Livestock disease surveillance and biosecurity priorities in the Pacific Island countries and territories

Thesis submitted by

Aurélie Brioudes

DVM, MSc

In May 2016

for the degree of Doctor of Philosophy

in the Discipline of Veterinary Sciences,

College of Public Health, Medical and Veterinary Sciences,

James Cook University

ACKNOWLEDGEMENTS

I would like to sincerely thank my principle supervisor Professor Bruce Gummow for his continuous and efficient guidance throughout my research work for the completion of this PhD degree. I would also like to extend my thanks to my co-supervisors Associate Professors Jeffrey Warner and Robert Hedlefs for their advice and assistance in completing the different stages of this long PhD process.

I would also like to sincerely thank the Animal Health and Production Team of the Secretariat for the Pacific Community for welcoming me among the team during the implementation phase of this study. I am particularly grateful to Andrew Tukana for his assistance in the preparation and the conduct of field missions in the selected Pacific Islands countries.

This research work was conducted in partnership between the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC) and the College of Public Health, Medical and Veterinary Sciences, James Cook University (JCU), Townsville, Queensland, Australia as part of the Food Animal Biosecurity Network (FABN). This study was developed and implemented thanks to the collaboration of the following institutions: the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC), the Department of Animal Health and Production of Fiji's Ministry of Primary Industries; the National Agriculture Quarantine and Inspection Authority (NAQIA) and the National Agricultural Research Institute (NARI) of PNG and the Departments of Livestock and Quarantine of Solomon Islands and of Vanuatu. This study wouldn't have been possible without the crucial contribution of the operatives from these institutions. I am most grateful to the regional and national animal health and livestock experts, the local animal health and production workers and to the farmers who agreed to participate in this study.

This study was possible due to financial support from the Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government (AUSAID agreement 54828/16).

My appreciation is also extended to my family and friends for their unconditional support while I was completing this thesis.

STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Aurélie Brioudes
20 May 2016

STATEMENT OF ACCESS

I, the undersigned, author of this work, understand that James Cook University will make this thesis available for use within the University Library and, via the Australian Digital Theses network, for use elsewhere. I understand that, as an unpublished work, a thesis has significant protection under the Copyright Act and I do not wish to place any further restriction on access to this work.

Aurélie Brioudes
20 May 2016

STATEMENT ON THE CONTRIBUTION OF OTHERS TO THE PhD STUDY

Title of thesis: Livestock disease surveillance and biosecurity priorities in the Pacific Island countries and territories

Name of candidate: Aurélie BRIOUDES

Nature of assistance	Contribution	Names, Titles (if relevant) and Affiliations of Co-Contributors
Intellectual support	Study design	Prof. Bruce Gummow (Principle Supervisor, JCU) A. Prof. Jeffrey Warner (Co-supervisor, JCU) Ad. Prof. Robert Hedlefs (Associate Supervisor, JCU)
Financial support	Field research Stipend IT equipment (laptop and SNA software)	Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government.
Material support	Facilities (office space) Access to SPC databases	Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC).
Field support	Workshop participation for the prioritization of animal diseases	- Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community; - Department of Animal Health and Production of Fiji's Ministry of Primary Industries; - National Agriculture Quarantine and Inspection Authority and National Agricultural Research Institute of PNG; - Departments of Livestock and Quarantine of Solomon Islands;

		- Departments of Livestock and Quarantine of Vanuatu.
	Workshop participation for the combined market chain analysis and disease risk assessment	- Department of Animal Health and Production of Fiji's Ministry of Primary Industries; - National Agriculture Quarantine and Inspection Authority, National Agricultural Research Institute, Livestock Development Corporation; Department of Agriculture and Livestock and Rhado Piggery Limited Company in PNG; - Department of Livestock of Solomon Islands; - Departments of Livestock and Biosecurity of Vanuatu.
	Survey questionnaire piloting	- Year 2 students undertaking - Animal Health Program at the College of Agriculture Forestry and Fishery (CAFF) department of the Fiji National University.
	Field interviews for the farmer survey	- Department of Animal Health and Production of Fiji's Ministry of Primary Industries; - National Agriculture Quarantine and Inspection Authority of PNG; - Departments of Livestock and Quarantine of Solomon Islands; - Departments of Livestock and Biosecurity of Vanuatu.

STATEMENT ON THE CONTRIBUTION OF OTHERS TO THE PUBLICATIONS

Title of thesis: Livestock disease surveillance and biosecurity priorities in the Pacific Island countries and territories

Name of candidate: Aurélie BRIOUDES

Chapter #	Details of publication(s) on which chapter is based	Nature and extent of the intellectual input of each author[1]	I confirm the candidate's contribution to this paper and consent to the inclusion of the paper in this thesis
Chapter 2	**Publication reference:** "A review of domestic animal diseases within the Pacific Islands region". Acta Trop 132C, 23-38 (2014)	Aurélie Brioudes: Project design, Conduct of the literature search and analysis, write up of the paper. Bruce Gummow: Project design, Supervision and guidance for the conduct of the activity and detailed editing and review of the paper, including methodology, results and discussion. R. Hedlefs: Final review of the paper. J. Warner: Final review of the paper.	Name (please print): Aurélie Brioudes Signature Name (please print): Bruce Gummow Signature Name (please print): Robert Hedlefs Signature Name (please print): Jeffrey Warner Signature
Chapter 3	**Publication reference:** "Diseases of livestock in the Pacific Islands region: setting priorities for food animal biosecurity." Acta Tropica, 143, 66-76 (2015)	Brioudes: Project Design, Conduct of the activities, collection and analysis of data, write up of the paper. Gummow: Project Design, Supervision and guidance for the conduct of the activity and detailed editing and review of the	Name (please print): Aurélie Brioudes Signature Name (please print): Bruce Gummow Signature

		paper, including methodology, results and discussion. R. Hedlefs: Final review of the paper. J. Warner: Final review of the paper.	Name (please print): Robert Hedlefs Signature Name (please print): Jeffrey Warner Signature
Chapter 4	**Publication reference:** "Understanding pig and poultry trade networks and farming practices within the Pacific Islands as a basis for surveillance". Transboundary and Emerging Diseases, (2015).	Brioudes: Design of the survey protocol, design of the survey questionnaire, training of the survey interviewers, coordination of the survey implementation, analysis of data, write up of the paper. Gummow: Project Design. Supervision and guidance for the conduct of the activity, detailed editing and review of the paper, including methodology, results and discussion.	Name (please print): Aurélie Brioudes Signature Name (please print): Bruce Gummow Signature
Chapter 5	**Publication reference**: "Field application of a combined pig and poultry market chain and risk pathway analysis within the Pacific Islands as a tool for targeted disease surveillance and biosecurity" Submitted for publication to Preventive Veterinary Medicine journal in Nov 2015.	Brioudes: Project Design, Conduct of the activities, collection and analysis of data, write up of the paper. Gummow: Project Design, Supervision and guidance for the conduct of the activity, detailed re editing and review of the paper, including methodology, results and discussion.	Name (please print): Aurélie Brioudes Signature Name (please print): Bruce Gummow Signature

DECLARATION OF ETHICS

The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the *National Statement on Ethics Conduct in Research Involving Human* (1999), the *Joint NHMRC/AVCC Statement and Guidelines on Research and Practice* (1997), the *James Cook University Policy on Experimentation Ethics Standard Practices and Guidelines* (2001) and the *James Cook University Statement and Guidelines on Research Practice* (2001). The proposed research methodology received clearance from the James Cook University Experimentation Ethics Review (Approval number H4421).

Aurélie Brioudes
20 May 2016

ELECTRONIC COPY

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of the technology available.

Aurélie Brioudes
20 May 2016

ABSTRACT

Livestock play an important role in the social, cultural and economic environment of the Pacific Island countries and territories (PICTs). Currently, the development of the livestock sector in the Pacific region is constrained by a number of factors, including animal health status requirements. So far, the Pacific Islands region has a favourable animal health situation but it is a challenge to maintain a disease free environment in an area composed of 25,000 islands dispersed over 180 million square kilometres. While most of the PICTs face a critical shortage of veterinarians and have limited financial resources, this study aims to examine ways by which animal disease surveillance in the Pacific Islands region could be better targeted to enable more efficient use of scarce resources in the PICTs.

Within this context, a literature review was conducted to synthesize data across studies from peer-reviewed and grey literature on the animal diseases in the Pacific Islands region. Based on the outputs of the meta-analysis, a multi-criteria prioritization process was then developed to identify animal diseases perceived to be of importance by decision makers within selected PICTs, at the regional and national levels. Pig and poultry husbandry being of primary importance for the Pacific communities, farmer practices and the movements of pigs and poultry were then examined in four selected PICTs (Fiji, Papua New Guinea, Solomon Islands and Vanuatu), using questionnaire survey and social network analysis tools in view of better predicting how diseases could potentially spread in the region. Finally, a combined pig and poultry market chain and risk pathway analysis was conducted in these four PICTs to identify the highest risk areas (risk hotspots) and risky practices and behaviours (risk factors) of animal disease introduction and/or spread, using highly pathogenic avian influenza (HPAI) and foot-and-mouth disease (FMD) as model diseases because of their potential importance in the region.

From the 158 eligible references retrieved from the literature review, only 77 (48.7%) were published since 1992 and analysed in more details. A total of 101 diseases and pathogens were reported on for domestic animals in the Oceania

region and in 17 PICTs in particular. Retrieved literature on animal diseases in PICTs was scarce and no longer up to date. There is a need to improve the published knowledge on the current animal disease status in the region.

The list of the top-twenty ranked diseases for the Pacific Islands region resulting from the structured prioritization process shows a mix of endemic zoonotic diseases (such as leptospirosis ranked first; brucellosis third; tuberculosis sixth and endoparasites and ectoparasites respectively eleventh and thirteenth) with exotic diseases (such as highly pathogenic avian influenza (HPAI) ranked second, foot-and-mouth disease (FMD) fifth and rabies ninth). There were different disease ranking lists for each of the four targeted PICTs, confirming different strategies of disease prevention and control may be required for each country, rather than a regional approach. Interviewed animal health and production workers were unfamiliar with most of the prioritized diseases and a majority acknowledged that they would not be able to recognise clinical signs if outbreaks were to occur in their area.

Results from the survey and the social network analysis indicate that a large proportion of farmers (44.6 to 61.3%) do not implement any preventive or control measures, yet, the majority (80.6 to 88%) did not experience any animal diseases over the past twelve-months. Most farmers never ask for veterinary care, never engage in laboratory testing and do not report when their animals show clinical signs. Many pig farmers (31.8%) trade within their communities only and sell directly to consumers (24.5%) which reduces the risk of diseases spreading. Our results show an association between farmers that report having had disease on their farm in the past twelve-months and movements of animals on and off their farms. The capitals of the studied provinces in PNG, Vanuatu and Solomon Islands were identified as the most connected nodes of both pig and poultry trade while Fiji networks appeared much less connected. Farmer practices increased the risk of disease spread but this was currently limited by trading practices.

The conduct of the combined market chain analysis with risk pathways was a practical way of communicating risk to animal health officials and improving biosecurity. It provided a participatory approach that helps officials to better understand the trading regulations in place in their country and to better evaluate their role as part of the control system. Common risk patterns were found to play a role in all four PICTs. Legal trade pathways rely essentially on preventive measures put in place in the exporting countries while no or only limited control measures are undertaken by the importing countries. Legal importations of animals and animal products are done mainly by commercial farms which then supply local smallholders. Targeting surveillance on these potential hotspots would limit the risk of introduction and spread of animal diseases within the pig and poultry industry. Swill feeding is identified as a common practice in the region that represents a non-negligible risk factor for dissemination of pathogens to susceptible species. Illegal introduction of animals and animal products is suspected, but appears restricted to small holder farms in remote areas, limiting the risk of spread of transboundary animal diseases along the market chain. Introduction of undeclared goods hidden within a legal trade activity was identified as a major risk pathway. Activities such as awareness campaigns for pig and poultry farmers regarding disease reporting, biosecurity measures or danger of swill feeding and training of biosecurity officers in basic animal health and import-associated risks are recommended to prevent and limit the spread of pathogens within the PICTs.

We put forward the methodology used for this study as a novel approach for more rational and transparent allocations of resources for enhancing food security and for better targeted approach to animal disease prevention and control. The results of this study are expected to lead to a more rational use of skilled manpower and increase the sensitivity of disease identification within the PICTs.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

GENERAL INTRODUCTION AND LITERATURE REVIEW

BACKGROUND

Spanning a quarter of the globe, the Pacific Ocean region is composed of 25,000 islands with a total land area of 550,000 km^2 and is home to approximately 9 million people. The area encompasses nations that are commonly identified as the Pacific Island Countries and Territories (PICTs), which fall under the following classification (de Bettencourt & Imminga-Berends, 2015):

– Independent island countries: Federated States of Micronesia, Fiji, Kiribati, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu, Vanuatu.

– Non-sovereign territories:

- Linked to the United States of America: American Samoa, Guam, Howland Island, Jarvis Island, Kingman Reef, Marshall Island, Northern Mariana Island
- Linked to New Zealand: Niue, Tokelau and Cook Island
- Linked to France: French Polynesia, New Caledonia, Wallis and Futuna
- Linked to the United Kingdom: Pitcairn

The region also comprises two larger countries: Australia and New Zealand.

While PICTs share some characteristics such as their small sizes, limited resources, fragile ecosystems and remoteness, they are not homogeneous. The region has historically been divided into three main geo-cultural sub-regions, Melanesia, Polynesia and Micronesia, and are characterised by diverse geographic, sociologic and economic features (Figure.1-1 and Table 1-1) (Argounes, Mohamed-Gaillard, & Vacher, 2011; Kushnir, 2013).

As this study was implemented in partnership with the Secretariat of the Pacific Community (SPC), it focused on its 22 member countries and territories (American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna), and excluded its four founding countries (Australia, France, New Zealand and the United States of America) (Secretariat of the Pacific Community, 2012).

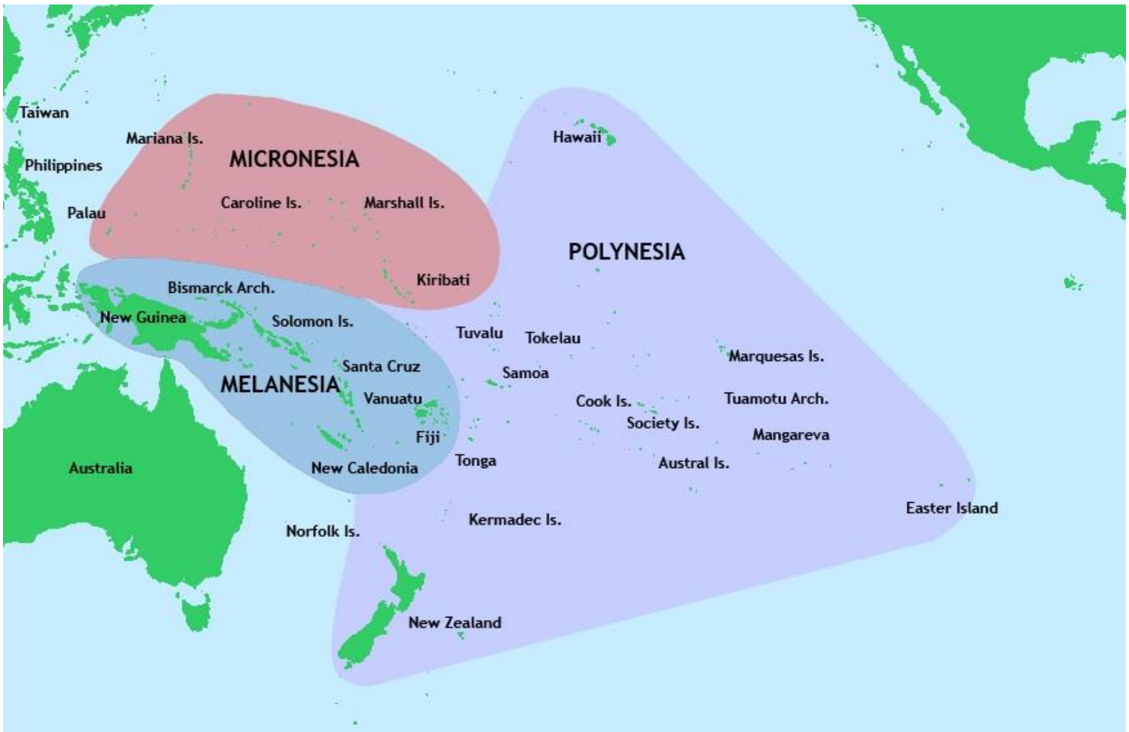


Figure 1-1: Main geo-cultural sub-regions of the Pacific Island countries and territories (Kahuroa, 2010).

Table 1-1: Pacific Island countries and territories key data (Argounes et al., 2011)

PICTs	Land area (Km^2)	Inhabitants (in 2008)	GDP (Thousand USD)	Exportation	Importation (Million USD)
Melanesia					
PNG	452,860	5,931,769	6,044,220	5,719	3,124
Solomon Islands	27,540	581,318	373,800	237	256
New-Caledonia	18,575	224,824	7,129,631	1,341	1,998
Fiji	18,270	931,741	2,695,666	1,202	3,120
Vanuatu	12,200	215,446	459,010	40	156
Total Melanesia	**529,445**	**7,885,098**	**16,702,327**	**8,539**	**8,654**
Micronesia					
Kiribati	811	110,356	61,433	17	62
Fed.St. of Micronesia	702	107,665	235,900	14	133
Guam	541	175,877	3,700,000	45	701
Palau	458	21,093	170,144	6	107
Northern Mariana Is.	477	86,616	946,659	98	214
Marshall Islands	181	63,174	149,219	19	79
Nauru	21	13,770	27,661	1	20
Total Micronesia	**3,191**	**578,551**	**5,291,016**	**200**	**1,316**
Polynesia					
French Polynesia	3,660	283,019	5,640,452	211	1,706
Samoa	2,934	217,083	532,000	131	324
Tonga	718	119,009	234,484	22	139
Wallis and Futuna	274	14,231	Not available	0	61
Niue	260	1,444	10,006	1	9
Cook Islands	238	12,271	182,175	5	81
American Samoa	199	64,827	437,900	446	309
Pitcairn	47	48	Not available	Not available	Not available
Tuvalu	26	12,117	17,514	1	13
Tokelau	10	1,433	Not available	0	1
Total Polynesia	**8,366**	**725,482**	**7,054,531**	**817**	**2,643**

Agriculture plays a central role in most PICT economies with, in some Pacific states, up to 30% of national GDP being attributed to this sector. The agricultural contribution to the local economy is results directly from the production of crops, but also includes livestock, predominantly poultry, small ruminants and pigs. In islands with larger land masses, cattle (both beef and dairy) also contributes to GDP.

The livestock sector plays a significant role in the Pacific economies, as it generates income, creates employment opportunities and provides export revenue for larger countries such as Papua New Guinea (PNG) (FAO, 1998; FAO Statistic Division, 2014; Secretariat of the Pacific Community, 2009b). It also contributes to the supply of protein for the local communities, although food security is an increasing challenge in the region. While traditional farming, fishing, hunting and gardening used to provide local communities with an adequate food supply, urbanisation and increased access to low quality and cheap imported food products have led to an overall negative impact on the Pacific Islanders health status (Synexe Consulting Limited, 2010). Various studies and initiatives across the region have highlighted the need for a greater degree of food security within the PICTs and for increased promotion of the production, consumption, and marketing of locally produced foods (Synexe Consulting Limited, 2010).

According to data from the trade statistics department of the Secretariat for the Pacific Community (SPC), the meat product imports for nine PICTs (Cook Islands, Fiji, Kiribati, New Caledonia, PNG, Samoa, Solomon Islands, Tonga and Vanuatu) in 2007 were almost 68 tonnes, worth $159 million USD. This figure confirms the strong demand for livestock products and the potential market for increased local production and exportation. Currently, this demand for livestock products is met from both local production and importation. The consumption of meat products over the last 30 years has been increasing steadily and this trend is expected to continue in the future. It represents a major opportunity for the development of the livestock sector in the Pacific (Secretariat of the Pacific Community, 2009b).

Livestock also plays a crucial role in Pacific traditions and cultures, with most of the important social and cultural events in island life involving the featuring of livestock (Guerrier, Foster, Metge, Chouvin, & Tui, 2013; Secretariat of the Pacific Community, 2009c, 2011; Yarrow, 2008). Pig and poultry production systems have a particular importance within the PICTs (Table 1-1), as beside their contribution to the local economy, they are part of the traditional way of life of the Pacific communities (Secretariat of the Pacific Community, 2009b). Based on the average distribution of livestock production between 1961 and 2011, according to Food and Agriculture Organisation of the United Nations (FAO) statistics, some PICTs have the largest pig and poultry densities in the world. Ten of the 22 PICTs are in the top-25 list of countries with the highest number of pigs per hectare of agricultural area, and 13 of the 22 PICTs are in the top half of the poultry density rankings (FAO Statistic Division, 2014).

