge of rabies

E.1 Have you heard about Rabies?

[1] Yes [2] No, go to question E.3

E.2 If yes, where have you heard about Rabies from? (Multiple answers are possible)

[1] Leaflet/Brochure [4] Relatives
[2] Newspaper [5] Government staff
[3] Television/Radio [6] School

E.3 Do you think that rabies is a dangerous disease (fatal disease)?

[1] Yes [2] No [3] Not sure

E.4 How do people get rabies?

[1] Bitten by dog [2] Play with dog [3] Keep [4] Dirty environment
[5] Not sure

E.5 Do you think rabies can be transmitted to humans through dog bite? (Ask this question, if the respondent did not mentioned dog bites)

[1] Yes [2] No [3] Not sure

E.6 Do you think that dogs can transmit disease to humans, other than rabies?

[1] Yes, what diseasea? [1] Itch [2] Asthma [3] Worm
[2] No [3] Not sure

E.7 Based on your understanding, please explain what is Rabies ?

[1] Dangerous diseasePenyakit berbahaya
[2] Mad dog disease / Anjing Gila
[3] Disease transmitted by dog
[4] Disease caused by dog bites
[5] Don't know
[6] Other [ ]

E.8 At your place of origin, do you know what government do to prevent dog transmitting disease to human, such as rabies? For example, if someone want to keep dog, it has to be caged/tethered and vaccinated or dog forbidden to be taken to other places other than its origin?

[ ]

Completion of questionnaire: Thank you very much for your participation.

Appendix 3 Questionnaire used to interview the 52 captains of boats from local Lombok

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

Boat Activity Household Questionnaire

The aim of this questionnaire is to obtain data on:

1. Dog management practices of households with boat activity and to record the number of dogs owned by this household.
2. Boat activity to rabies infected island by this household and to record the likelihood of bringing dogs from rabies infected island by this households.

All information obtained from this interview will only be used for this research purpose.

Code Identification No: [ ]

Village Name : 1. Batu Putih

Port Name: 1. Bangko-bangko

Ethnic : 1. Bali

2. Sasak

Type of respondent: 1. Boat activity owning dog household (please fill questionnaire part A;B; C; E; F&G)

2. Boat activity household, do not have dog but sailed to rabies infected island (please fill questionnaire part A; B; D; E; F & G)

Respondent No : three digit (00_)

Example of Code Identification No : **1111001** (Village 1;Subvillage 1;Ethnic Bali(1);

Type of respondent 1; Respondent No 1)

Name of interviewer: [ ]

Date of interview : [ ] (dd/mm/yy)

Instruction for interviewing

1. Interviewer will interview the head of the family in the household or member of the family at age ≥ 18, the interviewee should know the detail on boat trips.
2. Interviewer should read clearly the aim of the interview as written above, before starting the interview.
3. Questions and answer options should be read clearly to the respondent to ensure consistency.The validity of the survey will depend on the truthfulness of responses, therefore interviewer should not persuade the interviewee to answer the most desirable answers.
4. To answer each questions, please circle all relevant answers for each question, multiple answers are possible. If the respondent answers other than answer options, please circle the 'Other' option box and write in the 'please specify' textbox.
5. This questionnaire is a total of 11 pages. Please check before starting the interview that all pages are present.

1

A: Respondent Data

A.1 Name [ ]

A.2 Age [ ]

A.3 Gender 1 Male 2 Female

A.4 Education – Please circle the <u>highest</u> year of school completed:

1 School not attended of primary not completed
2 Primary school
3 Secondary school
4 High school
5 Bachelor degree
6 Undergraduate University degree
7 Postgraduate University degree

A.5 Agama 1 Islam 2 Catholic 3 Hindu 4 Buddhist 5 Christian

A.6 Occupation 1. Fishermen 2. Boat transporting passenger/goods 3. Work in groceries 4. Farmer 5. Other, please specify [ ]

A.7 Number of people living in household

Adult : [ ] persons Children: [ ] persons

B: Respondent Background

B.1 What animals do you keep on your property during last 12 months?