While the livestock sector in the region is characterised by production systems ranging from village subsistence farms to large commercial units, it is predominantly smallholder-based with a high proportion of the population living in rural settings and raising livestock with little to no biosecurity. Improved biosecurity at the different steps of the livestock market chain, from production to consumption, is needed. In particular, health certification and food safety standards must be improved to prevent the introduction of animal pathogens and limit their potential impact on the livestock production in the region and on the Pacific Island population (FAO, 1998; Secretariat of the Pacific Community, 2009b; Yarrow, 2008).

In recent years, PICTs have faced difficulties in managing the regulatory processes associated with access to markets. While products used to be traded easily in the past, new stringent market access protocols make it more difficult to meet requirements for new export opportunities (Secretariat of the Pacific Community, 2011). In particular, due to the lack of national animal disease reporting systems, the European Union introduced in 2009 new trade restrictions on the export of marine ornamental aquatic species from the Pacific region which are worth approximately US$20 million annually. Moreover, the lack of a well-documented surveillance system prevents PICTs from meeting international requirements to demonstrate freedom from disease. As a consequence some PICTs, such as Fiji, are unable to develop a beef export market as there is no reliable data to prove the absence of ‘Mad cow’ disease in the country (Secretariat of the Pacific Community, 2009a, 2010).

The World Organisation for Animal Health (OIE) is recognised as the reference organisation for improving animal health worldwide, in particular through the promotion of global transparent disease reporting (http://www.oie.int/about-us/our-missions/). However, of the 22 PICTs, only Fiji islands, Vanuatu, Papua New Guinea, New Caledonia and the Federate State of Micronesia are OIE members (Secretariat of the Pacific Community, 2009a, 2010).

The tropical environment of the PICTs, combined with a close human, wild animal and domestic animal interface and the inter-island movement of people between PICTs creates a situation that is conducive to the emergence of diseases (Gummow, 2010; Jones et al., 2008). Currently, the Pacific Islands region is said to have a favourable animal health status, with almost no major problems with serious livestock diseases. Nevertheless, these statements have to be viewed with caution because many PICTs do not have adequate animal disease surveillance systems to confirm this status (Secretariat of the Pacific Community, 2009a, 2009c).

In addition to giving the PICTs the opportunity to access international markets, establishing and maintaining a national animal disease surveillance and information management system would create in-country benefits by enabling early detection of disease outbreaks and reducing the impact of endemic diseases (Secretariat of the Pacific Community, 2009a).

PURPOSE OF THE RESEARCH

Within this context, this study aimed to examine ways by which animal disease surveillance in the Pacific Islands region could be better targeted to enable more efficient use of scarce resources in the PICTs.

The study had three specific objectives:

1. Produce an enhanced understanding of the current disease status in the Pacific Islands region;
2. Ascertain which of the diseases were of greatest importance within the Pacific Islands region;
3. Describe how these diseases could spread through livestock movements and identify the key trade hubs where diseases may be disseminated within the PICTs.

To achieve this, we first conducted a literature review to gain a better understanding of the current disease status in the Pacific Islands region (Chapter 2).

Then, based on the outputs of the literature review, a multi-criteria prioritization process was developed to identify the animal diseases of greatest importance within the Pacific Islands region, at both the regional and national levels (Chapter 3).

Next, with pig and poultry husbandry being of primary importance for the Pacific communities, farmer practices and the movements of pigs and poultry were examined in four selected PICTs (Fiji, Papua New Guinea, Solomon Islands and Vanuatu) using a questionnaire survey and social network analysis tools to describe how these diseases could spread and to identify the key trade hubs where diseases may be disseminated within the PICTs (Chapter 4).

Finally, a combined pig and poultry market chain and risk pathway analysis was used as a tool for identifying the highest risk areas (risk hotspots) and the practices and behaviors of market chain stakeholders (risk factors) in regards to animal disease introduction and/or spread in the hopes of enabling a more targeted use of scarce manpower and intervention strategies at specific high risk segments of the market chain (Chapter 5).

A diagrammatic representation of the research process is presented in Figure 1-2.

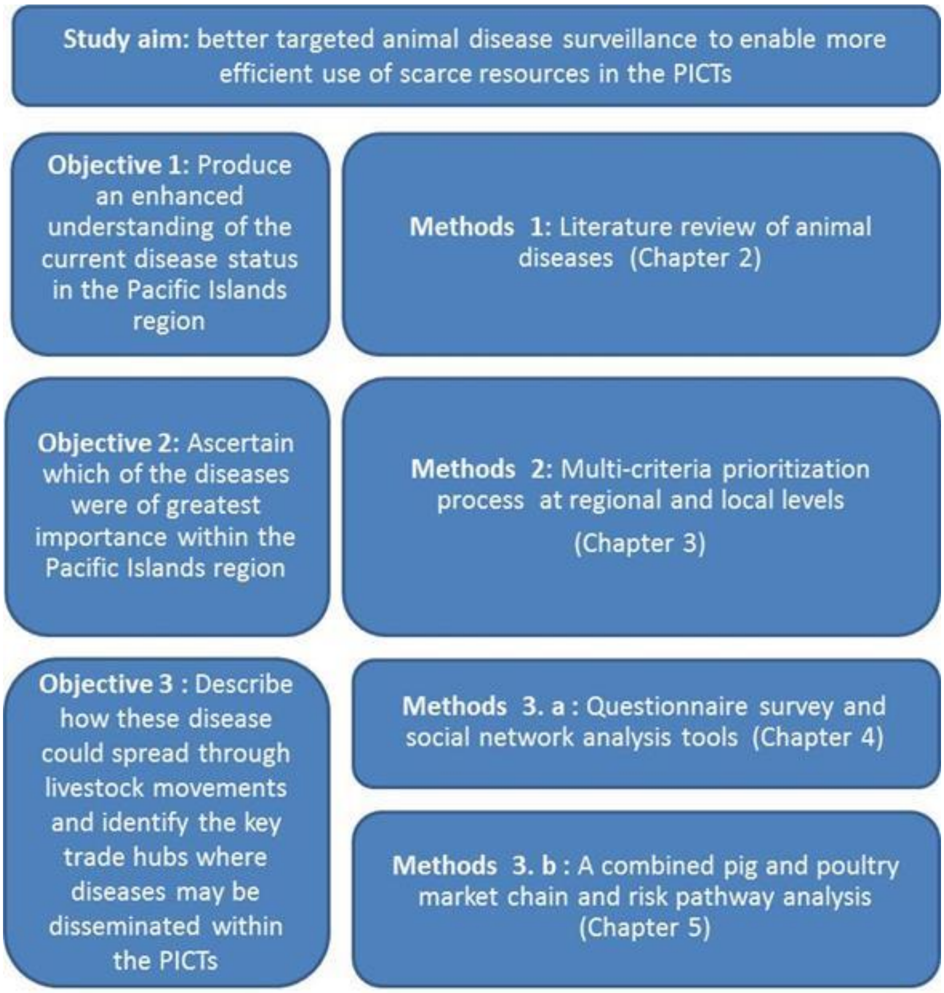


Figure 1-2: Diagrammatic representation of the research process.

LITERATURE REVIEW

Disease risk analysis for animals and animal products

In a globalised world, the risk of transboundary disease spread through the trade of animal and animal products is ever-present, and the entire world is potentially threatened when a single country is not in a position to properly prevent and control animal diseases (Angot, 2009). The introduction and spread of infectious diseases within a country could have severe consequences on the livestock production sector and may heavily impact the national economy and the international trade. There is a potential for social disruption and human infection if the disease has zoonotic potential. It is therefore acknowledged that it is more cost-effective to prevent a disease rather than having to control it once it is already established in a country. Therefore, countries are encouraged to invest in veterinary surveillance systems to prevent and/or control animal diseases early (Forman et al., 2012). However, human and financial resources are usually limited so countries have to rationalise their resource allocation. Countries are now encouraged to identify their priorities for surveillance on a risk-based approach.

According to the OIE, disease risk is the combination of two components: the likelihood of occurrence of an undesired event, and its impact on animal or human health, the environment and the economy (Murray et al., 2004). Consequently, risk analysis is the process defined by the identification and assessment of a risk with the objective of determining up to a certain level of confidence the probability of occurrence of a hazard, and its potential negative effects (Woolhouse et al., 2011).

OIE defined a framework for the Import Risk Analysis of Animals and Animal Products (Murray et al., 2004), as shown below in Figure 1-1, to estimate the likelihood of introduction of a particular pathogen in a country. The first step in risk assessment was previously called “release” assessment and is now referred to as “entry” assessment (OIE, 2010).

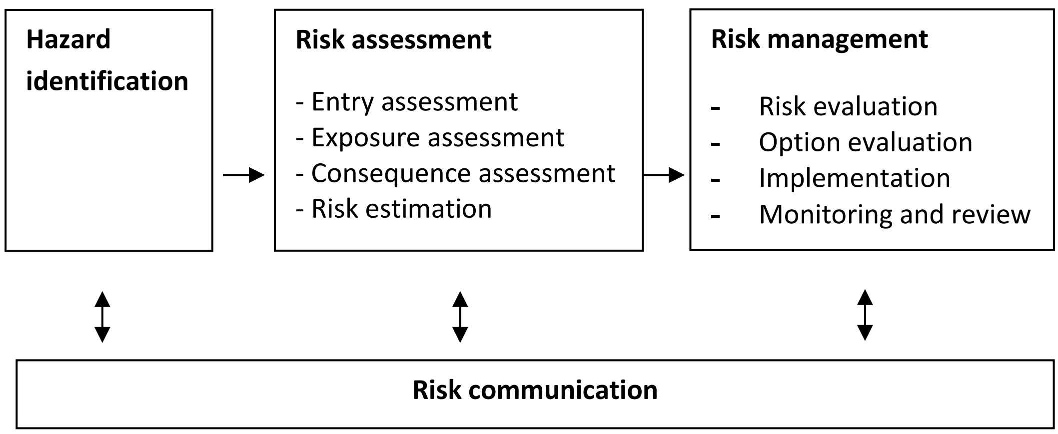


Figure 1-3: Structure of the OIE risk analysis process (Murray et al., 2004)

Prioritization of diseases

In a context of limited available resources, as in underdeveloped countries, there is now a general agreement on the need for cost-effective measures for the prevention and control of infectious diseases (Cardoen et al., 2009; Krause, 2008; Phylum, 2009; Woolhouse et al., 2011), but it is difficult to compare the importance of different diseases and decide which ones need to be addressed first. The decision-making process for identifying which disease to target as a priority is complex since it involves the assessment of not only technical information but also some value judgements (Kurowicka, Bucura, Cooke, & Havelaar, 2010). The process of prioritization, defined as the listing of diseases into a hierarchy considering their respective ranking, is thus a tool to assist decision-makers in selecting diseases that are worth being addressed by public policies with the perspective of using the result of this prioritization to determine which prevention and control measures to implement first (Phylum, 2009).

A review of the literature provides many examples of prioritization exercises, with some being applied to the animal health sector (Cardoen et al., 2009; Heffernan, 2009; McKenzie, Simpson, & Langstaff, 2007; Phylum, 2009). In most cases, data is obtained from an expert judgment process (Garabed, Perez, Johnson, & Thurmond, 2009) ideally involving multi-disciplinary teams, and conducted through face-to-face interviews or self-administered questionnaires (Fish et al., 2011; Humblet et al., 2012).

Three different methodologies are described in the literature (IFAH-Europe, 2009):

1. The qualitative approach in which experts are required to find an agreement by consensus, using criteria ranked on the basis of qualitative labels (e.g. low, medium and high). This method is quite simple and rapid but very subjective and lacking in transparency.
2. The semi-quantitative approach in which the criteria are divided into different classes and are scored on arbitrary scales (e.g. 0,1 … 5), with the overall score resulting from the aggregation of each criteria score. This approach provides acceptable transparency and repeatability. But

the linear relations between criteria do not reflect reality and may still bias the final result.

3. The quantitative approach using natural values for the scoring of the criteria leading then to an objective and transparent ranking of diseases but requiring a minimum amount of data.

In addition to the scoring of the criteria for each disease, weights can be attributed to the criteria to take into account the relative importance of each criterion. Additionally, the self-weighting assessment confidence factor gives the opportunity to participants to weight their confidence in their answers (according to their knowledge or their experience with the disease). This factor is of interest for semi-quantitative and quantitative approaches to lessen potential bias from experts' inputs. The overall value used for the ranking of diseases results from the aggregation of the scores with the weights of each criterion per disease (Krause, 2008; Kurowicka et al., 2010).

Most prioritization exercises for livestock diseases have been conducted at the institutional level (Doherty, 2000; Fish et al., 2011; Gibson, 2011; Krause, 2008). The few which attempted to prioritise diseases at the farmer level suffered limited data inputs along with practitioner and community-level bias (Heffernan, 2009; Kapiriri & Norheim, 2002; Uzochukwu, Onwujekwe, Nwobi, Ndu, & Onoka, 2007).

Prioritization processes applied to the animal health sector generally focuses on specific disease categories such as zoonoses (Ng & Sargeant, 2012a, 2012b, 2013; Rist, Arriola, & Rubin, 2014; Valenciano, 2001), foodborne zoonoses (Cardoen et al., 2009; Fosse, Seegers, & Magras, 2008) or wildlife pathogens (McKenzie et al., 2007). With the view of developing a non-specific disease ranking, Heffernan (2009) argues that all livestock species do not have the same economic value and thus the same disease would not induce an equal economic impact on various species. Therefore, he suggests beginning the prioritization by determining the importance of a particular species to household poverty and then only assesses the impact of particular diseases on species-derived income.

Nevertheless, it is recognised that the prioritization process is only useful in the context in which it is applied. More recent works have tried to improve the transparency and repeatability of the process (Krause & Working Group on Prioritisation at the Robert Koch, 2008; Kurowicka et al., 2010) as qualitative risk rating systems in particular are often proven to be unreliable (Cox, Babayev, & Huber, 2005). The most frequent reasons for failure in the prioritization process are reported to be a lack of data, the difficulty to define measurable criteria, the mixture in the nature of the criteria used and the difficulty in agreeing on a weighting scheme. Another observation is that experts are more and more specialized and thus it becomes difficult to have a deep knowledge in and experience with a wide range of diseases (Krause, 2008). Moreover, the experts' lack of knowledge or experience about the judgment process itself (e.g. rating, scoring, weighting or ranking) may also have an impact on the quality of their inputs (Van der Fels-Klerx, Goossens, Saatkamp, & Horst, 2002).

In the Pacific Islands region, the scientific literature gives only one reference to a semi-quantitative prioritization process conducted by the public health sector of the Federated States of Micronesia for a revised selection of diseases to include in the National Notifiable Diseases List (Pavlin, Kool, Samo, & Gerstel, 2010). Based on participants' feedback, the exercise was perceived as strongly academic, without practical application and with no added benefit in using a disease-criterion matrix in addition to the expert consensus discussion. Additionally, results were qualitatively similar with and without weighting of the criteria. One explanation presented for these anomalies is the use of linear scoring (limited in that case to 12) when in fact some criteria should have been considered of much higher importance than others. Authors also highlighted the absolute necessity of a reality check with the process to rectify any erratic outcomes.

Regarding the animal health sector in the Pacific Islands region, the review of grey literature from SPC shows some initial steps being taken towards the prioritization of livestock diseases. In 1974, a report by the South Pacific Commission on animal quarantine in the South Pacific area emphasised the need for homogenous quarantine regulations in the region relating to the internal disease status in the country, and to the presence of infectious diseases in neighbouring and trading countries (Osborne, 1974). At that time, the need for animal disease control was classified into three groups:

1. The most urgent need identified was for uniform inter-PICTs action to reduce the risk of introduction of foot and mouth disease, rinderpest, bluetongue, contagious bovine pleuropneumonia, classical swine fever, African swine fever, swine vesicular disease, newcastle disease and rabies.
2. Tuberculosis, brucellosis, leptospirosis and trichinosis were considered as “domestic” diseases influencing international trade and thus requiring local control but not directly threatening neighbouring countries.
3. “Domestic” diseases, such as vibriosis, trichomoniasis, babesiosis, anaplasmosis, cattle tick *boophilus microplus*, other external parasites, internal parasites, pullorum disease, enzootic pneumonia of pigs and Johne’s disease, which affect animal productivity but don’t threaten human health or international trade.

This report highlighted the need for continuing to administer surveys and maintain surveillance in order to obtain regular detailed knowledge of the diseases present within the PICTs. This information was recognised as essential for the development of any animal quarantine policies and for import-export regulations, acknowledging though that it requires adequately staffed veterinary services and diagnostic laboratories. However, trading cannot rely on the unsubstantiated statement of the PICTS that they are free from serious infectious livestock diseases.

The GF-TAD meeting organised by FAO and OIE in 2009 led to a categorization of livestock diseases at the regional level with:

- Brucellosis, leptospirosis and bovine tuberculosis being the three endemic zoonotic diseases requiring further concerted efforts for control and
- Highly pathogenic avian influenza (HPAI), newcastle disease, classical swine fever, foot and mouth disease, bluetongue, peste des petit ruminants and rabies being exotic diseases of potential threat for the Pacific region and thus necessitating preparedness plans.

The methodology used for these two lists was not clearly documented but seems to be based on the consultation and presentation on the day of the workshop of one representative per country of the Pacific region (Secretariat of the Pacific Community, 2009c).

Thus, in the light of this literature review, it appeared that no fully documented prioritization had yet been done for livestock diseases in the Pacific Islands region and that it would assist in identifying the most relevant hazards for the livestock production systems in view of a better rationalisation of the animal health sector’s resources for surveillance activities within the PICTs.

Livestock market chain analysis

A “market chain” is a group of people interacting with the goal being to supply a specific commodity (FAO, 2011). The term “value chain” is also found in the literature, and the two terms can be used interchangeably, but the term “market chain” was preferred for this study because there isn’t any economic component to the assessment conducted.

Livestock market chain analysis is recognised for providing a practical framework for disease risk assessment, as follows:

1. Identify the main people or groups of people in the livestock market chain, from the producer to the end consumer;
2. Identify and map the different potential or existing routes for livestock and livestock marketing;
3. Assess how well the market chain is working.

The original purpose of a market chain analysis is to improve production efficiency, but when used in the context of disease risk assessment, the process should look specifically at:

1. The opportunities for disease introduction and/or transmission along the market chain;
2. The practices aiming to reduce the risk of disease introduction and/or transmission along the market chain;

3. The potential capability of people involved in the chain to react to the introduction and/or transmission of diseases at any point along the market chain.

When the market chain analysis is being conducted through stakeholder consultation, it leads to a more transparent decision-making process with respect to animal disease management and plays a central role in risk communication.

Network analysis applied to livestock movements

Social Network Analysis (SNA) aims to describe the interactions between individuals within a group and to understand the collective behaviour of this group (Martinez-Lopez, Perez, & Sanchez-Vizcaino, 2009b). SNA involves a distinctive set of methods used for mapping, measuring and analysing the social relationships between people, groups and organisations (Borgatti, Mehra, Brass, & Labianca, 2009). Compared to other analytical approaches, SNA presents the advantage of handling relations like contacts between individuals, trade patterns or animal movements that are bi-directional (Martinez-Lopez et al., 2009b).

In SNA, “nodes” represent the elements of the network and “contacts” refer to the links or connections among the elements. SNA uses a theoretical framework, the “graph theory”, to identify the important components of a network, to measure the patterns of contacts and to compare different networks (Martinez-Lopez et al., 2009b).

When applied to health systems, SNA assists in providing better-adjusted health interventions where resources are particularly scarce. It enables the analysis and comparison of formal and informal information flows within a system and helps in the understanding of the influence of networks on behaviour and decisions. Although SNA has been applied to health systems for a long time, little has been done in this respect in low- and middle-income countries (Borgatti et al., 2009).

In human or animal populations, the degree of contact between individuals within a network determines the potential introduction and spread of contagious diseases (Kao, Green, Johnson, & Kiss, 2007; Kiss, Green, & Kao, 2006; Ortiz-Pelaez, Pfeiffer, Soares-Magalhaes, & Guitian, 2006). Similar to human health systems, SNA allows in preventive veterinary medicine a description of the contacts between animals and farms that leads to a better understanding of the potential risks of livestock disease transmission and dissemination among susceptible animal populations. Ultimately, the elements of a network which are identified as playing a key role in disease dissemination can be targeted by surveillance and control programmes (Martinez-Lopez et al., 2009b).

Towards this aim, SNA has the potential to contribute to various components of preventative veterinary medicine, such as selection of locations for targeted surveillance, or identification of groups of premises behaving as a single epidemiological unit of risk *("compartments"* as defined by OIE) for improved risk management and international trade. Considering that most of the risks for animal disease spread are related to animal movements, some European countries have developed near real-time surveillance systems to trace the origin and the route of animal and animal products trade. With identification of nodes most likely to create favourable conditions for disease spread (e.g. farms, market or slaughterhouse), this approach can assist in better targeting animal disease surveillance and in preparing better-oriented contingency plans (Stevenson, Sanson, Miranda, Lawrence, & Morris, 2007). This is particularly relevant in resource-limited contexts (Stark et al., 2006).

However, the SNA approach also faces some limits. When the size of a database is too large (with data collected at the country or continental scale, for instance), the computational power of available software becomes a limit. One option to deal with the high volume of data is then to break the data down again at lower geographical levels (such as countries, departments, districts or municipalities) and consider each minimal unit as a network that becomes a node within the network of the higher level (Martinez-Lopez et al., 2009b).

Another limitation for SNA is poor data. This might particularly true in low- and middle-income countries where data collection might be hampered by political, confidentiality or financial issues. Nevertheless, techniques such as participatory epidemiology have proven to be a reliable alternative for data collection in areas where traditional procedures could not be implemented (Martinez-Lopez et al., 2009b).

The inconsistent collection of data for each node is another limit in SNA studies, which then jeopardises the data analysis (for instance, if some farmers in a network are not surveyed). This can potentially lead to biased interpretation of the results. Particular attention must thus be given to the sampling methodology to ensure that no systematic error is introduced (Martinez-Lopez et al., 2009b).

If SNA allows for the characterisation of a network, its potential influence on the spread of diseases can be investigated only if the network links are associated with known risk factors for disease transmission (Waret-Szkuta, Ortiz-Pelaez, Pfeiffer, Roger, & Guitian, 2011). The potential role of a node in the dissemination of disease is closely associated with the transmissibility of the causative agent and thus needs to be considered on a disease by disease basis (Robinson & Christley, 2007). For instance, Kao (2007) demonstrated that, within a sheep population, the network dynamic could have a dramatic impact on the transmission of the highly infectious foot and mouth virus whereas it is likely to be insignificant for the transmission of scrapie due to the disease time-scale of years and of the lower probability of transmission via infectious contact.

The use of SNA is relatively recent in veterinary medicine, with several studies on animal movements conducted in the last decade, mostly in developed countries (Dube, Ribble, Kelton, & McNab, 2009; Lockhart, Stevenson, Rawdon, Gerber, & French, 2010; Martinez-Lopez, Perez, & Sanchez-Vizcaino, 2009a; Natale et al., 2009; Noremark, Hakansson, Lewerin, Lindberg, & Jonsson, 2011) and more particularly in the United Kingdom (Brennan, Kemp, & Christley, 2008; Dent, Kao, Kiss, Hyder, & Arnold, 2008; Green, Kiss, Mitchell, & Kao, 2008; Kao et al., 2007; Kiss et al., 2006; Ortiz-Pelaez et al., 2006; Robinson & Christley, 2007; Webb, 2005). Most of these studies conducted in developed countries benefit from pre-existing databases built from compulsory registration of livestock movements or from previously fully documented outbreak investigations.

Such information is usually not available in developing countries. So far, very few studies involving the use of SNA in preventive veterinary medicine have been conducted in low-income countries: in Cambodia (Van Kerkhove et al., 2009), Vietnam (Soares Magalhaes et al., 2010), Somalia (Ortiz-Pelaez et al., 2010), Ethiopia (Waret-Szkuta et al., 2011) and more recently in Eastern Indonesia (Leslie, Christley, Geong, Ward, & Toribio, 2015). In these studies, cross-sectional surveys were conducted to obtain data on animal movements, and a particular focus is made on markets, as they are known to create, in a limited space, the gathering of animal populations with diverse origins and potentially from fairly distant areas. As such, they are often considered as a key node within the risk pathway of pathogen emergence and dissemination and have thus been purposely targeted in this survey. Several studies demonstrated that animal markets are a strategic point for spreading infectious agents through animal populations. Markets with the highest source to destination ratio should then be targeted for disease surveillance and control programmes (Fournie et al., 2013; Fournie et al., 2012; Leslie et al., 2015; Martin et al., 2011; Robinson & Christley, 2007; Soares Magalhaes et al., 2010).

It appears from the literature review that the description of livestock movements within the PICTs and their potential role in the transmission and dissemination of animal diseases have not yet been studied. The use of the SNA tool seems of particular interest in identifying the nodes and contacts of importance within the PICTs livestock movement patterns.

SCOPE OF THE THESIS

Due to the complexity of the societies being studied and the multi-factorial nature of disease surveillance, a structured approach was used to identify what diseases are important and how they behave within the community. An official approach was offered by the OIE in the steps taken for assessing the risks of introducing diseases through the importation of animals or animal products into a country. By adopting this approach, we took into account the multifaceted aspects of disease identification, transmission, prevention and communication. We used this as the first step in providing a solid foundation upon which to build a surveillance system as it provides a framework for identifying the diseases of importance and how they are likely to move within communities based on existing knowledge.

In undeveloped rural communities, the sociological drivers play an important role in the flow of disease within these communities and their countries. By understanding the market flows and the driving forces behind them, it is possible to identify disease transmission hubs. Once these have been identified they can be used for identifying where disease surveillance should be targeted. This will allow for better utilisation of limited skilled resources and increase the sensitivity of disease identification. We modelled these social networks in order to identify networking hubs, thus allowing for focal areas of disease surveillance to be implemented.

By gaining an understanding of what surveillance should be targeting and where surveillance should be targeted, a clearer understanding will be gained on what activities should be targeted and how they should be targeted, thus providing a better overall understanding of how to implement effective surveillance in the PICTs and thus enhance food security and biosecurity within the region.

REFERENCES

Angot, J.L., 2009. [Surveillance and control of imported animal diseases. Role of the OIE and veterinary services]. Bull. Acad. Natl. Med. 193, 1861-1869; discussion 1869-1870.

Argounes, F., Mohamed-Gaillard, S., Vacher, L., 2011. Atlas de l'Oceanie. Editions Autrement, 77, rue du Faubourg-Saint-Antoine, 75011 Paris, France.

Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G., 2009. Network analysis in the social sciences. Science 323, 892-895.

Brennan, M.L., Kemp, R., Christley, R.M., 2008. Direct and indirect contacts between cattle farms in north-west England. Prev. Vet. Med. 84, 242-260.

Cardoen, S., Van Huffel, X., Berkvens, D., Quoilin, S., Ducoffre, G., Saegerman, C., Speybroeck, N., Imberechts, H., Herman, L., Ducatelle, R., Dierick, K., 2009. Evidence-based semiquantitative methodology for prioritization of foodborne zoonoses. Foodborne Pathog. Dis. 6, 1083-1096.

Cox, L.A., Jr., Babayev, D., Huber, W., 2005. Some limitations of qualitative risk rating systems. Risk analysis : an official publication of the Society for Risk Analysis 25, 651-662.

de Bettencourt, J., Imminga-Berends, H., 2015. Overseas Countries and Territories: Environmental Profiles. Final Report, Part 2 - Detailed Report, Section D - Pacific Region. https://ec.europa.eu/europeaid/sites/devco/files/octs-environmental-profiles-pacific-012015_en.pdf (accessed: 02 Sep 2015). Safège Consortium, Gulledelle 92, B-1200 Brussels - BELGIUM, p. 110.

Dent, J.E., Kao, R.R., Kiss, I.Z., Hyder, K., Arnold, M., 2008. Contact structures in the poultry industry in Great Britain: exploring transmission routes for a potential avian influenza virus epidemic. BMC Vet. Res. 4, 27.

Doherty, J.A., 2000. Establishing priorities for national communicable disease surveillance. The Canadian journal of infectious diseases 11, 21-24.

Dube, C., Ribble, C., Kelton, D., McNab, B., 2009. A review of network analysis terminology and its application to foot-and-mouth disease modelling and policy development. Transbound. Emerg. Dis. 56, 73-85.

FAO, 1998. Grazing Livestock in the Southwest Pacific: The Benefits from Improved Production. FAO Sub-Regional Office for the Pacific,, Private Bag, Apia, Samoa.

FAO, 2011. A value chain approach to animal diseases risk management - Technical foundations and practical framework for field application, Animal Production and Health Guidelines. No. 4. Rome, Italy.

FAO Statistic Division, 2014. FAOSTAT, http://faostat3.fao.org/download/Q/QA/E (accessed 20/10/2014).

Fish, R., Austin, Z., Christley, R., Haygarth, P.M., Heathwaite, A.L., Latham, S., Medd, W., Mort, M., Oliver, D.M., Pickup, R., Wastling, J.M., Wynne, B., 2011. Uncertainties in the governance of animal disease: an interdisciplinary framework for analysis. Philos. Trans. R. Soc. Lond. B Biol. Sci. 366, 2023-2034.

Forman, S., Plante, C., Murray, G., Rey, B., Belton, D., Evans, B., Steinmetz, P., World Organisation for Animal, H., 2012. Position paper: improving governance for effective veterinary services in developing countries--a priority for donor funding. Rev. Sci. Tech. 31, 647-660.

Fosse, J., Seegers, H., Magras, C., 2008. [Prioritising the risk of foodborne zoonoses using a quantitative approach: application to foodborne bacterial hazards in pork and beef]. Rev. Sci. Tech. 27, 643-655.

Fournie, G., Guitian, J., Desvaux, S., Cuong, V.C., Dung do, H., Pfeiffer, D.U., Mangtani, P., Ghani, A.C., 2013. Interventions for avian influenza A (H5N1) risk management in live bird market networks. Proc. Natl. Acad. Sci. U. S. A. 110, 9177-9182.

Fournie, G., Guitian, J., Desvaux, S., Mangtani, P., Ly, S., Cong, V.C., San, S., Dung do, H., Holl, D., Pfeiffer, D.U., Vong, S., Ghani, A.C., 2012. Identifying live bird markets with the potential to act as reservoirs of avian influenza A (H5N1) virus: a survey in northern Viet Nam and Cambodia. PLoS One 7, e37986.

Garabed, R.B., Perez, A.M., Johnson, W.O., Thurmond, M.C., 2009. Use of expert opinion for animal disease decisions: an example of foot-and-mouth disease status designation. Prev. Vet. Med. 92, 20-30.

Gibson, J.M., 2011. A burden of disease approach to prioritizing environmental policy initiatives: a case study in the Middle East. N. C. Med. J. 72, 136-140.

Green, D.M., Kiss, I.Z., Mitchell, A.P., Kao, R.R., 2008. Estimates for local and movement-based transmission of bovine tuberculosis in British cattle. Proceedings. Biological sciences / The Royal Society 275, 1001-1005.

Guerrier, G., Foster, H., Metge, O., Chouvin, C., Tui, M., 2013. Cultural contexts of swine-related infections in Polynesia. Clin. Microbiol. Infect. 19, 595-599.

Gummow, B., 2010. Challenges posed by new and re-emerging infectious diseases in livestock production, wildlife and humans. Livestock Science 130 (1-3), 41-46.

Heffernan, C., 2009. Panzootics and the poor: devising a global livestock disease prioritisation framework for poverty alleviation. Rev. Sci. Tech. 28, 897-907.

Humblet, M.F., Vandeputte, S., Albert, A., Gosset, C., Kirschvink, N., Haubruge, E., Fecher-Bourgeois, F., Pastoret, P.P., Saegerman, C., 2012. Multidisciplinary and evidence-based method for prioritizing diseases of food-producing animals and zoonoses. Emerg. Infect. Dis. 18 (4), e1. doi: 10.3201/eid1804.111151.

IFAH-Europe, 2009. Approaches to the prioritisation of diseases to focus and prioritise research in animal health: A worldwide review of existing methodologies. DISCONTOOLS Project. http://www.discontools.eu/upl/1/default/doc/WP%202%20Prioritisation%20Review%20Paper%20Final%2020120930.docx (accessed 01/03/2014).

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L., Daszak, P., 2008. Global trends in emerging infectious diseases. Nature 451, 990-993.

Kahuroa, 2010. Pacific Culture Areas. https://commons.wikimedia.org/wiki/File:Pacific_Culture_Areas.jpg#/media/File:Pacific_Culture_Areas.jpg (accessed 12 Mar 2016).

Kao, R.R., Green, D.M., Johnson, J., Kiss, I.Z., 2007. Disease dynamics over very different time-scales: foot-and-mouth disease and scrapie on the network of livestock movements in the UK. J. R. Soc. Interface 4, 907-916.

Kapiriri, L., Norheim, O.F., 2002. Whose priorities count? Comparison of community-identified health problems and Burden-of-Disease-assessed health priorities in a district in Uganda. Health expectations : an international journal of public participation in health care and health policy 5, 55-62.

Kiss, I.Z., Green, D.M., Kao, R.R., 2006. The network of sheep movements within Great Britain: Network properties and their implications for infectious disease spread. J. R. Soc. Interface 3, 669-677.

Krause, G., 2008. How can infectious diseases be prioritized in public health? A standardized prioritization scheme for discussion. EMBO reports 9 Suppl 1, S22-27.

Krause, G., Working Group on Prioritisation at the Robert Koch, I., 2008. Prioritisation of infectious diseases in public health--call for comments. Euro surveillance : bulletin Européen sur les maladies transmissibles = European communicable disease bulletin 13.

Kurowicka, D., Bucura, C., Cooke, R., Havelaar, A., 2010. Probabilistic inversion in priority setting of emerging zoonoses. Risk analysis : an official publication of the Society for Risk Analysis 30, 715-723.

Kushnir, I., 2013. Gross Domestic Product (GDP) in Oceania. Ivan Kushnir's Research, World macroeconomic research, http://kushnirs.org/macroeconomics/gdp/gdp_oceania.html (accessed 01/09/2015).

Leslie, E.E., Christley, R.M., Geong, M., Ward, M.P., Toribio, J.A., 2015. Analysis of pig movements across eastern Indonesia, 2009-2010. Prev. Vet. Med. 118, 293-305.

Lockhart, C.Y., Stevenson, M.A., Rawdon, T.G., Gerber, N., French, N.P., 2010. Patterns of contact within the New Zealand poultry industry. Prev. Vet. Med. 95, 258-266.

Martin, V., Zhou, X., Marshall, E., Jia, B., Fusheng, G., FrancoDixon, M.A., DeHaan, N., Pfeiffer, D.U., Soares Magalhaes, R.J., Gilbert, M., 2011. Risk-based surveillance for avian influenza control along poultry market chains in South China: The value of social network analysis. Prev. Vet. Med. 102, 196-205.

Martinez-Lopez, B., Perez, A.M., Sanchez-Vizcaino, J.M., 2009a. Combined application of social network and cluster detection analyses for temporal-spatial characterization of animal movements in Salamanca, Spain. Prev. Vet. Med. 91, 29-38.

Martinez-Lopez, B., Perez, A.M., Sanchez-Vizcaino, J.M., 2009b. Social network analysis. Review of general concepts and use in preventive veterinary medicine. Transbound. Emerg. Dis. 56, 109-120.

McKenzie, J., Simpson, H., Langstaff, I., 2007. Development of methodology to prioritise wildlife pathogens for surveillance. Prev. Vet. Med. 81, 194-210.

Murray, N., MacDiarmid, S.C., Wooldridge, M., Gummow, B., Morley, R.S., Weber, S.E., Giovannini, A., Wilson, D., 2004. Handbook on Import Risk Analysis for Animals and Animal Products: introduction and qualitative risk analysis. OIE, 12, rue de Prony, 75017 Paris, France.

Natale, F., Giovannini, A., Savini, L., Palma, D., Possenti, L., Fiore, G., Calistri, P., 2009. Network analysis of Italian cattle trade patterns and evaluation of risks for potential disease spread. Prev. Vet. Med. 92, 341-350.

Ng, V., Sargeant, J.M., 2012a. A quantitative and novel approach to the prioritization of zoonotic diseases in North America: a public perspective. PLoS One 7, e48519.

Ng, V., Sargeant, J.M., 2012b. A stakeholder-informed approach to the identification of criteria for the prioritization of zoonoses in Canada. PLoS One 7, e29752.

Ng, V., Sargeant, J.M., 2013. A quantitative approach to the prioritization of zoonotic diseases in North America: a health professionals' perspective. PLoS One 8, e72172.

Noremark, M., Hakansson, N., Lewerin, S.S., Lindberg, A., Jonsson, A., 2011. Network analysis of cattle and pig movements in Sweden: measures relevant for disease control and risk based surveillance. Prev. Vet. Med. 99, 78-90.

OIE, 2010. Handbook on Import Risk Analysis for Animals and Animals products - Volume I. Introduction and qualitative risk analysis, OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2011. Terrestrial Animal Health Code, OIE, 12, rue de Prony, 75017 Paris, France.

Ortiz-Pelaez, A., Pfeiffer, D.U., Soares-Magalhaes, R.J., Guitian, F.J., 2006. Use of social network analysis to characterize the pattern of animal movements in the initial phases of the 2001 foot and mouth disease (FMD) epidemic in the UK. Prev. Vet. Med. 76, 40-55.

Ortiz-Pelaez, A., Pfeiffer, D.U., Tempia, S., Otieno, F.T., Aden, H.H., Costagli, R., 2010. Risk mapping of Rinderpest sero-prevalence in Central and

Southern Somalia based on spatial and network risk factors. BMC Vet. Res. 6, 22.

Osborne, H.G., 1974. Animal quarantine in the South Pacific commission area. University of Queensland, Brisbane, Queensland, Australia, p. 56.

Pavlin, B.I., Kool, J.L., Samo, M.H., Gerstel, L., 2010. A standardized process for developing a national notifiable diseases list in a pacific island setting. Asia Pac. J. Public Health 22, 279-288.

Phylum, 2009. Listing and Categorisation of Priority Animal Diseases, including those Transmissible to Humans - Methodological Manual. Phylum, 9 allée Charles CROS – ZAC des Ramassiers – 31770 Colomiers - France.

Rist, C.L., Arriola, C.S., Rubin, C., 2014. Prioritizing zoonoses: a proposed one health tool for collaborative decision-making. PLoS One 9, e109986.

Robinson, S.E., Christley, R.M., 2007. Exploring the role of auction markets in cattle movements within Great Britain. Prev. Vet. Med. 81, 21-37.

Secretariat of the Pacific Community, 2006. The paravet training manual for the Pacific Islands - Introductory course, 2nd edition ed. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.

Secretariat of the Pacific Community, 2007. The importance of the Pig in Pacific Island Culture - A literature review. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 38.

Secretariat of the Pacific Community, 2009a. Annual Report 2009, Part 1 - Annual overview, Secretariat of the Pacific Community, Noumea, New Caledonia, p. 70.

Secretariat of the Pacific Community, 2009b. Livestock in the Pacific, Policy Brief. Secretariat of the Pacific Community, BP DS, 98848 Noumea Cedex, New Caledonia.

Secretariat of the Pacific Community, 2009c. Report of the first FAO/OIE subregional meeting of GF-TADs for the Pacific Community region in collaboration with SPC, 25-26 June 2009, Nadi, Fiji, Secretariat of the Pacific Community, Suva Regional Office, Private Mail Bag, Suva, Fiji Islands.

Secretariat of the Pacific Community, 2010. SPC Regional Terrestrial and Aquatic Animal Disease Reporting Workshop, Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 26.

Secretariat of the Pacific Community, 2011. PHAMA project target market access and high-value primary commodities, Land Ressources News. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 1.

Secretariat of the Pacific Community, 2012. SPC Website, Members of the Pacific Community. Secretariat of the Pacific Community, http://www.spc.int/en/about-spc/members.html (accessed 14/01/2012).

Soares Magalhaes, R.J., Ortiz-Pelaez, A., Thi, K.L., Dinh, Q.H., Otte, J., Pfeiffer, D.U., 2010. Associations between attributes of live poultry trade and HPAI H5N1 outbreaks: a descriptive and network analysis study in northern Vietnam. BMC Vet. Res. 6, 10.

Stark, K.D., Regula, G., Hernandez, J., Knopf, L., Fuchs, K., Morris, R.S., Davies, P., 2006. Concepts for risk-based surveillance in the field of veterinary medicine and veterinary public health: review of current approaches. BMC Health Serv. Res. 6, 20.

Stevenson, M.A., Sanson, R.L., Miranda, A.O., Lawrence, K.A., Morris, R.S., 2007. Decision support systems for monitoring and maintaining health in food animal populations. N. Z. Vet. J. 55, 264-272.

Synexe Consulting Limited, 2010. Valuing Culture in Oceania, Methodology and indicators for valuing culture, including traditional knowledge, in Oceania, Human Development Programme of the Secretariat of the Pacific Community, Noumea, New Caledonia, p. 78.

Uzochukwu, B.S., Onwujekwe, O.E., Nwobi, E.A., Ndu, A.C., Onoka, C., 2007. Households' perceptions and prioritization of tropical endemic diseases in Nigeria: implications for priority setting for resource allocation. World Health Popul 9, 36-47.

Valenciano, M., 2001. Definition des priorites dans le domaine des zoonoses non alimentaires, Institut de Veille Sanitaire, 12, rue du Val d'Osne, 94415 Saint-Maurice cedex, France, p. 40.

Van der Fels-Klerx, I.H., Goossens, L.H., Saatkamp, H.W., Horst, S.H., 2002. Elicitation of quantitative data from a heterogeneous expert panel: formal process and application in animal health. Risk analysis : an official publication of the Society for Risk Analysis 22, 67-81.