1 Dog
2 Cat
3 Goats
4 Poultry
5 Pigs
Cat 6 Buffalo
7 Monkey
8 Other, please specify [ ]

If the respondent do not have a dog, please go to part D questions

2

B.2 How many dogs do you have? For each dog, please record

No	1 Gender 1. Male 2. Female	2 Age (years)	3 Breed 1.Local 2.Non local/Pure	4 Where did you get your dog? Tick the selected option then ask further questions in the bracket where necessary: 1 Keep them since they were little	2 Gift (Where from and which year)	3 Purchase (Where from and which year)	4 Took it from the street (in Lombok or outside)	5 Dog came by itself	5 What is your reason to keep these dogs? 1.Guard dog 2.As pet 3.To consume/cultural tradition 4.For trade 5.Other,specify
1.									
2.									
3.									
4.									
5.									
6.									

B.3 Have you kept dogs for consumption/cultural tradition? 1. Yes 2. No

If yes, please specify your answer

Consumption

When you have a dog for consumption what do you generally do

1	2	3	4	5
Where did you get dogs for this use? 1.Took it from the street 2.Kept it since little 3.Buy it in Lombok 4.Buy it in another island	If the dog were bought from another island, which island? 1. Bali 2. Sumbawa 3. Flores 4. Jawa	If the dog were bought or you took the dog from the street, did you keep the dog for a while before slaughter it? 1. Yes 2. No	If yes, how many days did you keep the dog? ____ days	How you keep the dog: 1. Caged it 2. Chained it 3. Free to roam

Cultural tradition

When you have a dog for cultural tradition what do you generally do

1	2	3	4	5
Where did you get dogs for this use? 1.Took it from the street 2.Kept it since little 3.Buy it in Lombok 4.Buy it in another island	If the dog were bought from another island, which island? 1. Bali 2. Sumbawa 3. Flores 4. Jawa	If the dog were bought or you took the dog from the street, did you keep the dog for a while before slaughter it? 1. Yes 2. No	If yes, how many days did you keep the dog? ____ days	How you keep the dog: 1. Caged it 2. Chained it 3. Free to roam

B.4 House/property fence type

1 House fenced with gate
2 House fenced without gate
3 House without fence

C. Sailing Practices (part C is questions for boat activity owning dog household)

C.1 In average, how many times do you sail in a month?

1 Every day
2 Twice a week
3 Other, please specify
4 Once a week
5 More than twice a week

C.2 In a year, in what month you usually do not go sailing?

What is the reason? 1. Bad weather

2. Not many fish in the sea that can be catch

3. Other, specify

C.3 Have you ever take animal in your boat while sailing in the last 12 months?

1 Dog
4 Poultry
7 Other, please specify
2 Cat
5 Pigs
3 Goat
6 Cattle/Buffalo
8 Never take animals

If the answer is option 2, 3, 4, 5, 6, 7 & 8 please go to part E questions

C.4 How many times in a year do you sail with a dog? ______ times

C.5 What is the main purpose of having a dog with you while you are sailing?

1 Safety reason
3 As companion
4 Other, please specify
2 As a gift/to sell to other person on your destination

C.6 In the last 12 months, where did you sail to when you have a dog in your boat? (Multiple answers are possible)

1 Bali
2 Sumbawa
3 Flores
4 Sulawesi
5 Maluku Island
6 Other, please specify

C.7 In the last 12 months, how many trips did you make to the island/s you mentioned above?

1	2	3	4	5
Island	Number of trips in last 12 months	Average number of days spent at the island on each trip in last 12 months	What did you do with your dog while you were at the island? 1. No dog 2. Left it in the boat 3. Caged it 4. Free to roam 5. Other,please specify	Did your dog return home to Lombok with you? 1. Yes 2. No
1. Bali				
2. Sulawesi				
3. Flores				
4. Maluku				
5. Other, please specify				

C.8 To your knowledge, during the time when staying at these other islands, did your dog have contact with other/local dog?

1 Yes
2 No
3 Not sure

C.9 Has your dog even been bitten by another dog when visiting another island?

1 Yes — If yes – List name of island/s
2 No
3 Not sure

C.10 Have you brought a new dog back to Lombok from any place that you visit?