Van Kerkhove, M.D., Vong, S., Guitian, J., Holl, D., Mangtani, P., San, S., Ghani, A.C., 2009. Poultry movement networks in Cambodia: implications for surveillance and control of highly pathogenic avian influenza (HPAI/H5N1). Vaccine 27, 6345-6352.

Waret-Szkuta, A., Ortiz-Pelaez, A., Pfeiffer, D.U., Roger, F., Guitian, F.J., 2011. Herd contact structure based on shared use of water points and grazing points in the Highlands of Ethiopia. Epidemiol. Infect. 139, 875-885.

Webb, C.R., 2005. Farm animal networks: unraveling the contact structure of the British sheep population. Prev. Vet. Med. 68, 3-17.

Woolhouse, M.E.J., Fevre, E.M., Handel, I., Heller, J., Tildesley, M.J., Parkin, T., Reid, S.W.J., 2011. Guide to Good Practice for Quantitative Veterinary Epidemiology, http://www.qve-goodpracticeguide.org.uk/ (accessed 21/05/2011).

Yarrow, R., 2008. Increasing veterinary capacity in the Pacific, Third regional meeting of Heads of Agriculture and Forestry Services (HOAFS), 3-5 September 2008, Apia, Samoa. Secretariat of the Pacific Community, Suva, Fiji, p. 4.

CHAPTER 2

A REVIEW OF DOMESTIC ANIMAL DISEASES WITHIN THE PACIFIC ISLANDS REGION

Aurélie Brioudes[1], Jeffrey Warner[1], Robert Hedlefs[1] and Bruce Gummow[1, 2]

[1] *Discipline of Veterinary Sciences, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville 4811, Queensland, Australia*

[2] *Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa*

Published in Acta Tropica Journal (2014)

132 c, 23-38

ABSTRACT

The Pacific Island countries and territories (PICTs) are reported to be free of the most serious infectious livestock diseases which are prevalent in other parts of the globe, such as Highly Pathogenic Avian Influenza, Foot and Mouth Disease or Rabies. Yet there is a lack of scientifically based evidence to confirm this animal health status. This paper reviews what has been published on diseases of domestic animals in the Pacific Islands region with a particular focus on data from the last 20 years (1992-2012). Relevant published papers were identified by a computerized literature search of two electronic databases (PubMed and Web of Knowledge). The latest reports on the animal health situation submitted by the PICTs to the World Organisation for Animal Health (OIE) were accessed on the World Animal Health Information Database (WAHID) interface and included in this review. Additionally, paper searches of resources were undertaken at the library of the Secretariat of the Pacific Community (SPC) in Fiji to retrieve any relevant grey literature for this review. The study eligibility criteria included qualitative or quantitative information on any disease (bacterial, viral, parasitic and other health disorders) affecting domestic terrestrial animals (mammals, reptiles, birds and bees) in any of the 22 PICTs members of the SPC. A total of 158 eligible references were retrieved of which only 77 (48.7%) were published since 1992 and analysed in more details. One hundred and one diseases and pathogens were reported on for bee, bird, carabao (Asian Swamp Buffalo), cat, cattle, crocodile, deer, dog, donkey, goat, horse, pig, pigeon, poultry and sheep in the Oceania region and in 17 PICTs in particular. The paper gives information about known animal diseases, their reported prevalence and diseases not reported within the Pacific Islands region. The study found retrieved literature on animal diseases in PICTs was scarce and no longer up to date. There is a need to improve the published knowledge on the current animal disease status in the region.

KEYWORDS

Pacific island; Domestic animal; Animal disease; Literature review.

INTRODUCTION

Emerging infectious diseases pose a major concern for animal health and have significant economic impact on the global livestock industry. These emerging diseases usually have no country boundaries and if they originate in a developing country could quickly spread to industrialized countries and other developing countries, and vice versa, mainly due to translocation of people and animals or through trade (Gummow, 2010). The tropical environment of Pacific Island Countries and Territories (PICTs), coupled with a close human, wild animal and domestic animal interface and the inter-island movement of people between PICTs all create situations that are conducive to the emergence of diseases (Gummow, 2010; Jones et al., 2008). However little has been published on what diseases of domestic animals occur within these islands or their prevalence.

The PICTs are said to be free of the most serious infectious livestock diseases which are prevalent in other parts of the world such as Highly Pathogenic Avian Influenza (HPAI), Classical Swine Fever (CSF), Foot and Mouth Disease (FMD) and Rabies (Angus, 1986; Newman & McKenzie, 1991; Secretariat of the Pacific Community, 2009; Yarrow, 2008). But there appears to be a lack of scientifically based evidence to confirm this status. To date, the only known work which compiled information on animal diseases in Oceania is an annotated bibliography on animal husbandry and diseases in the Pacific area dating back 45 years (Pacific Science Information Center, Bernice P. Bishop Museum Honolulu, 1966). Therefore, a systematic review of papers compiling information on any diseases affecting domestic animals is warranted.

The objective of this study was to systematically review the current knowledge about the disease status of domestic animals in the Pacific Islands region, with a view to highlighting the gaps in knowledge and identifying the potential needs in terms of animal disease surveillance in this region.

METHODS

A review was carried out on what has been published on diseases of domestic animals in the Pacific Islands region with a particular focus on data from the last 20 years (1992-2012). The review included relevant published papers identified by a computerized literature search of two electronic databases (PubMed and Web of Knowledge), reports on the animal health situation submitted by the PICTs to the World Organisation for Animal Health (OIE) and paper searches of resources at the library of the Secretariat of the Pacific Community (SPC) in Fiji. The SPC is an international organisation working in various domains, including agriculture and in particular animal health and production, to help Pacific Island people achieve sustainable development.

Search strategy

PubMed and Web of Knowledge databases

Peer-reviewed studies were sought in January 2013 on the PubMed and ISI Web of Knowledge databases using the following search strategy:

Search 1: (animal* OR livestock* OR herd* OR farm* OR cattle* OR bovine OR pig* OR swine OR sheep* OR ovine OR goat* OR caprine OR horse* OR equine OR chick* OR duck* OR bird* OR poultry OR bee OR bees OR apiculture* OR dog* OR cat* OR canine OR crocodile*)

Search 2: (health OR infection* OR sick* OR disease*OR zoono* OR outbreak* OR bacteria* OR virus* OR parasite* OR prevention OR control OR surveillance)

Search 3: (“Pacific” OR “Oceania” OR “Micronesia” OR “Melanesia” OR “Polynesia” OR “American Samoa” OR “Cook Island” OR “Federated States of Micronesia” OR “Fiji” OR “French Polynesia” OR “Guam” OR “Kiribati” OR “Marshall Islands” OR “Nauru” OR “New Caledonia” OR “Niue” OR “Northern Mariana Islands” OR “Palau” OR “Papua New guinea” OR “Pitcairn Islands” OR

"Samoa" OR "Solomon Islands" OR "Tokelau" OR "Tonga" OR "Tuvalu" OR "Vanuatu" OR "Wallis" OR "Futuna")

Search 1 AND Search 2 AND Search 3

The "all fields" option in PubMed and "Topic" option in Web of Knowledge were used to allow retrieval of publications in which the search terms appeared in the titles or the abstracts or the keywords.

Secretariat of the Pacific Community local database

The grey literature (i.e. print and electronic formats that have not been formally published by commercial publishers) were reviewed by scrutinising the SPC library database and the electronic documents archived in the shared-drive of the Animal Health and Production team from the Land and Resources Division.

WAHID interface

All official animal health reports submitted by countries from Oceania to the World Organisation for Animal Health (OIE) were reviewed via the World Animal Health Information Database (WAHID) interface (OIE)*. However, few PICTs are currently OIE member countries and/or report their animal health status. Hence data is only available on this database for Fiji, Federate States of Micronesia (FSM), New Caledonia, Papua New Guinea (PNG), Samoa, Tonga and Vanuatu. Moreover, some of these countries do not report consistently to OIE (some yearly reports are missing for some of the PICTs).*

Eligibility criteria

Inclusion criteria

A publication was considered eligible for this review if it included qualitative or quantitative information on any disease (bacterial, viral, parasitic and fungal) affecting domestic terrestrial animals in any of the PICTs. Following the OIE definition, domestic terrestrial animals (mammals, birds and bees) are animals with “a phenotype selected by humans” and that “live under supervision or control by humans” (OIE, 2011). The selection of the countries and territories to be included in this review is based on the official list of 22 PICTs members of the SPC and included American Samoa, Cook Islands, FSM, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, PNG, Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna.

Exclusion criteria

Experimental studies and studies on aquatic species were systematically excluded. Studies investigating zoonotic diseases in humans were included whenever data was also provided for domestic animals (even if the study focused on humans). Since this paper focused on domestic animals, references on wild animals were excluded unless the data was collected from captive native animals (birds in particular). Publications focusing on crocodile, deer and pigeon health were included as these animals are being farmed in PNG and New Caledonia.

When more than one reference was retrieved for the same study or related work between the different databases under different formats (publications, project reports, conference presentation), only one reference was kept (the most compressive one) to avoid duplication.

The inclusion and exclusion criteria were applied to the title and abstract of all retrieved references. Considering the general literature search applied, the access to various databases of particular relevance for animal diseases in the Pacific Islands region and the ability of the author to review articles written in English and in French, which are the 2 most widely used languages in the studied area, this literature review probably includes most of the accessible references on the subject in the public domain.

Data collection process

The data collection process was undertaken in 2 steps. First, basic information was collected from all retrieved articles in order to assess which diseases have been reported in which PICTs. For this basic analysis, the following information was systematically recorded: the publication date, the country, the species, the disease, the type of causative agent (bacteria, virus, parasite, alga, toxins, tumour, fungi, rickettsiae), if the reference focus was on a zoonotic disease or not, and the type of study (case report, case series, review or survey). In a second step, considering that the objective of this review was to obtain a better understanding of the current animal disease situation in PICTs, only documents published or written in the last 20 years were selected to focus on the most recent information. A more detailed analysis of the key findings from these references was then performed by collecting additional data. When quantitative data was available, the time of the study, the number of animals tested and number of positive analyses were recorded to calculate the apparent prevalence of the disease. For references without quantitative data, the status of the disease was recorded using qualitative terminology (enzootic, present, clinical disease, outbreak notification etc).

RESULTS

Selected references

The search strategy retrieved 6,336 publications on PubMed of which only 107 were considered relevant when applying the inclusion and exclusion criteria. Similarly, 3,585 publications were obtained initially from Web of Knowledge, and after discarding the overlapping references with PubMed, 12 extra references were selected making a list of 119 references selected from these two scientific literature databases. Additionally, a further 47 references were identified from the SPC local database and the OIE database for the Oceania region. This database combines all the reports submitted by the PICTs between 2005 and 2011. For eight references, abstracts were not available and the full text document could not be retrieved. Moreover, one publication was written in German and had no abstract available in English. These references (see Table 2-1) were thus excluded. A final list of 158 references was identified as matching the inclusion criteria from which only 77 (48.7%) were published within the last 20 years (from 1992 to 2012) and were processed further.

Table 2-1: References excluded from the literature review

1. Anonymous (1946). "CONTROL of infectious animal diseases in the South-West Pacific area." The Veterinary record 58: 165.
2. Aslanian, R. G. and E. B. Cheliadinova (1970). "[Current nosoareal of brucellosis. II. The distribution of brucellosis in the countries of Africa, Asia and Oceania]." Zhurnal mikrobiologii, epidemiologii, i immunobiologii 47(5): 72-77.
3. Jones, H. I. (1976). "The role of pigs in the dissemination of ascaris and hookworm infections in Papua New Guinea." P N G Med J 19(3): 153-155.
4. Steele, J. H. (1977). "The zoonoses in the South Pacific and their public health significance." International journal of zoonoses 4(1): 1-20.
5. Fleury, H. J., J. F. Bonnici, et al. (1985). "Antibodies against paramyxoviruses of serotypes 1, 2 and 6 in birds from New Caledonia." Vet Rec 117(20): 530.
6. Hellyar, A. G. (1985). "The introduction of brucellosis into the Solomon Islands." Trans R Soc Trop Med Hyg 79(4): 567-568.
7. Wernery, U. and F. W. Schmidt (1985). "[Occurrence of enzootic bovine leukosis in Papua New Guinea]." Dtsch Tierarztl Wochenschr 92(5): 170-172.
8. Thevenon, J., M. Vassart, et al. (1989). "SURVEY OF CONTAGIOUS-DISEASES IN NEW CALEDONIAN APIARIES." Recueil De Medecine Veterinaire 165(11): 899-903.
9. Bergin, B. (1996). "Parker Ranch: Pacific pioneer in animal health." Veterinary heritage : bulletin of the American Veterinary History Society 19(2): 30-32.

Study characteristics

As shown in Fig. 2-1, the number of references decreased over the years since the 1980's. Most of the references consist of surveys (65%) and case series or case reports (20%). Only one reference classified as a "review" was dedicated specifically to Papua New Guinea (Hide, 2003) while the remaining reviews are generally papers looking at a particular disease worldwide with little data provided for the Pacific Islands region. Among the 22 PICTs included in the eligibility criteria for this literature review, half of the references were providing data for PNG and for New Caledonia, with 35% and 24% of papers retrieved respectively for these 2 countries (Fig. 2-1). A quarter (25%) of the references provided data on diseases for more than two animal species (coded as "multi species"), 18% reported on diseases of cattle and 15% on pigs (Fig. 2-2). When looking at the agent involved in the diseases studied, almost half of the references (46% with n= 235) reported on parasitic diseases, one quarter on bacterial diseases (25%) and another quarter on viral diseases (24%) (Fig. 2-3). About 59 % of the references (93/158) provided data on at least one zoonotic disease. The number of references published annually is very irregular. Peaks of publications were observed in 2004 and 2011(Fig. 2-4).

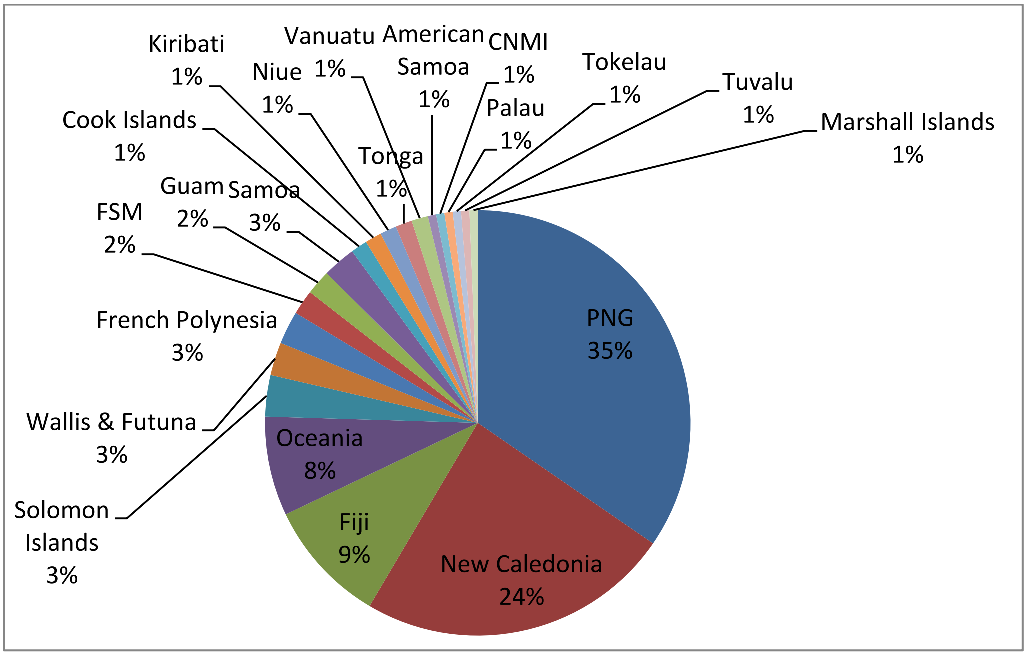


Figure 2-1: Distribution of references cited per country in the Pacific Island countries and territories between 1992 and 2012 (n=159)

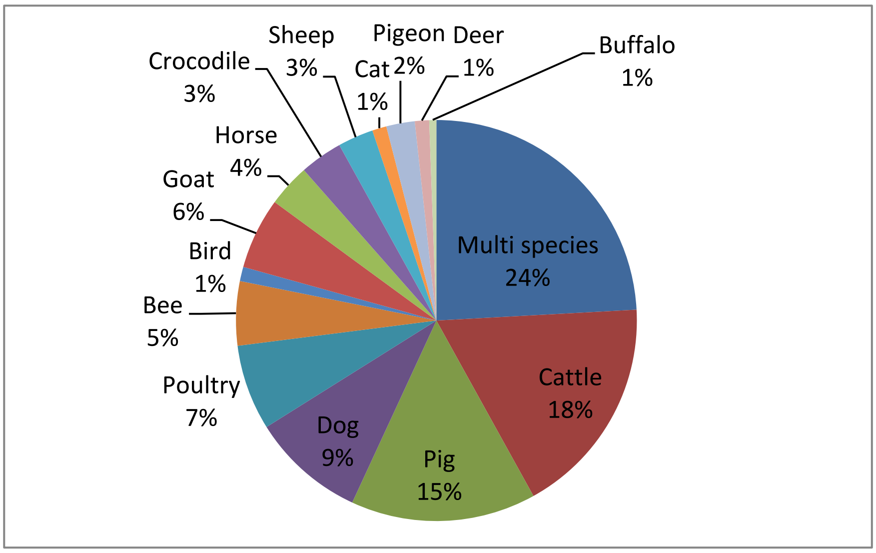


Figure 2-2: Distribution of references cited per species in the Pacific Island countries and territories between 1992 and 2012 (n= 174)

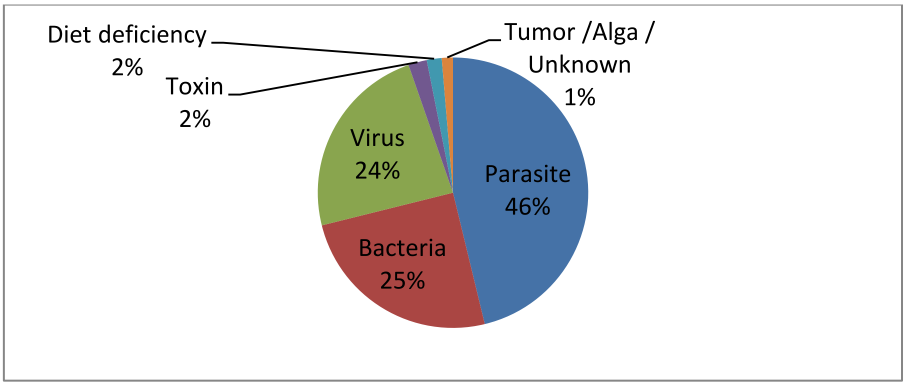


Figure 2-3: Distribution of references cited per agent in the Pacific Island countries and territories between 1992 and 2012 (n=225)

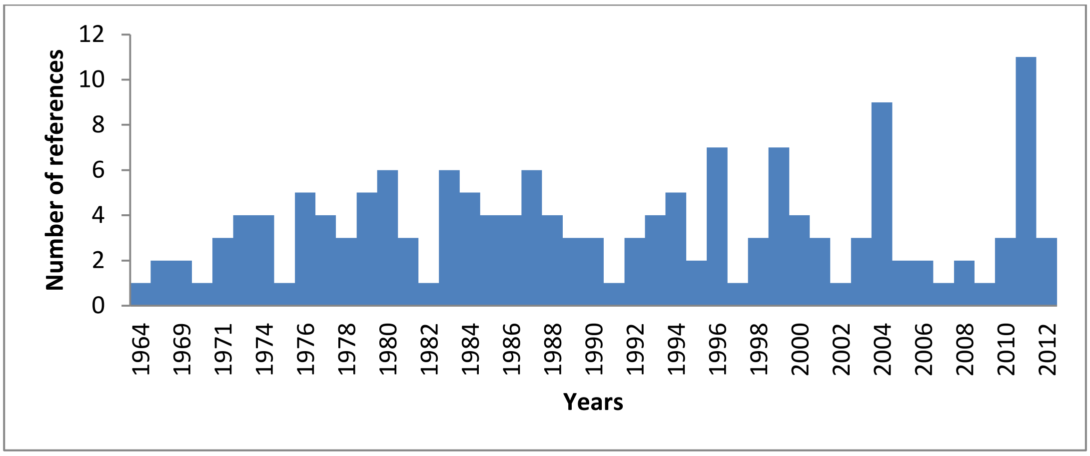


Figure 2-4: Distribution of references cited per year in the Pacific Island countries and territories between 1992 and 2012 (n=158)

Results of individual studies from 1992 to 2012

All the data on domestic animal diseases compiled from the 77 references between 1992 and 2012 for the Pacific Islands region are presented in Table 2-2 and Table 2-3. Table 2-2 shows a summary of data for diseases detected through surveys or reported as present. Table 2-3 gives the list of diseases not detected (based on negative laboratory results) or reported as not present (based on the absence of any clinical case observed) in the region. The dates presented in Tables 2-1 and 2-2 are the dates when the study was conducted, when this information was provided and the date of publication of the reference.

The term “Oceania” is used for data provided for the Pacific Islands region in general without detailed specification of the affected countries.

The disease lists are presented with two categories of data: Quantitative data with the estimated prevalence of the studied animal disease and qualitative data with a description of the status of the animal disease in the specific PICTs. Categories of qualitative data include disease declared as not present or undetected (-); disease reported as present or detected (+); disease said to be common, very common or enzootic (+++); diseases being suspected but not confirmed (+?).

A comparison of diseases or pathogens listed in Tables 2-2 and 2-3 shows that 16 diseases were sought but could not be found using the described methodology, in the Pacific Islands region. These diseases included borreliosis, psittacosis, bovine ephemeral fever, canine distemper virus, classical swine fever, equine infectious anaemia, equine viral arteritis, foot and mouth disease, porcine rotavirus, simbu serogroup, swine influenza, vesicular stomatitis, *Amblyomma* spp., avian malaria, cryptosporidiosis and cysticercosis. However, since this literature review focuses exclusively on domestic animals, wildlife reservoirs for these diseases cannot be excluded. Two recent literature reviews on parasitic zoonoses and parasites of animals recorded at the National Veterinary Laboratory in PNG were retrieved but the extensive lists of parasites presented in these papers could not be included in the Table 2-2 (Owen, 2005, 2011). No references were retrieved between 1992 and 2012 for five of the 22 PICTs included in this review, namely: American Samoa, Marshall Islands, Nauru, Pitcairn Islands and Tuvalu. Among the 77 references from 1992 to 2012, 31 (40.3%) were from the grey literature retrieved from the SPC local database.

Table 2-2: Animal diseases detected or reported as present in the Pacific Islands region based on the selected references from 1992 to 2012

Disease	Species	Country	Date	Key result[a]	Reference
BACTERIAL DISEASES					
Actinomycosis	Multi species	French Polynesia	2010	+	(OIE)
American foulbrood	Bee	Cook Islands	1990	5.3	(SPC, 2004a)
	Bee	Fiji	2001	+	(SPC, 2004b)
	Bee	Fiji	2011	+	(OIE)
	Bee	French Polynesia	2005-2007,2011	+	(OIE)
	Bee	New Caledonia	2005-2007,2011	+	(OIE)
	Bee	Niue	1998	+	(SPC, 2004c)
	Bee	Tonga	1991	+	(SPC, 2004e)
Anaplasmosis	Carabao	Guam	1999	14.3	(Duguies, Nusbaum, & Saville, 2000)
	Cattle	Guam	1999	21.7	(Duguies et al., 2000)
	Cattle	Niue	1992	1.5	(Saville, 1996b)
	Cattle	Samoa	1997	3.2	(T. Martin, 1999a)
	Cattle	Solomon Islands	1998	2.2	(T. Martin & Epstein, 1999)
	Dog	Samoa	2010-2011	6.1	(Carslake, Hill, Sjolander, Prattley, & Acke, 2012)
Anthrax	Multi species	PNG	2011	+	(OIE)
Avian encephalomyelitis	Poultry	Cook Islands	1993-1994	50.0	(Saville, 1994)
	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2010	+	(OIE)
	Poultry	Guam	1999	91.2	(Duguies et al., 2000)
	Poultry	Kiribati	1992-1994	18.5	(Saville, 1996a)
	Poultry	Palau	1996	22.0	(Saville, 1999)
	Poultry	Samoa	1997	70.0	(T. Martin, 1999a)
	Poultry	Solomon Islands	1998	35.9	(T. Martin & Epstein, 1999)
	Poultry	Tokelau	1998	2.2	(T. Martin, 1999b)
	Poultry	Tonga	1992-1994	42.9	(Saville, 1996c)
	Poultry	Wallis & Futuna	1997-1998	36.9	(T. Martin, 1999c)
Bartonellosis	Cat	New Caledonia	2009	+	(Mediannikov, Davoust, Cabre, Rolain, & Raoult, 2011)
	Cattle	New Caledonia	2009	+	(Mediannikov et al., 2011)
	Deer	New Caledonia	2009	31.0	(Mediannikov et al., 2011)
Blackleg	Multi species	Fiji	2008	+	(OIE)
	Multi species	New Caledonia	2009	+	(OIE)
Botulism	Multi species	French Polynesia	2010	+	(OIE)
	Multi species	New Caledonia	2010	+	(OIE)
	Poultry	Kiribati	1992-1994	+	(Saville, 1996a)
Bov. genital campylobacteriosis	Cattle	New Caledonia	2005-2007,2011	+	(OIE)
	Cattle	Vanuatu	2005-2007,2011	+	(OIE)

Disease	Species	Country	Date	Key result[a]	Reference
Brucellosis	Cattle	Samoa	1997	3.5	(T. Martin, 1999a)
	Multi species	Fiji	2011	+	(OIE)
	Multi species	French Polynesia	2006, 2010	+	(OIE)
	Multi species	Tonga	2011	+?	(OIE)
	Pig	French Polynesia	2005, 2007, 2011	+	(OIE)
	Pig	FSM	2009	+	(OIE)
	Pig	PNG	2011	+?	(OIE)
	Pig	Tonga	2011	+?	(OIE)
	Pig	Tonga	1992-1994	22.5	(Saville, 1996c)
	Pig	Wallis & Futuna	2004	7.1	(SPC, 2004f)
	Pig	Wallis & Futuna	2007	+	(OIE)
	Pig	Wallis & Futuna	2011	34.0	(Antras & Garin-Bastuji, 2011)
Campylobacter contamination	Poultry	New Caledonia	2005-2006	96.7	(Garin et al., 2012)
Chlamydiosis	Crocodile	PNG	2008	+	(Huchzermeyer, Langelet, & Putterill, 2008)
	Pigeon	New Caledonia	1992	7.4	(Thevenon, Rantoen, Carton, Costa, & Trap, 1992)
	Poultry	New Caledonia	2005-2007,2011	+	(OIE)
Chlamydiosis	Poultry	Tonga	2010	+?	(OIE)
	Sheep	New Caledonia	2005-2008	+	(OIE)
Clostridial infections	Goat	Guam	1999	+	(Duguies et al., 2000)
	Goat	Kiribati	1992-1994	+	(Saville, 1996a)
	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2010	+	(OIE)
	Poultry	New Caledonia	2010	+	(OIE)
Commensal & opportunistic bacteria	Bird	Guam	1982-86	54.7	(Savidge, Sileo, & Siegfried, 1992)
Dermatophilosis	Multi species	French Polynesia	2005	+	(OIE)
	Multi species	New Caledonia	2005	+	(OIE)
Enterotoxaemia	Multi species	Fiji	2008	+	(OIE)
	Multi species	New Caledonia	2010	+	(OIE)
Enzootic pneumonia	Pig	Samoa	1997	+	(T. Martin, 1999a)
	Pig	Solomon Islands	1998	+	(T. Martin & Epstein, 1999)
European foulbrood	Bee	French Polynesia	2005-2007	+	(OIE)
	Bee	New Caledonia	2005-2007,2011	+	(OIE)
Foot-rot	Multi species	Fiji	2008	+	(OIE)
Fowl cholera	Poultry	New Caledonia	2005-2007,2010	+	(OIE)
	Poultry	Samoa	2005, 2008	+	(OIE)
Fowl typhoid	Poultry	Kiribati	2011	+	(OIE)
Infectious coryza	Poultry	Fiji	2008	+	(OIE)
	Poultry	Tonga	1992-1994	+	(Saville, 1996c)
Leptospirosis	Cattle	Cook Islands	1993-1994	6.1	(Saville, 1994)
	Cattle	Fiji	2002	69.6	(Lupo, 2003)
	Cattle	French Polynesia	1997	15.0	(Desvars, Cardinale, & Michault, 2011)
	Cattle	Palau	1994	40.0	(Saville, 1999)

Disease	Species	Country	Date	Key result[a]	Reference
Leptospirosis (cont')	Cattle	Palau	1996	50.0	(Saville, 1999)
	Cattle	PNG	2001	+	(S. Reid et al., 2001)
	Cattle	Samoa	1997	39.6	(T. Martin, 1999a)
	Cattle	Solomon Islands	1998	83.2	(T. Martin & Epstein, 1999)
	Cattle	Tonga	1992-1994	6.2	(Saville, 1996c)
	Dog	Fiji	2002	55.9	(Lupo, 2003)
	Dog	FSM	1998	53.5	(Simms, 1998)
	Dog	New Caledonia	1997	+++	(Desvars et al., 2011)
	Dog	PNG	2006	4.5	(Wai'in, 2007)
	Dog	Wallis & Futuna	1997-1998	20.0	(T. Martin, 1999c)
	Donkey	New Caledonia	1999	97.4	(Desvars et al., 2011)
	Goat	Fiji	2002	38.5	(Lupo, 2003)
	Goat	Palau	1996	42.9	(Saville, 1999)
	Goat	Solomon Islands	1998	15.9	(T. Martin & Epstein, 1999)
	Horse	Fiji	2002	82.6	(Lupo, 2003)
	Horse	New Caledonia	1999	+++	(Desvars et al., 2011)
	Horse	Samoa	1997	44.4	(T. Martin, 1999a)
	Horse	Solomon Islands	1998	71.0	(T. Martin & Epstein, 1999)
	Horse	Wallis & Futuna	1997-1998	50.0	(T. Martin, 1999c)
	Multi species	French Polynesia	2005-2007,2011	+	(OIE)
	Multi species	FSM	2011	+	(OIE)
	Multi species	Kiribati	2011	+	(OIE)
	Multi species	New Caledonia	2005-2007,2011	+	(OIE)
	Multi species	PNG	2001	+	(S. Reid et al., 2001)
	Multi species	PNG	2011	+	(OIE)
	Multi species	Samoa	2010	+	(OIE)
	Multi species	Tonga	2011	+?	(OIE)
	Multi species	Wallis & Futuna	2007	+?	(OIE)
	Pig	Cook Islands	1993-1994	1.7	(Saville, 1994)
	Pig	Fiji	2002	16.9	(Lupo, 2003)
	Pig	FSM	1998	33.5	(Simms, 1998)
	Pig	Niue	1992	25.0	(Saville, 1996b)
	Pig	Palau	1996	40.0	(Saville, 1999)
	Pig	PNG	2001	+	(S. Reid et al., 2001)
	Pig	PNG	2006	2.9	(Wai'in, 2007)
	Pig	Samoa	1997	23.0	(T. Martin, 1999a)
	Pig	Solomon Islands	1998	12.4	(T. Martin & Epstein, 1999)
	Pig	Tokelau	1998	3.4	(T. Martin, 1999b)
	Pig	Tonga	1992-1994	3.1	(Saville, 1996c)
	Pig	Wallis & Futuna	1997-1998	20.2	(T. Martin, 1999c)
Melioidosis	Multi species	New Caledonia	2008	+	(OIE)
Mycoplasmosis	Goat	Guam	1999	+	(Duguies et al., 2000)

Disease	Species	Country	Date	Key result[a]	Reference
Mycoplasmosis (cont')	Poultry	Cook Islands	1993-1994	78.7	(Saville, 1994)
	Poultry	French Polynesia	2005-2008,2011	+	(OIE)
	Poultry	Guam	1999	55.8	(Duguies et al., 2000)
	Poultry	Kiribati	1992-1994	71.9	(Saville, 1996a)
	Poultry	Kiribati	2011	+	(OIE)
	Poultry	New Caledonia	2005-2007,2011	+	(OIE)
	Poultry	Tonga	1992-1994	87.0	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
Ovine epididymitis	Sheep	New Caledonia	2007, 2011	+	(OIE)
Paratuberculosis (Johne's disease)	Cattle	Cook Islands	1993-1994	16.3	(Saville, 1994)
	Cattle	New Caledonia	2005-2007,2011	+	(OIE)
	Cattle	Palau	1994	10.0	(Saville, 1999)
	Cattle	Solomon Islands	1998	3.1	(T. Martin & Epstein, 1999)
	Cattle	Tonga	2010	+?	(OIE)
	Cattle	Tonga	1992-1994	2.9	(Saville, 1996c)
Pasteurelloses	Goat	Guam	1999	+	(Duguies et al., 2000)
	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2010	+	(OIE)
	Poultry	New Caledonia	2010	+	(OIE)
Salmonellosis	Poultry	Cook Islands	1993-1994	44.4	(Saville, 1994)
	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2010	+	(OIE)
	Poultry	Kiribati	1992-1994	69.1	(Saville, 1996a)
	Poultry	New Caledonia	2010	+	(OIE)
	Poultry	Tonga	1992-1994	40.3	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
	Sheep	New Caledonia	2005-2007,2011	+	(OIE)
Serpulina pilosicoli	Dog	PNG	1997	5.3	(Trott et al., 1997)
	Dog	PNG	1998	+	(Trott, Mikosza, Combs, Oxberry, & Hampson, 1998)
	Pig	PNG	1997	17.0	(Trott et al., 1997)
	Poultry	PNG	1997	50.0	(Trott et al., 1997)
Streptococcus suis type 2	Pig	PNG	1993	47.5	(Paterson et al., 1993)
Swine erysipelas	Pig	Fiji	2008	+	(OIE)
	Pig	New Caledonia	2010	+	(OIE)
	Pig	Samoa	1997	+	(T. Martin, 1999a)
	Pig	Solomon Islands	1998	+	(T. Martin & Epstein, 1999)
	Pig	Wallis & Futuna	1997-1998	+	(T. Martin, 1999c)
Tetanus	Goat	Cook Islands	1993-1994	+	(Saville, 1994)
	Pig	Cook Islands	1993-1994	+	(Saville, 1994)
	Pig	Samoa	1997	+	(T. Martin, 1999a)
Tuberculosis	Cattle	Fiji	2007, 2011	+	(OIE)
	Cattle	Samoa	1997	1.4	(T. Martin, 1999a)

Disease	Species	Country	Date	Key result[a]	Reference
Tuberculosis (cont')	Cattle	Tonga	2011	+?	(OIE)
	Poultry	Guam	1999	28.6	(Duguies et al., 2000)
Vibrionic dysentery	Pig	New Caledonia	2010	+	(OIE)
VIRAL DISEASES					
Akabane virus	Cattle	Palau	1995	30.0	(Saville, 1999)
Aujeszky's disease (Pseudorabies)	Dog	Tonga	1992-1994	+	(Saville, 1996c)
	Pig	Samoa	1997	22.9	(T. Martin, 1999a)
	Pig	Tokelau	1998	86.4	(T. Martin, 1999b)
	Pig	Tonga	1992-1994	50.0	(Saville, 1996c)
	Pig	Tonga	2011	+?	(OIE)
	Pig	Wallis & Futuna	1997-1998	8.5	(T. Martin, 1999c)
Avian infectious bronchitis	Poultry	Cook Islands	1993-1994	24.1	(Saville, 1994)
	Poultry	French Polynesia	2005-2007,2011	+	(OIE)
	Poultry	Guam	1999	49.3	(Duguies et al., 2000)
	Poultry	Kiribati	1992-1994	38.8	(Saville, 1996a)
	Poultry	New Caledonia	2005-2007,2011	+	(OIE)
	Poultry	Niue	1991-93	38.9	(Saville, 1996b)
	Poultry	Palau	1996	90.2	(Saville, 1999)
	Poultry	Samoa	1997	96.7	(T. Martin, 1999a)
	Poultry	Samoa	2005	+?	(OIE)
	Poultry	Solomon Islands	1998	98.3	(T. Martin & Epstein, 1999)
	Poultry	Tokelau	1998	100.0	(T. Martin, 1999b)
	Poultry	Tonga	1992-1994	7.8	(Saville, 1996c)
	Poultry	Wallis & Futuna	1997-1998	88.7	(T. Martin, 1999c)
Avian infectious laryngotracheitis	Poultry	Cook Islands	1993-1994	14.8	(Saville, 1994)
	Poultry	French Polynesia	2007, 2011	+	(OIE)
	Poultry	Guam	1999	52.5	(Duguies et al., 2000)
	Poultry	Kiribati	2011	+	(OIE)
	Poultry	New Caledonia	2005-2008	+	(OIE)
	Poultry	Palau	1996	2.4	(Saville, 1999)
	Poultry	Samoa	1997	7.7	(T. Martin, 1999a)
	Poultry	Samoa	2005	+?	(OIE)
	Poultry	Solomon Islands	1998	50.0	(T. Martin & Epstein, 1999)
	Poultry	Tokelau	1998	92.2	(T. Martin, 1999b)
	Poultry	Tonga	1992-1994	3.9	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
	Poultry	Wallis & Futuna	1997-1998	27.5	(T. Martin, 1999c)
Avian leukosis	Poultry	Kiribati	1992-1994	+	(Saville, 1996a)
Black queen cell virus	Bee	Niue	1992, 1994	+++	(Saville, 1996b)
	Bee	Solomon Islands	1993	2.0	(G. M. Reid & Van Eaton, 1993)
Bluetongue	Cattle	Guam	1999	8.3	(Duguies et al., 2000)
	Cattle	Solomon Islands	1998	4.2	(T. Martin & Epstein, 1999)

Disease	Species	Country	Date	Key result[a]	Reference
Bluetongue (cont')	Multi species	PNG	2011	+?	(OIE)
Bovine virus diarrhea	Cattle	Cook Islands	1993-1994	16.3	(Saville, 1994)
	Cattle	French Polynesia	2006-2007,2011	+	(OIE)
	Cattle	New Caledonia	2006-2007,2011	+	(OIE)
	Cattle	Samoa	1997	45.3	(T. Martin, 1999a)
	Cattle	Tonga	1992-1994	8.2	(Saville, 1996c)
	Cattle	Tonga	2011	+?	(OIE)
Caprine arthritis encephalitis	Goat	Palau	1996	16.7	(Saville, 1999)
Chronic paralysis virus	Bee	Niue	1992, 1994	+	(Saville, 1996b)
	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Solomon Islands	1993	+++	(G. M. Reid & Van Eaton, 1993)
Enterovirus encephalomyelitis	Pig	Cook Islands	1993-1994	+	(Saville, 1994)
Enzootic bovine leukosis	Cattle	French Polynesia	2005-2007, 2011	+	(OIE)
	Cattle	Guam	1999	11.8	(Duguies et al., 2000)
	Cattle	Palau	1994	44.4	(Saville, 1999)
	Cattle	Solomon Islands	1998	2.7	(T. Martin & Epstein, 1999)
	Cattle	Tonga	1992-1994	1.2	(Saville, 1996c)
Enzootic bovine leukosis	Cattle	Tonga	2010	+?	(OIE)
	Cattle	Vanuatu	2005	+?	(OIE)
Equine influenza	Horse	Guam	1999	25.2	(Duguies et al., 2000)
Equine rhinopneumonitis	Horse	Guam	1999	67.9	(Duguies et al., 2000)
	Horse	New Caledonia	2005-2007,2011	+	(OIE)
	Horse	Samoa	1997	36.5	(T. Martin, 1999a)
	Horse	Samoa	2005	+	(OIE)
	Horse	Solomon Islands	1998	71.0	(T. Martin & Epstein, 1999)
	Horse	Tonga	1992-1994	1.1	(Saville, 1996c)
	Horse	Tonga	2010	+?	(OIE)
	Horse	Wallis & Futuna	1997-1998	16.7	(T. Martin, 1999c)
Fowl pox	Poultry	Cook Islands	1993-1994	+	(Saville, 1994)
	Poultry	French Polynesia	2005	+	(OIE)
	Poultry	Kiribati	1992-1994	+++	(Saville, 1996a)
	Poultry	New Caledonia	2005	+	(OIE)
	Poultry	Palau	1996	+	(Saville, 1999)
	Poultry	Samoa	1997	+	(T. Martin, 1999a)
	Poultry	Samoa	2005	+	(OIE)
	Poultry	Tonga	1992-1994	+++	(Saville, 1996c)
Getah virus	Horse	Oceania	2000	+++	(Fukunaga, Kumanomido, & Kamada, 2000)
Hepatitis E virus	Pig	New Caledonia	2011	6.5	(Kaba, Davoust, Cabre, & Colson, 2011)
Infectious bovine rhinotracheitis	Cattle	French Polynesia	2005-2007,2011	+	(OIE)
	Cattle	Guam	1999	2.8	(Duguies et al., 2000)
	Cattle	New Caledonia	1991	45.8	(Vilain, Thevenon, Costa, & Rantoen, 1994)
	Cattle	New Caledonia	2005-2007,2011	+	(OIE)