1 Yes
2 No

C.11 If yes, please provide information on each dog you brought back to Lombok (then please go to questions part E)

No.	Where from (Island) 1. Bali 2. Flores 3. Sumbawa 4. Jawa 5. Other,specify	Year when you brought the dog or the age of the dog at that time	Have it vaccinated at that time? 1. Yes, what kind of vaccination? 2. No 3. Don't know
1.			

2.			
3.			
4.			
5.			
6.			

D : Sailing Practices (D is questions for boat activity household, not having dog/s but sailed to rabies infected island/s)

D.1 Which of the following islands have you visit during your boat trips?

1 Java
2 Bali
3 Flores
4 Sulawesi
5 Maluku Island

D.2 How many times in a year did you sailed to that island/s?

No.	Island	Number of visits to each island/year
1.	Java	
2.	Bali	
3.	Flores	
4.	Sulawesi	
5.	Maluku Island	

D.4 In the last 5 years, have you ever transport dogs to Lombok from any place that you visit?

1 Yes
2 No, please go to question E.9

D.5 If yes, how many times in a year did you brought dogs back to Lombok? ____ times

D.6 Please provide information on each dog you brought back to Lombok

No.	Where from (island) 1. Bali 2. Flores 3. Sumbawa 4. Java 5. Other, specify	Year when you brought the dog or the age of the dog at that time	Have it vaccinated at that time? 1. Yes, what kind of vaccination? 2. No 3. Don't know	What is the purpose of bringing these dogs? 1. To sell 2. To keep 3. To give to other people 4. Other,specify	How many dogs in average that you brought?
1.					
2.					
3.					

4.					
5.					
6.					

D.7 Is there any letters (e.g health certification letter) for the dogs that you brought back?

[1] Yes [2] No

D.8 If yes, what kind of letter?

[1] Health Certificate [2] Dog ownership

[3] Other, please specify [ ]

E. Dog Management

E.1 How do you keep your dogs (or dogs that you transport) when you are at home in Lombok? Please circle the answer then give list for each dog the respondent have

Dog number	How do you keep your dogs (or dogs that you transport)?	How many hours/day you let your dog roam outside your property?
	1	2
1.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam 5. The dog taken by other people directly when arrive	
2.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam 5. The dog taken by other people directly when arrive	
3.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam 5. The dog taken by other people directly when arrive	
4.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam 5. The dog taken by other people directly when arrive	
5.	1. Caged 2. Tethered next to your house 3. Roam inside your property 4. Free to roam 5. The dog taken by other people directly when arrive	

E.2 What is the main purpose of your dogs (or dogs that you transport) going outside your property?

[1] Looking for food [2] Play with other dog [5] To guard crops in the field

[3] Mating [4] To guard house/property [6] Other, specify [ ]

E.3 To your knowledge, when your dogs (or dogs that you transport) are outside your property, does it have contact with other dogs?

[1] Yes [2] No [3] Not sure

E.4 What do you feed your dogs (or dogs that you transport)?

[1] Commercial dog food [2] Table scraps from home

[3] Other, please specify [ ]

E.5 Do you provide water for your dogs (or dogs that you transport)?

[1] Yes [2] No. If not, where do your dogs get access to water?

[1] The dog get water from outside the property

[2] The dog get water somewhere inside the property

[3] The dog get water inside and outside the property

E.6 Do you or members of your family often interact with your dog/s (or dogs that you transport)? E.g. play with the dog?

[1] Yes [2] No [3] Not sure

E.7 Have you or members of household been bitten by one of your dog (or dogs that you transport) in last 5 years?

[1] Yes [2] No

E.8 Have you or members of household been bitten by one of your dog (or dogs that you transport) in last 12 months?

[1] Yes [2] No

E.9 Have you or members of household bitten by other dog in last 5 years?

[1] Yes [2] No

E.10 Have you or members of household bitten by other dog in last 12 months?

[1] Yes [2] No, please go to question E.13

E.11 If yes, what is the age and gender of the person bitten? Please list for each of the dog bites reported by the respondent

No.	Age of the person bitten	Gender of the person bitten 1. Male 2. Female	Bitten by 1.Own dog 2.Other people's dog 3. Unowned dog 4. Dog that you transport for other people	Part of the body bitten 1. Leg part 2. Hand 3. Stomach 4. Hip 5. Shoulder/neck
	1	2	3	4
1.				
2.				
3.				