Disease	Species	Country	Date	Key result[a]	Reference
Infectious bovine rhinotracheitis (cont')	Cattle	Palau	1994	50.0	(Saville, 1999)
	Cattle	Samoa	1997	68.7	(T. Martin, 1999a)
	Cattle	Solomon Islands	1998	52.7	(T. Martin & Epstein, 1999)
	Cattle	Tonga	1992-1994	18.1	(Saville, 1996c)
	Cattle	Tonga	2010	+?	(OIE)
	Cattle	Vanuatu	2005	+?	(OIE)
Infectious Bursal Disease (Gumboro)	Poultry	Cook Islands	1993-1994	37.1	(Saville, 1994)
	Poultry	Fiji	2007	+?	(OIE)
	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2005-2007,2011	+	(OIE)
	Poultry	Guam	1999	73.9	(Duguies et al., 2000)
	Poultry	Kiribati	1992-1994	67.4	(Saville, 1996a)
	Poultry	Kiribati	2011	+	(OIE)
	Poultry	New Caledonia	2005-2007,2011	+	(OIE)
	Poultry	Niue	1991-93	15.0	(Saville, 1996b)
	Poultry	Palau	1996	12.2	(Saville, 1999)
	Poultry	PNG	2011	+?	(OIE)
	Poultry	Samoa	1997	22.5	(T. Martin, 1999a)
	Poultry	Solomon Islands	1998	2.7	(T. Martin & Epstein, 1999)
	Poultry	Tokelau	1998	72.2	(T. Martin, 1999b)
	Poultry	Tonga	1992-1994	45.5	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
	Poultry	Wallis & Futuna	1997-1998	92.9	(T. Martin, 1999c)
Japanese encephalitis virus	Horse	Samoa	1997	10.2	(T. Martin, 1999a)
	Multi species	PNG	2011	+?	(OIE)
Kashmir bee virus	Bee	Solomon Islands	1993	13.9	(G. M. Reid & Van Eaton, 1993)
Low pathogenic avian influenza	Poultry	PNG	2011	+?	(OIE)
Malignant catarrhal fever	Cattle	New Caledonia	2005-2006	+	(OIE)
Marek's disease	Poultry	Cook Islands	1993-1994	25.9	(Saville, 1994)
	Poultry	French Polynesia	2005-2007,2011	+	(OIE)
	Poultry	Guam	1999	44.1	(Duguies et al., 2000)
	Poultry	Kiribati	1992-1994	3.9	(Saville, 1996a)
	Poultry	New Caledonia	2005-2007,2011	+	(OIE)
	Poultry	Niue	1991-93	5.0	(Saville, 1996b)
	Poultry	Palau	1996	46.3	(Saville, 1999)
	Poultry	Samoa	1997	39.6	(T. Martin, 1999a)
	Poultry	Solomon Islands	1998	54.0	(T. Martin & Epstein, 1999)
	Poultry	Tokelau	1998	11.2	(T. Martin, 1999b)
	Poultry	Tonga	1992-1994	36.4	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
	Poultry	Wallis & Futuna	1997-1998	5.7	(T. Martin, 1999c)
Murray valley encephalitis virus	Poultry	PNG	2011	+++	(Schuster, Ebert, Stevenson, Corner, & Johansen, 2011)

Disease	Species	Country	Date	Key result[a]	Reference
Newcastle disease	Poultry	Cook Islands	1993-1994	15.4	(Saville, 1994)
	Poultry	Kiribati	1992-1994	56.2	(Saville, 1996a)
	Poultry	Tonga	1992-1994	41.6	(Saville, 1996c)
	Poultry	Tonga	2010	+?	(OIE)
Parvovirus	Dog	Kiribati	1992-1994	+	(Saville, 1996a)
	Dog	Samoa	1997	80.0	(T. Martin, 1999a)
	Dog	Tonga	1992-1994	+	(Saville, 1996c)
	Dog	Wallis & Futuna	1997-1998	25.0	(T. Martin, 1999c)
	Pig	Cook Islands	1993-1994	25.0	(Saville, 1994)
	Pig	Guam	1999	50.0	(Duguies et al., 2000)
	Pig	Kiribati	1992-1994	10.0	(Saville, 1996a)
	Pig	Tokelau	1998	97.7	(T. Martin, 1999b)
	Pig	Wallis & Futuna	1997-1998	+	(T. Martin, 1999c)
Porcine respiratory and reproductive syndrome	Pig	French Polynesia	2006-2007,2011	+	(OIE)
Q fever	Cattle	Guam	1999	1.4	(Duguies et al., 2000)
	Goat	Guam	1998	8.6	(Duguies et al., 2000)
	Goat	Solomon Islands	1998	3.1	(T. Martin & Epstein, 1999)
	Multi species	Vanuatu	2011	+?	(OIE)
Ross River virus	Multi species	Oceania	1995	+++	(Sammels, Coelen, Lindsay, & Mackenzie, 1995)
	Multi species	PNG	2001	+++	(Harley, Sleigh, & Ritchie, 2001)
Rotavirus	Pig	Solomon Islands	1998	71.4	(T. Martin & Epstein, 1999)
Sacbrood virus	Bee	Niue	1992, 1994	+	(Saville, 1996b)
	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Solomon Islands	1993	7.9	(G. M. Reid & Van Eaton, 1993)
Transmissible gastroenteritis	Pig	French Polynesia	2011	+	(OIE)
Turkey rhinotracheitis	Poultry	French Polynesia	2006-2007	+	(OIE)
PARASITIC DISEASES					
Amoeba disease	Bee	Niue	1992, 1994	+	(Saville, 1996b)
Ancylostomiasis	Cat	New Caledonia	1993	+	(Beugnet & Gadat, 1993)
	Dog	New Caledonia	1993	+	(Beugnet & Gadat, 1993)
Babesiosis	Cattle	French Polynesia	2005-2007,2011	+	(OIE)
	Cattle	New Caledonia	2007	+	(Barre et al., 2011)
	Cattle	New Caledonia	2008	+	(S. Martin, 2009)
	Cattle	New Caledonia	2011	+	(OIE)
	Cattle	Samoa	1997	8.5	(T. Martin, 1999a)
	Cattle	Samoa	2008	+	(OIE)
	Cattle	Solomon Islands	1998	6.9	(T. Martin & Epstein, 1999)
	Cattle	Tonga	1992-1994	0.6	(Saville, 1996c)
Capillariasis	Dog	Samoa	2010-2011	2.0	(Carslake et al., 2012)
Coccidiosis	Poultry	Fiji	2008	+	(OIE)
	Poultry	French Polynesia	2010	+	(OIE)
	Poultry	New Caledonia	2010	+	(OIE)

Disease	Species	Country	Date	Key result[a]	Reference
Contagious pustular dermatitis	Multi species	New Caledonia	2009	+	(OIE)
Crocodylocapillaria longiovata	Crocodile	PNG	1998	+	(Moravec & Spratt, 1998)
Dermatophilosis	Cattle	Guam	1999	+	(Duguies et al., 2000)
	Goat	Cook Islands	1993-1994	+	(Saville, 1994)
	Goat	Kiribati	1992-1994	100.0	(Saville, 1996a)
Dipylidiasis	Dog	Samoa	2010-2011	4.4	(Carslake et al., 2012)
	Dog	New Caledonia	1993	57.0	(Beugnet, Bimablum, & Chardonnet, 1993)
	Dog	New Caledonia	1994	50.3	(Beugnet, Rous, Leurs, & Chardonnet, 1994)
	Dog	New Caledonia	2009	22.4	(Watier-Grillot, Marie, Cabre, & Davoust, 2011)
	Dog	Samoa	1980	+++	(Samarawickrema, Kimura, Sones, Paulson, & Cummings, 1992)
	Dog	Samoa	2010-2011	46.8	(Carslake et al., 2012)
Ehrlichiosis	Dog	Samoa	1997	60.0	(T. Martin, 1999a)
	Dog	Wallis & Futuna	1997-1998	71.4	(T. Martin, 1999c)
Fasciolosis	Cattle	Samoa	1997	+	(T. Martin, 1999a)
Filariosis	Multi species	French Polynesia	2010	+	(OIE)
	Multi species	New Caledonia	2010	+	(OIE)
Fleas	Dog	Samoa	2010-2011	83.7	(Carslake et al., 2012)
Gastrointestinal parasites	Goat	Fiji	1996	+	(Manueli, 1996)
	Goat	PNG	2011	89.1	(Koinari, Karl, Ryan, & Lymbery, 2012)
	Sheep	Fiji	1996	+	(Manueli, 1996)
	Sheep	PNG	2011	71.8	(Koinari et al., 2012)
Giardiasis	Dog	Samoa	2010-2011	14.6	(Carslake et al., 2012)
Hippoboscidae	Pigeon	New Caledonia	1996	+	(Beugnet, Gadat, & Chardonnet, 1996)
Hookworm	Dog	Samoa	2010-2011	90.7	(Carslake et al., 2012)
Leishmaniosis	Dog	New Caledonia	2011	+	(OIE)
Lice	Dog	Samoa	2010-2011	8.1	(Carslake et al., 2012)
Mallophaga lice species	Pigeon	New Caledonia	1997	+	(Beugnet et al., 1996)
Mammomonogamus spp.	Cat	CNMI	2008	+	(Tudor, Lee, Armato, & Bowman, 2008)
Mange	Sheep	New Caledonia	2008	+	(OIE)
Mites	Bee	Niue	1998	+	(SPC, 2004c)
	Bee	Samoa	1996	+	(SPC, 2004d)
Nematophagous fungi	Goat	Fiji	1999	+	(Manueli, Waller, Faedo, & Mahommed, 1999)
	Sheep	Fiji	1999	+	(Manueli et al., 1999)
Nosemosis	Bee	Fiji	2008	+	(OIE)
	Bee	New Caledonia	2010	+	(OIE)
	Bee	Niue	1992, 1994	+++	(Saville, 1996b)
	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Solomon Islands	1993	31.0	(G. M. Reid & Van Eaton, 1993)
Pentastomid parasites	Crocodile	Oceania	2006	+	(Junker & Boomker, 2006)
Rhipicephalus spp.	Cattle	French Polynesia	2010	+	(Barre & Uilenberg, 2010)
	Cattle	New Caledonia	1995	+++	(Beugnet & Chardonnet, 1995)
	Cattle	New Caledonia	2010	+	(Barre & Uilenberg, 2010)

Disease	Species	Country	Date	Key result[a]	Reference
Rhipicephalus spp. (cont')	Cattle	New Caledonia	2010	+	(De Meeus, Koffi, Barre, de Garine-Wichatitsky, & Chevillon, 2010)
	Cattle	PNG	2010	+	(Barre & Uilenberg, 2010)
Rickettsia africae	Bird	New Caledonia	2001-2007	+	(Eldin et al., 2011)
Screwworm (C. Bezziana)	Multi species	PNG	2011	+	(OIE)
Subcutaneous filarial worm	Pigeon	New Caledonia	1996	+	(Beugnet et al., 1996)
Theileriosis	Cattle	New Caledonia	2011	+	(OIE)
	Cattle	Palau	1994	22.2	(Saville, 1999)
	Cattle	Samoa	1997	82.6	(T. Martin, 1999a)
	Cattle	Samoa	2008	+	(OIE)
	Cattle	Solomon Islands	1998	16.5	(T. Martin & Epstein, 1999)
	Cattle	Tonga	1992-1994	29.8	(Saville, 1996c)
	Cattle	Tonga	2010	333.0	(OIE)
Ticks	Dog	Samoa	2010-2011	42.1	(Carslake et al., 2012)
Toxocariasis	Cat	New Caledonia	1993	+	(Beugnet & Gadat, 1993)
	Dog	New Caledonia	1993	+	(Beugnet & Gadat, 1993)
	Dog	Samoa	2010-2011	3.4	(Carslake et al., 2012)
Toxoplasmosis	Cat	New Caledonia	2009	50.0	(Roqueplo, Halos, Cabre, & Davoust, 2011)
	Cattle	New Caledonia	2009	3.3	(Roqueplo et al., 2011)
	Deer	New Caledonia	2009	13.8	(Roqueplo et al., 2011)
	Dog	New Caledonia	2009	32.8	(Roqueplo et al., 2011)
	Goat	Cook Islands	1993-1994	63.3	(Saville, 1994)
	Goat	Guam	1998	51.6	(Duguies et al., 2000)
	Goat	Kiribati	1992-1994	100.0	(Saville, 1996a)
	Goat	Niue	1992, 1994	87.5	(Saville, 1996b)
	Goat	Palau	1996	100.0	(Saville, 1999)
	Goat	Solomon Islands	1998	84.4	(T. Martin & Epstein, 1999)
	Goat	Tonga	1992-1994	52.0	(Saville, 1996c)
	Horse	New Caledonia	2009	16.0	(Roqueplo et al., 2011)
	Multi species	Fiji	2008	+	(OIE)
	Multi species	New Caledonia	2008	+	(OIE)
	Pig	New Caledonia	2009	2.0	(Roqueplo et al., 2011)
Trichinellosis	Crocodile	PNG	2004	11.1	(Edoardo Pozio, Owen, Marucci, & La Rosa, 2004)
	Crocodile	PNG	2005	21.2	(E. Pozio, Owen, Marucci, & La Rosa, 2005)
	Pig	Cook Islands	1993-1994	25.4	(Saville, 1994)
	Pig	Fiji	2001	+	(S. Reid et al., 2001)
	Pig	Kiribati	2001	+	(S. Reid et al., 2001)
	Pig	Kiribati	2011	+	(OIE)
	Pig	Kiribati	1992-1994	44.7	(Saville, 1996a)
	Pig	Palau	1996	1.7	(Saville, 1999)
	Pig	PNG	1988-1998	+	(E. Pozio et al., 1999)
	Pig	PNG	2000	+	(Owen, Sims, Wigglesworth, & Puana, 2000)
	Pig	PNG	2001	+++	(S. Reid et al., 2001)

Disease	**Species**	**Country**	**Date**	**Key result[a]**	**Reference**
Trichinellosis (cont')	Pig	PNG	2005	12.3	(E. Pozio et al., 2005)
	Pig	PNG	2011	+	(OIE)
	Pig	Samoa	1997	6.7	(T. Martin, 1999a)
	Pig	Solomon Islands	1998	1.6	(T. Martin & Epstein, 1999)
	Pig	Tonga	2010	+?	(OIE)
	Pig	Wallis & Futuna	1997-1998	0.6	(T. Martin, 1999c)
Trichomonosis	Multi species	New Caledonia	2005-2007,2011	+	(OIE)
Trichophyton verrucosum	Deer	New Caledonia	1994	+++	(Lebel & Beugnet, 1994)
Trichuris spp.	Dog	Samoa	2010-2011	6.9	(Carslake et al., 2012)
Tropilaelaps infestation	Bee	PNG	2011	+	(OIE)
Trypanosomosis	Dog	PNG	1998	+	(S. A. Reid & Copeman, 2003)
	Goat	PNG	1998	+	(S. A. Reid & Copeman, 2003)
	Horse	PNG	1998	+	(S. A. Reid & Copeman, 2003)
	Pig	PNG	1998	+	(S. A. Reid & Copeman, 2003)
Varroasis	Bee	PNG	2011	+	(OIE)
OTHER DISEASES					
Chalkbrood	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Tonga	1991	+	(SPC, 2004e)
Equine leucoencephalomalacia	Horse	New Caledonia	1996	+	(Le Bars & Le Bars, 1996)
Half moon disorder	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Solomon Islands	1993	+	(G. M. Reid & Van Eaton, 1993)
Heat-stable enterotoxin II -producing E. coli	Pig	New Caledonia	1994	+	(Germani et al., 1994)
Shiga-like toxin I-producing E. Coli	Cattle	New Caledonia	1994	+	(Germani et al., 1994)
Wax moth	Bee	Niue	1992, 1994	+	(Saville, 1996b)
	Bee	Samoa	1996	+	(SPC, 2004d)
	Bee	Solomon Islands	1993	+	(G. M. Reid & Van Eaton, 1993)

[a] Key result: Estimated prevalence in %
+: Disease clinically observed, detected or reported as present
+++: Disease enzootic or very common
+? : Disease suspected to be present

Table 2-3: Animal diseases not detected or reported as not present in the Pacific Islands region (selected references from 1992 to 2012)

Animal diseases	Cook Islands[a]	Fiji[b]	Guam[c]	Kiribati[d]	New Caledonia[e]	Niue[f]	Oceania[g]	Palau[h]	PNG[i]	Samoa[j]	Solomon Islands[k]	Tokelau[l]	Tonga[m]	Vanuatu[n]	Wallis & Futuna[o]
Bacterial diseases															
Anaplasmosis															
Cattle	1993							1995					1992		
Avian encephalomyelitis															
Poultry						1991									
Bartonellosis															
Dog					2009										
Horse					2009										
Borreliosis															
Dog										2010					
Brucellosis															
Carabao			1999												
Cattle	1993		1999			1992		1994			1998		1992		
Dog										1997					1997
Goat	1993		1998			1992		1996			1998		1992		1997
Pig	1993		1999	1992		1994		1996		1997	1998	1998			1997
Enzootic pneumonia															
Pig			1999												
European foulbrood															
Bee											1993				
Leptospirosis															
Cat		2002													
Cattle			1999			1992			2006						
Goat															1997
Horse									2006						
Pig			1999	1992											
Paratuberculosis (Johne's disease)															
Cattle			1999			1992				1997					
Goat	1993										1998				1997
Psittacosis															
Poultry						1991									
Salmonellosis															
Poultry						1991									
Tuberculosis															
Carabao			1999												
Cattle	1993		1999			1992		1994			1998		1992		
Goat	1993		1998												

Animal diseases	Cook Islands[a]	Fiji[b]	Guam[c]	Kiribati[d]	New Caledonia[e]	Niue[f]	Oceania[g]	Palau[h]	PNG[i]	Samoa[j]	Solomon Islands[k]	Tokelau[l]	Tonga[m]	Vanuatu[n]	Wallis & Futuna[o]
Viral diseases															
Akabane virus															
Cattle	1993												1992		
Aujeszky's disease (Pseudorabies)															
Pig	1993		1999	1992		1994		1996			1998				
Avian infectious laryngotracheitis															
Poultry						1991									
Avian influenza															
Poultry	1993		1999	1992		1991	2003	1996		1997	1998	1998	1992		1997
Bluetongue															
Carabao			1999												
Cattle	1993					1992		1994		1997			1992		
Goat	1993		1998	1992		1992		1996			1998		1992		1997
Bovine ephemeral fever															
Cattle	1993					1992		1995					1992		
Bovine virus diarrhea															
Cattle						1992		1994			1998				
Canine distemper virus															
Dog										1997					1997
Caprine arthritis encephalitis															
Goat	1993		1998	1992		1992							1992		1997
Classical swine fever															
Pig				1992				1996		1997		1998			1997
Enzootic bovine leukosis															
Cattle	1993					1992				1997					
Equine infectious anaemia															
Horse	1993		1999							1997	1998		1992		1997
Equine influenza															
Horse	1993									1997			1992		
Equine rhinopneumonitis															
Horse	1993														
Equine viral arteritis															
Horse			1999								1998				1997
Foot and mouth disease															
Cattle	1993														
Goat	1993														
Pig	1993														
Infectious bovine rhinotracheitis															
Carabao			1999												
Cattle	1993					1992									

Animal diseases	Cook Islands[a]	Fiji[b]	Guam[c]	Kiribati[d]	New Caledonia[e]	Niue[f]	Oceania[g]	Palau[h]	PNG[i]	Samoa[j]	Solomon Islands[k]	Tokelau[l]	Tonga[m]	Vanuatu[n]	Wallis & Futuna[o]
Japanese encephalitis virus															
Dog										1997					1997
Goat										1997					1997
Horse			1999												1997
Pig								1997		1997		1998			1997
Newcastle disease															
Poultry		2000	1999			1991		1996		1997	1998	1998			1997
Porcine respiratory and reproductive syndrome															
Pig			1999					1996		1997	1998	1998			1997
Porcine rotavirus															
Pig						1994									
Q fever															
Carabao			1999												
Cattle						1992									
Goat	1993			1992		1992		1996					1992		1997
Simbu serogroup															
Cattle	1993							1995					1992		
Swine influenza															
Pig			1999												
Transmissible gastroenteritis															
Pig			1999							1997	1998	1998			1997
Vesicular stomatitis															
Cattle	1993														
Goat	1993														
Horse	1993														
Pig	1993														
Parasitic diseases															
Amblyomma spp.															
Bird							2010								
Cattle					2010		2010								
Avian malaria															
Poultry				1992											
Babesiosis															
Carabao			1999												
Cattle	1993		1999			1992		1995							
Cryptosporidiosis															
Dog										2010					
Cysticercosis															
Dog									1999						
Pig									1999						

Animal diseases	Cook Islands[a]	Fiji[b]	Guam[c]	Kiribati[d]	New Caledonia[e]	Niue[f]	Oceania[g]	Palau[h]	PNG[i]	Samoa[j]	Solomon Islands[k]	Tokelau[l]	Tonga[m]	Vanuatu[n]	Wallis & Futuna[o]
Ehrlichiosis															
Dog										2010					
Leishmaniosis															
Dog										2010					
Rhipicephalus spp.															
Cattle		2010											2010	2010	
Theileriosis															
Cattle	1993					1992									
Toxoplasmosis															
Goat															1997
Trichinellosis															
Pig			1999			1994			2000			1998	1992		
Trypanosomosis															
Cattle									1998						
Deer									1998						
Multi species									2002						

Dates presented in the table above represent the year the study was conducted or the year the disease report was released.

[a] (Saville, 1994)
[b] (Angus, 2001; Barre & Uilenberg, 2010; Lupo, 2003)
[c] (Duguies, Nusbaum, & Saville, 2000)
[d] (Saville, 1996a)
[e] (Barre & Uilenberg, 2010; Mediannikov, Davoust, Cabre, Rolain, & Raoult, 2011)
[f] (Saville, 1996b)
[g] (Barre & Uilenberg, 2010; Senne, 2003)
[h] (Saville, 1999)
[i] (Owen, 2006; Owen, Sims, Wigglesworth, & Puana, 2000; S. A. Reid, 2002; S. A. Reid & Copeman, 2000; Wai'in, 2007)
[j] (Carslake, Hill, Sjolander, Prattley, & Acke, 2012; Martin, 1999a)
[k] (Martin & Epstein, 1999; G. M. Reid & Van Eaton, 1993)
[l] (Martin, 1999b)
[m] (Barre & Uilenberg, 2010; Saville, 1996c)
[n] (Barre & Uilenberg, 2010)
[o] (Martin, 1999c)

DISCUSSION

Data and language limitations

While the original objective of our work was to conduct a meta analysis, we found that too few up-to-date studies were available to do so. Therefore, the work presented in this paper resulted in being a descriptive review of the data available on domestic animal diseases in the Pacific Islands region. The only similar kind of work performed is an annotated bibliography on animal husbandry and diseases in the Pacific area dating from 1966 (Pacific Science Information Center Bernice P. Bishop Museum Honolulu, 1966). The work presented in this present paper may help fill the gap in knowledge of animal diseases for the region and should give a wider access to currently available data.

Thanks to the access to the database available at the Secretariat for the Pacific Community and because we were able to review papers written either in English or in French (which are the 2 main official languages in the region), we think that we have been able to retrieve and analyse the majority and the most relevant references available on domestic animal diseases in the Pacific Islands region. It is acknowledged that the PICTs may have individually conducted animal disease studies without publishing the results on the databases selected for this study. This data would thus be missing in this literature review.

This review has extracted data from grey literature usually only accessible to a limited number of stakeholders within the Pacific Islands region and made this available to the scientific community. However, the possibility of intentional non-reporting or public disclosure of animal diseases for fear of the negative impact on trade and tourism cannot be excluded.

The type of data collected varied between papers and reports. Some studies presenting only one piece of information for a particular animal disease in one species and for only one PICT while other studies gave an extensive list of data for several animal diseases studied in multiple species. In particular, SPC has conducted a series of animal disease surveys in 10 PICTs between 1994 and 2000 that provide an extensive amount of information for the main animal diseases in the region. However these data are already about 15 years old and would benefit from updated methods of disease detection.

The large number of references providing information for PNG and New Caledonia presumably reflects the interest and the investment in terms of animal disease surveillance and investigation done in these two countries by Australia and France respectively. This literature review shows that for 17 other PICTs less than five references were retrieved per country, emphasising the lack of information or lack of diseases in these countries.

The fact that a majority of data compiled focused on parasitic diseases may reflect the particular interest in such diseases in this part of the world and/or may indicate that these diseases are a main issue faced by local farmers. But it may also reflect the fact that few PICTs are actually equipped with diagnostic laboratories and most of the PICTs have to send samples abroad for a proper laboratory diagnosis of bacterial or viral diseases.

Our literature review shows that there is no clearly defined focus on a specific disease in the Pacific Islands region and that the research done so far in the region does not seem to highlight any one disease of particular significance to a single PICT or the region generally.

Most of the published data was related to cattle and pigs and this may reflect the importance of these two species for the livestock industry in the region but also the very particular role of pigs in Pacific society for traditional and social events (SPC, 2007). However, the proportionally limited amount of data retrieved for poultry is surprising considering the importance of that sector in most of the PICTs at the commercial and semi-commercial level but also at the village level as a subsistence product for locals.

Diseases of zoonotic interest to the region

In the literature reviewed, all samples tested for avian influenza were reported to be negative. The studies did not specify which strains were tested but our database query assessed whether there had been signs of pathology and/or high mortality in the local poultry population if a virulent strain was circulating in any of the PICTs. Only a low pathogenic strain of avian influenza was suspected in PNG in 2011 (OIE, 2011).

Leptospirosis is an endemic zoonosis in Oceania (Kline, McCarthy, Pearson, Loukas, & Hotez, 2013) and is consistently reported as present in animals by the OIE member countries. The latest sero-prevalence studies on animals are from 2002 in Fiji (Lupo, 2003) and 2006 in PNG (Wai'in, 2007). Recent public health studies have been conducted in American Samoa and have been looking at the risk factors related to backyard piggeries (Lau, Clements, et al., 2012; Lau & DePasquale, 2012; Lau, Dobson, et al., 2012). More studies within the susceptible animal populations and extended to the other PICTs are required to complement these studies in American Samoa.

Animal disease reports submitted for the year 2011 to OIE confirmed the presence of Brucellosis in Fiji and French Polynesia and suspicion of occurrence in Tonga. The only recent sero-prevalence study retrieved for this disease was conducted in Wallis and Futuna islands (Antras & Garin-Bastuji, 2011).

Domestic animals are known to be the hosts of some arboviral infections such as Japanese encephalistis, Murray Valley encephalitis and Ross River virus (Kuno, 2001; Russell, 2002; Sabchareon & Yoksan, 1998) but only very limited information on these diseases was retrieved for domestic animals while they are identified as being of major importance in Oceania from a public health perspective (Kline et al., 2013).

Based on the references retrieved through this literature search, rabies has not been detected or reported in domestic animals since 1992 and this status seems to be confirmed by the "no" to "low" risk for humans of contracting rabies within the PICTs ((WHO, 2008, 2011). Bat rabies was nevertheless reported as "present" in the Oceania region in 2007 (WHO, 2007).

Diseases of economic importance and potential risk to the region:

Foot and Mouth disease and Classical Swine Fever are reported in various countries of South East Asia but PICTs seem to have remained free of these transboundary diseases. Similarly, Porcine respiratory and reproductive syndrome is now widely spreading in various parts of Asia (An, Tian, Leng, Peng, & Tong, 2011), but within our PICT survey seems only to have been detected in French Polynesia. (OIE, 2011). The Pacific Islands region therefore appears to be relatively free of economically important diseases. In an area composed of 25,000 islands dispersed over 180 million square kilometres and hosting 9 million people it is a challenge to maintain a disease free environment. So far, the Pacific region is said to have a “favourable animal health status” with almost no serious livestock diseases. Nevertheless, these statements have to be viewed with caution by the fact that many PICTs do not have adequate animal disease surveillance and reporting systems to confirm this status (Secretariat of the Pacific Community, 2009a, 2009b). However, an AusAID funded project is currently supporting the establishment of a network of laboratories in the region to address this issue (personal communication, Fiona Clarke, Senior Program Officer, Department of Foreign Affairs and Trade, Dec 2013).

Besides giving the PICTs the opportunity to access international markets, establishing and maintaining a national animal disease surveillance and information management system would create in-country benefits by enabling early detection of disease outbreaks and emerging diseases and reduce the impact of endemic diseases (Secretariat of the Pacific Community, 2009a)

CONCLUSION

This paper reviews the current knowledge on domestic animal diseases in 22 PICTs with an emphasis on data from 1992 to 2012 and shows that very little information is available for this region. While our review was seeking information on any domestic animal disease, no single disease appears to be a principal concern for the region. Considering the very broad scope of this review in terms of animal diseases, retrieved literature is scarce and no longer up-to-date. This paper stresses the need for more investment on animal disease status in Pacific Islands region, particularly given the tropical environment and ideal conditions for disease emergence. Responsible, commensurate investments and international coordination are needed to improve the knowledge of the current animal health status in the region and to enable PICTs wishing to control diseases of public health concern or to access international trade in live animals and animal products.

ACKNOWLEDGEMENTS

This review was conducted in partnership between the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC) and the School of Veterinary and Biomedical Sciences of James Cook University (JCU), Townsville, Queensland, Australia as part of the Food Animal Biosecurity Network. The project received funding support under the Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government.

We are most grateful to the Secretariat for the Pacific Community who provided access to their databases.

REFERENCES

An, T.Q., Tian, Z.J., Leng, C.L., Peng, J.M., Tong, G.Z., 2011. Highly pathogenic porcine reproductive and respiratory syndrome virus, Asia. Emerg Infect Dis 17, 1782-1784.

Angus, S.D., 1986. Epidemiology and control of Helminth infections of domestic livestock on Pacific atolls, Master of Science in Tropical Veterinary Medicine - Center for Tropical Veterinary Medicine University of Edinburgh, 75 pp.

Angus, S.D., 2001. A Survey to Determine the Status of the Fiji Islands Concerning Newcastle Disease, Volume 221 of SPC technical paper Secretariat of the Pacific Community. 24 pp.

Antras, V., Garin-Bastuji, B., 2011. La brucellose porcine a Wallis et Futuna, Bulletin Epidemiologique, Sante Animale et Alimentation, pp. 31-34.

Barre, N., Happold, J., Delathiere, J.M., Desoutter, D., Salery, M., de Vos, A., Marchal, C., Perrot, R., Grailles, M., Mortelecque, A., 2011. A campaign to eradicate bovine babesiosis from New Caledonia. Ticks Tick Borne Dis 2, 55-61.

Barre, N., Uilenberg, G., 2010. Spread of parasites transported with their hosts: case study of two species of cattle tick. Rev Sci Tech 29, 149-160, 135-147.

Beugnet, F., Bimablum, S., Chardonnet, L., 1993. Epidemiologic-study of dog dirofilariasis in New-Caledonia - Choice of a diagnosis methodology. Revue De Medecine Veterinaire 144, 891-897.

Beugnet, F., Chardonnet, L., 1995. Tick resistance to pyrethroids in New Caledonia. Veterinary Parasitology 56, 325-338.

Beugnet, F., Gadat, R., 1993. Survey on Toxocara spp eggs and Ancylostoma spp larvae in soil extracts from Noumea, New-Caledonia. Revue De Medecine Veterinaire 144, 523-525.

Beugnet, F., Gadat, R., Chardonnet, L., 1996. Parasitologic note: Parasites of Notu (Ducula goliath, Columbiform). About some observations. Recueil De Medecine Veterinaire 172, 421-424.

Beugnet, F., Rous, V., Leurs, M., Chardonnet, L., 1994. Age in cardiopulmonary Dirofilariasis of dog - Consequences on chemoprophylaxis. Revue De Medecine Veterinaire 145, 59-64.

Carslake, R.J., Hill, K.E., Sjolander, K., Prattley, D., Acke, E., 2012. Prevalence of selected infectious diseases in the Samoan dogs. Journal of Veterinary Internal Medicine 26, 788-788.

De Meeus, T., Koffi, B.B., Barre, N., de Garine-Wichatitsky, M., Chevillon, C., 2010. Swift sympatric adaptation of a species of cattle tick to a new deer host in New Caledonia. Infect Genet Evol 10, 976-983.

Desvars, A., Cardinale, E., Michault, A., 2011. Animal leptospirosis in small tropical areas. Epidemiol Infect 139, 167-188.

Duguies, M., Nusbaum, S., Saville, P., 2000. ADAP Animal Health Survey for Guam 1999. American Samoa Community College, College of Micronesia, Northern Marianas College, University of Guam, and University of Hawaii., 24 pp.

Eldin, C., Mediannikov, O., Davoust, B., Cabre, O., Barre, N., Raoult, D., Parola, P., 2011. Emergence of Rickettsia africae, Oceania. Emerg Infect Dis 17, 100-102.

Fukunaga, Y., Kumanomido, T., Kamada, M., 2000. Getah virus as an equine pathogen. Vet Clin North Am Equine Pract 16, 605-617.

Garin, B., Gouali, M., Wouafo, M., Perchec, A.-M., Pham Minh, T., Ravaonindrina, N., Urbes, F., Gay, M., Diawara, A., Leclercq, A., Rocourt, J., Pouillot, R., 2012. Prevalence, quantification and antimicrobial resistance of Campylobacter spp. on chicken neck-skins at points of slaughter in 5 major cities located on 4 continents. International Journal of Food Microbiology 157, 102-107.

Germani, Y., Morillon, M., Begaud, E., Dubourdieu, H., Costa, R., Thevenon, J., 1994. Two-year study of endemic enteric pathogens associated with acute diarrhea in New Caledonia. J Clin Microbiol 32, 1532-1536.

Gummow, B., 2010. Challenges posed by new and re-emerging infectious diseases in livestock production, wildlife and humans. Livestock Science, 130 (1-3). pp. 41-46.

Harley, D., Sleigh, A., Ritchie, S., 2001. Ross River virus transmission, infection, and disease: a cross-disciplinary review. Clin Microbiol Rev 14, 909-932.

Hide, R., 2003. Pig husbandry in New Guinea. A literature review and bibliography.ACIAR Monograph No. 108, xvi + 291 pp.

Huchzermeyer, F.W., Langelet, E., Putterill, J.F., 2008. An outbreak of chlamydiosis in farmed Indopacific crocodiles (Crocodylus porosus). J S Afr Vet Assoc 79, 99-100.

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L., Daszak, P., 2008. Global trends in emerging infectious diseases. Nature 451, 990-993.

Junker, K., Boomker, J., 2006. Check-list of the pentastomid parasites crocodilians and freshwater chelonians. Onderstepoort J Vet Res 73, 27-36.

Kaba, M., Davoust, B., Cabre, O., Colson, P., 2011. Hepatitis E virus genotype 3f in pigs in New Caledonia. Aust Vet J 89, 496-499.

Kline, K., McCarthy, J.S., Pearson, M., Loukas, A., Hotez, P.J., 2013. Neglected tropical diseases of Oceania: review of their prevalence, distribution, and opportunities for control. Plos Neglected Tropical Diseases 7, e1755.

Koinari, M., Karl, S., Ryan, U., Lymbery, A.J., 2012. Infection levels of gastrointestinal parasites in sheep and goats in Papua New Guinea. Journal of Helminthology, 1-7.

Kuno, G., 2001. Persistence of arboviruses and antiviral antibodies in vertebrate hosts: its occurrence and impacts†. Rev Med Virol 11, 165-190.Lau, C.L., Clements, A.C., Skelly, C., Dobson, A.J., Smythe, L.D., Weinstein, P., 2012a. Leptospirosis in American Samoa--estimating and mapping risk using environmental data. Plos Neglected Tropical Diseases 6, e1669.

Lau, C.L., DePasquale, J.M., 2012. Leptospirosis, diagnostic challenges, American Samoa. Emerging Infectious Diseases 18, 2079-2081.

Lau, C.L., Dobson, A.J., Smythe, L.D., Fearnley, E.J., Skelly, C., Clements, A.C., Craig, S.B., Fuimaono, S.D., Weinstein, P., 2012b. Leptospirosis in American Samoa 2010: epidemiology, environmental drivers, and the management of emergence. The American Journal of Tropical Medicine and Hygiene 86, 309-319.

Le Bars, J., Le Bars, P., 1996. Recent acute and subacute mycotoxicoses recognized in France. Vet Res 27, 383-394.

Lebel, S., Beugnet, F., 1994. Ringworm cases on rusa deer in New-Caledonia. Revue De Medecine Veterinaire 145, 721-721.

Lupo, C., 2003. Epidémiologie de la leptospirose animale aux îles Fidji. Thèse d'exercice, Ecole Nationale Vétérinaire de Toulouse - ENVT, 2003, 151 pp.

Manueli, P.R.; Le Jambre, L.F.; Know, M.R., 1996. Conference Paper Date: 22-25 April, 1996, Conference Location: Bogor, Indonesia Pages: 92-97 Publisher: Australian Centre for International Agricultural Research (ACIAR) Canberra, Australia.

Manueli, P.R., Waller, P.J., Faedo, M., Mahommed, F., 1999. Biological control of nematode parasites of livestock in Fiji: screening of fresh dung of small ruminants for the presence of nematophagous fungi. Vet Parasitol 81, 39-45.

Martin, S., 2009. Bovine Babesiosis in New Caledonia, Report of the first FAO/OIE subregional meeting of the GF-TADs for the Pacific Community region in collaboration with SPC. Secretariat of the Pacific Community, Nadi, Fiji Islands, 48 pp.

Martin, T., 1999a. The animal health status of Samoa. Secretariat of the Pacific Community, Noumea (New Caledonia), 34 pp.Martin, T., 1999b. The animal health status of Tokelau Secretariat of the Pacific Community, Noumea (New Caledonia) 17 pp.

Martin, T., 1999c. The animal health status of Wallis & Futuna. Secretariat of the Pacific Community, Noumea (New Caledonia) 29 pp.

Martin, T., Epstein, V., 1999. The animal health status of the Solomon Islands. Secretariat of the Pacific Community, Noumea (New Caledonia) 34 pp.

Mediannikov, O., Davoust, B., Cabre, O., Rolain, J.M., Raoult, D., 2011. Bartonellae in animals and vectors in New Caledonia. Comp Immunol Microbiol Infect Dis 34, 497-501.

Moravec, F., Spratt, D.M., 1998. Crocodylocapillaria longiovata n. gen., n. sp. (Nematoda: Capillariidae) from the stomach of crocodiles in Australia and New Guinea. J Parasitol 84, 426-430.

Newman, S., McKenzie, A., 1991. Organisation of veterinary public health in Australasia and the Pacific Islands. Revue Scientifique et Technique 10, 1159-1184.

OIE, World Animal Health Information Database (WAHID) Interface. http://*www.oie.int/wahis/public.php (accessed 30 January 2013).*

OIE, 2011a. Animal health situation in Oceania. World Animal Health Information Database (WAHID) Interface.

http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Animalsituation (accessed 30 January 2013).

OIE, 2011b. Terrestrial animal health code, General provisions, pp. 435.

Owen, I.L., 2005. Parasitic zoonoses in Papua New Guinea. J Helminthol 79, 1-14.

Owen, I.L., 2006. Current status of Taenia solium and cysticercosis in Papua New Guinea. Parasitol Int 55 Suppl, S149-153.

Owen, I.L., 2011. Parasites of animals in Papua New Guinea recorded at the National Veterinary Laboratory: a catalogue, historical review and zoogeographical affiliations. Zootaxa, 1-163.

Owen, I.L., Sims, L.D., Wigglesworth, M.C., Puana, I., 2000. Trichinellosis in Papua New Guinea. Aust Vet J 78, 698-701.

Pacific Science Information Center, Bernice P. Bishop Museum Honolulu, H., 1966. Annotated bibliography on animal husbandry and diseases in the Pacific area, South Pacific Comission Technical meeting on livestock production and health, Suva , FIJI.

Paterson, R.A., Robertson, I.D., Sanders, R.C., Siba, P.M., Clegg, A., Hampson, D.J., 1993. The carriage of Streptococcus suis type 2 by pigs in Papua New Guinea. Epidemiol Infect 110, 71-78.

Pozio, E., Owen, I.L., La Rosa, G., Sacchi, L., Rossi, P., Corona, S., 1999. Trichinella papuae n.sp. (Nematoda), a new non-encapsulated species from domestic and sylvatic swine of Papua New Guinea. Int J Parasitol 29, 1825-1839.

Pozio, E., Owen, I.L., Marucci, G., La Rosa, G., 2004. Trichinella papuae in saltwater crocodiles (Crocodylus porosus) of Papua New Guinea. Emerging Infectious Diseases 10, 1507-1509.

Pozio, E., Owen, I.L., Marucci, G., La Rosa, G., 2005. Inappropriate feeding practice favors the transmission of Trichinella papuae from wild pigs to saltwater crocodiles in Papua New Guinea. Vet Parasitol 127, 245-251.

Reid, G.M., Van Eaton, C., 1993. A survey of honey bee pests and diseases in the Solomon Islands. Ministry of External Relations and Trade, Wellington.

Reid, S., Puana, I., Kapo, N., Owen, I., Wai'in, P., Angus, S.D., Fenwick, S., Robertson, I., Smythe, L., 2001. The identification of constraints and possible remedies to livestock production by zoonotic diseases in the South Pacific. ACIAR, 47 pp.

Reid, S.A., 2002. Trypanosoma evansi control and containment in Australasia. Trends Parasitol 18, 219-224.

Reid, S.A., Copeman, D.B., 2000. Surveys in Papua New Guinea to detect the presence of Trypanosoma evansi infection. Aust Vet J 78, 843-845.

Reid, S.A., Copeman, D.B., 2003. The development and validation of an antibody-ELISA to detect Trypanosoma evansi infection in cattle in Australia and Papua New Guinea. Prev Vet Med 61, 195-208.

Roqueplo, C., Halos, L., Cabre, O., Davoust, B., 2011. Toxoplasma gondii in wild and domestic animals from New Caledonia. Parasite 18, 345-348.