4.				
5.				
	Please also write if the respondent reported other people in the same village who are bitten by dog			
6.				
7.				
8.				

E.12 What did you or members of family do to the wound?

1 Clean it
4 Clean it and give simple medication (e.g. Iodine)
2 Go to seek medication to the hospital
5 Do Nothing
3 Give the wound traditional medication, such as oil

E.13 Has one of your dogs (or dogs that you transport) ever bitten a person outside your household?

1 Yes
2 No, please go to question E.16

E.14 What did you do to your dog (or dogs that you transport) that bit you or other people?

1 Do Nothing. Why?
2 Repel the dog
3 Kill the dog

E.15 What do you to other people who bitten by your dog (or dogs that you transport)?

1 Clean that person's wound and then give simple medication (e.g. iodine)
2 Go to seek medication to the hospital
3 Give the wound traditional medication
4 Do nothing. Why?

E.16 What will you do if there is a person bitten by unowned dog?

1 Clean that person's wound and then give simple medication (e.g. iodine)
2 Go to seek medication to the hospital
3 Give the wound traditional medication
4 Do nothing. Why?

E.17 Do you use identification with any of your dogs?

1 Yes. If yes,please specify type of identification 1 Collar 2 Tatto 3 Other,specify
2 No

For respondent that have female dogs

E.18 Please fill in the questions

1	2	3	4
In average, how many puppies do the female dog usually delivered?	In average, how many times /year the female dog delivering puppies?	In what month do puppies born the most?	What do you usually do with the puppies? 1.Keep the puppies 2.Throw it away, where? 3.Give it to other people

F. Dog Health

F.1 What signs indicate to you that a dog is sick?

1 Loss of appetite
4 Diarrhea
2 Depression
5 Itch
3 Vomit
6 Don't know

F.2 What do you usually do when you realise your dog is sick?

1 Take the dog to the veterinarian
4 Do Nothing
2 Call the veterinarian/paramedics at the animal care centre?
3 Give the dog medication yourself, specify
5 Other,please specify

Ex. Diarrhea gives guava leaf

G. Knowledge of Rabies

G.1 Have you heard about rabies?

1 Yes
2 No, please go to question G.3

G.2 If yes, where have you heard about rabies from? (Multiple answers are possible)

1 Leaflet/Brochure
4 Relatives
2 Newspaper
5 Government staff
3 Television/Radio
6 School

G.3 Do you think that rabies is a dangerous disease (fatal disease)?

1 Yes
2 No
3 Not sure/don't know

G.4 How do people get rabies?

1 Bitten by dog
2 Play with dog
3 Keep a dog
4 From dirty environment
5 Don't know

G.5 Do you think rabies can be transmitted to humans through dog bite? (Ask this question, if the respondent did not mention dog bites on question G.4)

1 Yes
2 No
3 Not sure

G.6 Do you think that dogs can transmit disease to humans, other than rabies?

- 1 Yes, what disease? — 1 Itch — 2 Asthma — 3 Parasites, such as worm
- 2 No

G.7 Based on your understanding, please explain what is Rabies

- 1 Dangerous disease
- 2 Mad dog disease
- 3 Disease transferred from dogs
- 4 Disease caused by dog bites
- 5 Don't know
- 6 Other, please specify ______

Completion of questionnaire: Thank you very much for your participation.

Would you willing to provide additional information if we need to contact you for further inquiries?

1 Yes 2 No

11

Appendix 4 Questionnaire used to interview the 158 people in vehicle at Padang Bai ferry harbour Bali

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA — **Questionnaire for people in vehicle at ferry harbour**

Introduction to project: The aim of this questionnaire is to obtain data on people's practice on transporting dogs to Lombok, management of the transported dog, time of the year dog mostly transported and origin, type and composition of the transported dogs.
All information obtained from this interview will only be used for this research purpose.

Code Identification No : [ ] Example of Code Identification No : PB1001 (Padang Bai; Ethnic ; Respondent Code)

Ferry harbor name : Padang Bai of Bali Island (PB)

Ethnic : 1. Balinese 2. Sasakese 3. Chinese 4. Java 5. Other [ ]

Respondent Code : three digits (00_)

Name of interviewer [ ]

Date of interview : [ ] (dd/mm/yy)

Time of interview : [ ]

Instructions for interviewing

1. Interviewer will interview the person in the vehicle at ferry harbor whom responsible for the transported dog or who have previous experience of bringing dog.
2. Interviewer should read clearly the aim of the interview as written above, before starting the interview.
3. Questions and answer options should be read clearly to the respondent to ensure consistency. The validity of the survey will depend on the truthfulness of responses, therefore interviewer should not persuade the interviewee to answer the most desirable answers.
4. To answer each questions, please circle all relevant answers for each question, multiple answers are possible. If the respondent answers other than answer options, please circle the 'Other' option box and write in the 'please specify' textbox.
5. This questionnaire is a total of 5 pages. Please check before starting the interview that all pages are present.

1

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA — **Questionnaire for people in vehicle at ferry harbour**

A. Respondent Data

A.1 Age : [ ]

A.2 Gender : [1] Male [2] Female

A.3 Religion : [1] Islam [2] Hindu [3] Kristen [4] Katolik [5] Buddhist

A.4 Island you depart from (and the part of the island, for example Java; East Java): [1] Java [ ] [2] Bali [ ] [3] Sumatera [ ] [4] Other, please specify [ ]

A.5 Are you a Lombok resident or has stay in Lombok for the last 2 years? : [1] Yes, district and sub district name [ ]
[2] No, please specify Island of resident [ ]
province of resident [ ]
District and subdistrict name [ ]

A.6 Type of vehicle : [1] Car [2] Truck

B. Respondent Background

B.1 Have you ever bring dog in the last 5 years? [1] Yes [2] No (completion of questionnaire)

B.2 Have you ever bring dog in the last 12 months? [1] Yes [2] No

B.3 How many times in the last 12 months you brought dog to Lombok? [ ]

B.4 In what month you brought dog to Lombok? (Answer could be more than one) [ ]

2

B.5 What is the reason of taking dog from outside Lombok to Lombok instead of keeping dog that available in Lombok?

B.6 Please record for each dog you brought to Lombok in the last 5 years

No.	1	2	3	4					5	6
				Where did you get your dog? Tick the selected option then asked questions in the bracket					Vaccination status	
				1	2	3	4	5		
	Gender 1. M 2. F	Age (years)	Breed 1. Local 2. Pedigree What breed? Such as Kintamani (the Bali dog) or other	Keep them since they were little	Gift (Where from – name of city and which year)	Purchase (a. Pet shop / Non pet shop (b. Where from-name of city) (c. which year)	Took it from the streets (Where from-name of city)	Dog come by itself (in region where you depart or where)	Has the dog vaccinated? 1. Yes. If yes, who vaccinate it? What kind of vaccination 2.No	What is the dog/s function ? 1.Guard dog 2.As pet 3.Toconsume/cultural tradition 4.To breed 5.To trade 6.As gift 7.Order from someone in Lombok 8.Other, please specify
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

B.7 Do you bring dog in this trip? [1] Yes [2] No

3

B.7 How many dogs do you take in this trip? For each dog, please record

No.	1	2	3	4					5	6
				Where did you get your dog? Tick the selected option then asked questions in the bracket					Vaccination status	
				1	2	3	4	5		
	Gender 1. M 2. F	Age (years)	Breed 1. Local 2. Pedigree What breed? Such as Kintamani (the Bali dog) or other	Keep them since they were little	Gift (Where from – name of city and which year)	Purchase (a. Pet shop / Non pet shop b. Where from-name of city) c. which year)	Took it from the streets (Where from-name of city)	Dog come by itself (in region where you depart or where)	Has the dog vaccinated? 1. Yes. If yes, who vaccinate it? What kind of vaccination 2.No	What is the dog/s function ? 1.Guard dog 2.As pet 3.Toconsume/cultural tradition 4.To breed 5.To trade 6. As gift 7. Order from someone in Lombok 8. Other, please specify
1										
2										
3										
4										
5										

C. Dog Management

C.1 How do you keep the dog/s before you brought it to Lombok? Please circle the answer then give list for the each dog

Dog no	How do you keep your dog?					How many hours/day do you let your dog free to roam outside?
1	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	
2	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	
3	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	
4	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	
5	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	
6	1. Caged	2. Tethered next to your house	3. Roam inside your property	4. Free to roam	5. Took the dog from previous owner then directly brought it to Lombok	

4

C.2 What kind of transportation you mainly used when you brought the dog/s to Lombok?

1 Car, by ferry 2 Truck by ferry 3 Bus by ferry 4 Put the dog in boat (fishermen/cargo/passenger boat) 5 By plane 6 Other, please specify

C.3 Do you need to sedate the dog/s that you brought to Lombok during transportation?

1 Yes. Do you sedate the dog/s by yourself or other person did it for you? Please describe

2 No

C.4 Did you provide letter of health certification or such for the dog/s that you brought to Lombok?

1 Yes. If yes, what kind of letter, who issued and how you obtain it?

2 No. Have you ever experience quarantine inspection to your dog? 1 Yes, please describe (For ex: the dog taken away by quarantine)

2 No

Completion of questionnaire: Thank you very much for your participation.

Would you willing to provide additional information if we need to contact you for further inquiries?

1 Yes 2 No

Appendix 5 Dog counting form used during capture-recapture activity at the urban and rural site

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

Introduction to project: The aim of this observation is to gather information and understanding of the relationship between dog and human at ports/harbours and observe behaviour of people towards dogs. These observations will be recorded on an observation record form and digital photos of dogs taken if appropriate.

Observation record form

District Name: ____________

Sub district Name: ____________

Village Name: ____________

Observer: ____________

Date of observation: ____________ (dd/mm/yy)

Table 1 Dogs on and around the boats and interaction between dogs and people with boat activity

No.	Activity			Additional information
	Dogs on and around the boats			
1.	Number of boats bringing dogs (BASED ON NUMBER OF BOATS OBSERVED)			
2.	Number of dogs seen on the boats			
3.	Number of boats with caged dogs			
4.	Number of boats with non caged dogs			
3.	Number of dogs seen close to boats			
4.	Origin of boats with dogs	Island	Number of boats	
	Interaction between dogs and people with boat activity	Yes	No	Additional information
5.	Food provided for the dogs (dogs on the boats)			
6.	People in the boat pet/play with the dog in the boat			

1

Table 2 The presence of dogs around port area and interaction between these dogs and people in the port

No.	Activity			Additional information
1.	Number of local dogs seen in the port (not close to boats) a. Number of adult dogs b. Number of puppies			
2.	Category of dogs seen in the port (not close to boats)	Number of dogs		
	a. Dogs with owner (dogs leashed) b. Dogs with owner (not leashed) c. Dogs without owner but have collar d. Dogs without collar			
	Interaction between dogs and people in the port and interaction between local dogs and dogs in the boat			
		Yes	No	Additional information
3.	People give food to dogs in the port			
4.	Local dogs move easily around people in the port			
5.	People in the port do not feel disturbed with the dogs presence			
6.	Dogs get food from waste, such as remaining of fish, garbage in the port			
7.	Local dogs get contact with dog from the boats			

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Appendix 6 Dog observation form used at the informal ports

ASSESSMENT OF THE RISK OF RABIES INTRODUCTION AND ESTABLISHMENT IN LOMBOK, INDONESIA

Introduction to project: The aim of this observation is to estimate the numbers of unowned dogs at urban and rural sites on Lombok Island. These observations will be recorded on an observation record form and digital photos of dogs will be taken..

Observation record form

Name of surveyor :
Date of counting : (dd/mm/yy)
Time of counting start :
Time of counting end :
Weather : Cold/Windy/Raining/Warm
Traffic condition : Light/Medium/Heavy
Visibility : Clear/Fair/Poor
Amount of garbage : 1 2 3 4 5

Dog counting form

Site/Location name	Description of the dogs						Sighting status			
	Dog number	Sex	Age	Body size	Fur colour	Tail	Seen in day 1	Re-seen status	'New dog' seen in day 2	Description of place the dog sighted

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