Russell, R.C., 2002. Ross River virus: Ecology and distribution. Annual Review of Entomology 47, 1.

Sabchareon, A., Yoksan, S., 1998. Japanese encephalitis. Annals of Tropical Paediatrics 18, 5.

Samarawickrema, W.A., Kimura, E., Sones, F., Paulson, G.S., Cummings, R.F., 1992. Natural infections of Dirofilaria immitis in Aedes (Stegomyia) polynesiensis and Aedes (Finlaya) samoanus and their implication in human health in Samoa. Trans R Soc Trop Med Hyg 86, 187-188.

Sammels, L.M., Coelen, R.J., Lindsay, M.D., Mackenzie, J.S., 1995. Geographic distribution and evolution of Ross River virus in Australia and the Pacific Islands. Virology 212, 20-29.

Savidge, J.A., Sileo, L., Siegfried, L.M., 1992. Was disease involved in the decimation of Guam's avifauna? J Wildl Dis 28, 206-214.

Saville, P., 1994. The animal health status of the Cook Islands. Secretariat of the Pacific Community, Noumea (New Caledonia) 12 pp.

Saville, P., 1996a. The animal health status of Kiribati. Secretariat of the Pacific Community, Noumea (New Caledonia) 10 pp.

Saville, P., 1996b. The animal health status of Niue. Secretariat of the Pacific Community, Noumea (New Caledonia) 10 pp.

Saville, P., 1996c. The animal health status of Tonga. Secretariat of the Pacific Community, Noumea (New Caledonia) 18 pp.

Saville, P., 1999. The animal health status of Palau. Secretariat of the Pacific Community, Noumea (New Caledonia) 19 pp.

Schuster, G., Ebert, E.E., Stevenson, M.A., Corner, R.J., Johansen, C.A., 2011. Application of satellite precipitation data to analyse and model arbovirus activity in the tropics. Int J Health Geogr 10, 8.

Secretariat of the Pacific Community, 2009a. Annual Report 2009, Part 1 - Annual overview.

Secretariat of the Pacific Community, 2009b. Report of the first FAO/OIE subregional meeting of GF-TADs for the Pacific Community region in collaboration with SPC.

Secretariat of the Pacific Community, 2004a. Apiculture in Cooks Islands, Country report and future strategy. Secretariat of the Pacific Community, Suva (Fiji), 9 pp.

Secretariat of the Pacific Community, 2004b. Apiculture in Fiji, Country report and future strategy. Secretariat of the Pacific Community, Suva (Fiji), 12 pp.

Secretariat of the Pacific Community, 2004c. Apiculture in Niue, Country report and future strategy. Secretariat of the Pacific Community, Suva (Fiji), 11 pp.

Secretariat of the Pacific Community, 2004d. Apiculture in Samoa, Country report and future strategy. Secretariat of the Pacific Community, Suva (Fiji), 13 pp.

Secretariat of the Pacific Community, 2004e. Apiculture in Tonga, Country report and future strategy. Secretariat of the Pacific Community, Suva (Fiji), 11 pp.

Secretariat of the Pacific Community, 2004f. Brucella suis brucellosis outbreak in Wallis and Futuna. Inform'Action 18.

Secretariat of the Pacific Community, 2007. The Importance of the pig in Pacific Island Culture. An annotated bibliography. Secretariat of the Pacific Community, Suva (Fiji), 43 pp.

Senne, D.A., 2003. Avian influenza in the Western Hemisphere including the Pacific Islands and Australia. Avian diseases 47, 798-805.

Simms, J.R., 1998. Animal leptospirosis in the Federated States of Micronesia. Pacific Health Dialog 5, 30-37.

Thevenon, J., Rantoen, D., Carton, D., Costa, R., Trap, D., 1992. [Infection by avian chlamydiosis in breeding pigeons in New Caledonia]. Ann Rech Vet 23, 63-71.

Trott, D.J., Combs, B.G., Mikosza, A.S., Oxberry, S.L., Robertson, I.D., Passey, M., Taime, J., Sehuko, R., Alpers, M.P., Hampson, D.J., 1997. The prevalence of Serpulina pilosicoli in humans and domestic animals in the Eastern Highlands of Papua New Guinea. Epidemiol Infect 119, 369-379.

Trott, D.J., Mikosza, A.S., Combs, B.G., Oxberry, S.L., Hampson, D.J., 1998. Population genetic analysis of Serpulina pilosicoli and its molecular epidemiology in villages in the eastern Highlands of Papua New Guinea. Int J Syst Bacteriol 48 Pt 3, 659-668.

Tudor, E.G., Lee, A.C., Armato, D.G., Bowman, D.D., 2008. Mammomonogamus auris infection in the middle ear of a domestic cat in Saipan, Northern Mariana Islands, USA. J Feline Med Surg 10, 501-504.

Vilain, O., Thevenon, J., Costa, R., Rantoen, D., 1994. Serologic survey for antibodies to IBR IPV virus in cattle in New-Caledonia. Recueil De Medecine Veterinaire 170, 539-545.

Wai'in, P.M., 2007. Epidemiology of infection with Leptospira species in Livestock in Papua New Guinea, School of Biomedical and Veterinary Sciences Murdoch University Perth, 214 pp.

Watier-Grillot, S., Marie, J.L., Cabre, O., Davoust, B., 2011. Survey of Canine Dirofilaria immitis Infection in New Caledonia. Vet Med Int 2011, 380680.

WHO 2007. Presence/absence of rabies in 2007. http://www.who.int/rabies/Absence_Presence_Rabies_07_large.jpg (accessed 16 December 2013).

WHO 2008. Rabies, countries or areas at risk. http://www.who.int/rabies/Global_Rabies_ITH_2008.png (accessed 16 December 2013).

WHO 2011. Distribution of risk levels for humans contracting rabies, worldwide, 2011.

http://www.who.int/rabies/Global_distribution_risk_humans_contracting_rabies_2011.png (accessed 16 December 2013).

Yarrow, R., 2008. Increasing veterinary capacity in the Pacific, Secretariat of the Pacific Community - Third regional meeting of Heads of Agriculture and Forestry Services (HOAFS), 4 pp.

CHAPTER 3

DISEASES OF LIVESTOCK IN THE PACIFIC ISLANDS REGION: SETTING PRIORITIES FOR FOOD ANIMAL BIOSECURITY

Aurélie Brioudes[1], Jeffrey Warner[1], Robert Hedlefs[1] and Bruce Gummow[1, 2]

[1] *Discipline of Veterinary Sciences, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville 4811, Queensland, Australia*

[2] *Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa*

Published in Acta Tropica Journal (2015)
143, 66-76

ABSTRACT

Most Pacific Island Countries and Territories (PICTs) have developing economies and face a critical shortage of veterinarians with limited financial resources allocated to their animal disease surveillance programmes. Thus, animal health authorities have to set priorities for better focussing their scarce resources. The main objective of this study was to identify animal diseases perceived to be of importance by decision makers within selected PICTs, at the regional and national levels, to ensure better targeting of animal health resources. A second objective was to investigate whether the targeted surveillance programmes resulting from this rationalised approach would also benefit the local communities engaged in livestock production. A multi-criteria prioritization process was developed, involving local experts, to score and rank 132 animal diseases based on their priority at the regional and national levels for four PICTs: Fiji, Papua New Guinea, Solomon Islands and Vanuatu, which form part of a regional Food Animal Biosecurity Network. In parallel interviews with farmers and field animal health and production workers were conducted to assess their perception of animal diseases. The list of the top-twenty ranked diseases for the Pacific Islands region shows a mix of endemic zoonotic diseases (such as leptospirosis ranked first; brucellosis third; tuberculosis sixth and endoparasites and ectoparasites respectively eleventh and thirteenth) with exotic diseases (such as HPAI ranked second, FMD fifth and rabies ninth). There were different disease ranking lists for each of the four targeted PICTs, confirming different strategies of disease prevention and control may be required for each country, rather than a regional approach. Interviewed animal health and production workers were unfamiliar with most of the prioritized diseases and a majority acknowledged that they would not be able to recognise clinical signs if outbreaks were to occur in their area. Leptospirosis, which is endemic and identified as the top priority disease at the regional level, was never mentioned by any interviewed farmer. Farmers did not name any emerging infectious diseases as priorities. Instead, they identified endemic diseases (parasites, flu, coccidiosis and scabies) as the most important. While animal disease priorities appear to differ widely between the targeted regions and countries, it also varies significantly between experts and farmers. Better

targeted surveillance programmes may thus result in more rational and transparent allocation of resources, and thus enhanced food security, but may not directly match the needs of the local communities.

KEYWORDS

Pacific Island; Tropical Diseases; Prioritization; Animal Health; Livestock; Food Animal Biosecurity.

INTRODUCTION

In the Pacific Island countries and territories (PICTs) zoonotic diseases such as leptospirosis, scabies, bovine tuberculosis and brucellosis are endemic (Brioudes, Warner, Hedlefs, & Gummow, 2014; Kline, McCarthy, Pearson, Loukas, & Hotez, 2013), but these island countries tend to be free of serious infectious livestock diseases such as highly pathogenic avian influenza, foot and mouth disease, classical swine fever and rabies (Brioudes et al., 2014; Newman & McKenzie, 1991; Secretariat of the Pacific Community, 2009; Yarrow, 2008). The potential introduction and/or dissemination of diseases threatens the development of the livestock sector and also represents a risk to humans who might be exposed to zoonoses, which account for about 75% of all emerging animal diseases. Veterinarians and field animal health workers are key players required to actively protect this favourable animal health situation but they are in severe shortage in the region (Osborne, 1974; Secretariat of the Pacific Community, 2006; Williams, 2008; Yarrow, 2008). In this context of limited human and financial resources allocated to animal health and animal production programmes, a targeted, cost-efficient surveillance programme is crucial to protect the animal health status and to facilitate the trade of animals and animal products (Cardoen et al., 2009; Krause, 2008; Phylum, 2009; Woolhouse et al., 2011). The decision-making process for identification of which disease to target as a priority is complex, as it involves the combination of, not only technical information, but also some value judgements (Kurowicka, Bucura, Cooke, & Havelaar, 2010). The process of prioritization, defined as the listing of diseases into a hierarchy considering their respective impacts, is thus a tool to assist decision-makers in selecting diseases that are most worthy of being addressed by public policies. The result of this prioritization can then be used to determine which prevention and control measures to implement first (Phylum, 2009).

Transparent and documented disease prioritization processes have now been quite widely conducted across the world, mostly in Europe (Balabanova et al., 2011; Gilsdorf & Krause, 2011; Havelaar et al., 2010; Humblet et al., 2012; McAnulty, Stewart, & Network, 2003; Simoes et al., 2012), but also in Africa (Uzochukwu, Onwujekwe, Nwobi, Ndu, & Onoka, 2007), in the Middle East (Gibson, 2011), and more recently in North America (Ng & Sargeant, 2012a, 2012b, 2013). It appears that only a limited number of prioritization exercises have been implemented for animal diseases globally (Humblet et al., 2012; McKenzie, Simpson, & Langstaff, 2007; Phylum, 2009; Van der Fels-Klerx, Goossens, Saatkamp, & Horst, 2002). In the Pacific Islands region, a semi-quantitative prioritization process has been conducted by the public health sector of the Federate States of Micronesia for a revised selection of diseases to include in the National Notifiable Diseases List (Pavlin, Kool, Samo, & Gerstel, 2010). Besides the initial steps taken towards a prioritization of livestock diseases in 1974 (Osborne, 1974) and the ranking of animal diseases during the GTADs conferences in 2009 and 2013 (Secretariat of the Pacific Community, 2009, 2013), the rational and structured prioritization of animal diseases in the entire Pacific Islands region has yet to be conducted.

In 2010, a Food Animal Biosecurity Network (FABN) was established between Fiji, Papua New Guinea (PNG), Vanuatu and Solomon Islands (hereafter defined as “FABN countries”), with the aim of “delivering enhanced animal health field and laboratory capability to the Pacific islands, particularly in the area of animal disease surveillance, to allow assessment under OIE guidelines for trade in animals and animal products”. This paper focuses on the FABN countries which can be viewed as a well-defined cluster of Pacific Island countries representative of the PICTs.

The primary objective of this study was to prioritize the animal diseases of greatest importance within the Pacific Islands region, at both the regional and national levels, based on the opinion of animal health officials.

In addition, the study investigated whether targeted surveillance programmes based on the opinion of animal health officials would also benefit the local communities making their living from livestock production.

METHODS

This study comprises two components: first the rational and structured prioritization of animal diseases through an expert elicitation process, and secondly a field survey to capture the animal disease perception of farmers and field-based animal health and production workers (AHPW).

Prioritization of diseases by regional and national experts:

Eligible animal diseases:

The first step in the prioritization of diseases was to create a comprehensive list of eligible diseases in order to avoid elimination *a priori* of any diseases of interest for the region. The list included present and exotic diseases that could potentially pose a risk to the study area. Because the surveillance of aquatic animal diseases fits into a very specific and generally different veterinary public health approach, the study list was limited to terrestrial domestic animal diseases only.

The selection of diseases for the list was based on Brioudes et al's work (Brioudes & Gummow, 2013; Brioudes et al., 2014) that provided a review of diseases within the Pacific Islands region. The list also included diseases that had been officially reported by neighbouring countries of the Pacific Islands countries (i.e. Australia, New Zealand and Indonesia) to the World Organisation for Animal Health (OIE) between 2008 (starting date of the World Animal Health Information Database (OIE)) and 2012. Since the detailed and extensive list of parasites presented in some of the references retrieved through the literature review could not be realistically included in the list of eligible diseases, these parasites were compiled under the generic terminologies of “endoparasites” and “ectoparasites” (Martin, 1999a, 1999b, 1999c; Martin & Epstein, 1999; Owen, 2005, 2011; Saville, 1994, 1996a, 1996b, 1996c, 1996d, 1999). In total, this selection process produced a list of 132 selected diseases for the prioritization exercise.

Panel of experts:

A two-stage expert opinion elicitation study was conducted to prioritize animal disease at the regional and national levels in the four FABN countries.

Regional experts

The Secretariat of the Pacific Community (SPC) is an international organisation that works in various areas, including public health and agriculture to help the people from its 22 member countries and territories achieve sustainable development. While this organisation appoints experts from all around the world, a majority of them are from the Pacific Island region.

Regional experts used in the study were from the Animal Health and Production Team, Land Resources Division and from the Public Health Division of SPC as well as experts from the local representation of the World Health Organisation. They were invited to participate in two workshops conducted at SPC, in Suva, Fiji. In total, five technical staff from the Animal and Production Team of SPC participated in this prioritization of animal diseases of the Pacific Island region.

A Delphi technique was used to elicit expert opinion at the workshops held in May and July 2012. The first workshop started with a general presentation on disease prioritization processes. The list of diseases selected on the basis of the literature review was presented to the group of experts and a discussion was held on whether to include other diseases. The key results obtained from the literature review on domestic animal diseases of the Pacific Islands region were distributed for information to the experts to assist them with the most up-to-date data on the diseases to be scored. A list of 10 criteria was defined on the basis of the literature review and the needs for criteria modification and for inclusion or exclusion of some criteria were discussed among the group of experts. The scoring system for each of the selected criteria was presented and revised based on experts' suggestions. Experts were directed not to score a criterion if they felt insufficiently competent in relation to a particular disease. The option of attributing different weights to the criteria for taking into account their relative importance was discussed before starting the scoring of the diseases. The regional experts decided as a consensus not to apply any such weighting. The matrix for the scoring of each of the 132 diseases against the 10 selected criteria was then distributed to each expert.

Based on a review of published prioritization processes (Cardoen et al., 2009; Doherty, 2000; IFAH-Europe, 2009; Krause, 2008; McKenzie et al., 2007; World Health Organization, 2006), six categories, divided into a total of 10 criteria, were considered for assessing the diseases:

- Animal health impact:
    - Criteria 1: Occurrence in live animals
    - Criteria 2: Severity of the disease for animals
- Public health impact:
    - Criteria 3: Occurrence in humans
    - Criteria 4: Severity of the disease for humans
- Epidemiology:
    - Criteria 5: Epidemic potential (threat of spread) among animals
- Prevention and control measures:
    - Criteria 6: Effectiveness of animal surveillance system
- Economic Impact:
    - Criteria 7: Economic impact of the disease on local / national trade
    - Criteria 8: Economic impact of the disease on regional / international trade

- Social Impact:
    - Criteria 9: Impact of the disease on farmers' livelihood
    - Criteria 10: Impact of the disease on the food supply for consumers / community

A semi-quantitative approach with a 4-tired scoring system was adopted for assessing the diseases against each criterion with; 0 for a non-occurrence or for an impact or a disease severity assessed as "Nil"; 1 for "Low"; 2 for "Moderate" and 3 for "High".

After this first workshop, experts were given one month for the scoring of the 132 diseases. Tables were then sent back to the study coordinator who compiled the scores attributed by the experts using a Median function to rank the diseases from highest to lowest median score. Results obtained from the expert's scoring were presented during a second workshop and a discussion was then held among the experts to identify the diseases for which the total score was assessed as too high or too low within the ranking list. Diseases for which consensus was not reached regarding their ranking position had their scores revised. Experts were offered the option to re-attribute scores individually and send back their new scoring matrix within a 2 week-period, but they chose to handle it by a collective approach during a third workshop. A consensus was finally reached and the 132 selected diseases were then ranked according to their updated total score.

In addition to this regional priority setting and in order to take into account the specificities of the PICTs, this prioritization process was also carried out at the national level in the four FABN countries.

National experts

The study coordinator engaged with the following institutions: the Department of Animal Health and Production of Fiji's Ministry of Primary Industries, the National Agriculture Quarantine and Inspection Authority (NAQIA) and the National Agricultural Research Institute (NARI) of PNG, the Departments of Livestock and Quarantine of Solomon Islands and of Vanuatu (named hereafter as “local counterparts”). These groups assisted with identification and invitation of the national experts for the prioritization process in each country. A total of 45 national experts (8 from Fiji, 21 from PNG, 11 from Vanuatu and 5 from Solomon Islands) participated in this study.

A similar Delphi approach was used however, to simplify the process and make it more practically manageable, at the national level an arbitrary cut off was decided and only the top-twenty diseases from the regional prioritization were selected for national experts to rank. To ensure that no disease was missed that could be relevant for a particular country, prior to the scoring of diseases, the national experts were requested to name, according to their own experience and knowledge, the five most important livestock diseases for their country (being diseases currently present or diseases that could potentially be introduced to their country). When an expert suggested a disease that was not included in the top-twenty regional priority list the named disease was then added to the list of selected diseases to be scored by that expert.

Questionnaires for the scoring of the diseases against the 10 criteria listed above were completed by the participating national experts during the first round of workshops conducted in-country between July and December 2012. Results from the compiled scores were presented, discussed and validated during a second round of workshops in each of the targeted PICTs between March and May 2013.

Perception of animal disease by communities involved in livestock production within the PICTs:

Field Animal Health and Production Workers’ perception

A short self-administered questionnaire was developed for collecting information from field animal health and production workers (AHPW) regarding their perception of the animal diseases representing the greatest risk in their locality; whether it be diseases currently present in the region, or pathogens that could potentially be introduced and propagate in the future.

Additionally, they were requested to document if they knew or had ever heard about the twenty top-ranked diseases and if they thought they would be able to recognize their clinical signs in the event of an outbreak within their locality.

Data was collected for three of the four FABN countries during the first round of missions between July and December 2012. Vanuatu is composed of an archipelago of small islands and does not have field animal health staff other than those of the Department of Livestock and Quarantine, who had already been involved as national experts in the prioritization process. For that reason no AHWP were included from Vanuatu in this part of the analysis. In total, 86 AHPW (19 from Fiji, 25 from Papua New Guinea and 42 from Solomon Islands) participated in this study.

Farmer's perception

A multi-stage sampling strategy was developed to obtain a representative sample of farmers. First, a purposive selection of at least 2 provinces per country was performed in consultation with local counterparts from the four FABN countries, based on the importance of the pig and poultry sectors and on their accessibility to field staff conducting the survey. Then, for the second stage 2% of the total number of villages within these provinces was to be selected in PNG, 3% in Solomon Islands and 10% in Vanuatu and Fiji using a simple random sampling based on the list of villages within the four FABN countries. The sampling frames were provided by SPC. Once in the village, interviewers were required to randomly identify and interview 4 farmers (two pig farmers and two poultry farmers). A total of 801 farmers participated in the study.

Prior to the launching of the field survey, the questionnaire was tested by interviewing 10 pig farmers and 10 poultry farmers located within the Central division of Fiji and revised based on their feed-back before implementation. After consultation with SPC and local counterparts, a translation of the questionnaire in the respective local languages of the four FABN countries was judged to be unnecessary. Operatives from the local counterpart agencies were trained to perform the farmer's interview and the survey was conducted from July 2012 to July 2013 in the four FABN countries.

RESULTS

Background and experience of participants

The educational background of the 5 regional, 45 national experts and 86 AHPW is presented in Figure 3-1. Figure 3-2 summarized the professional experience of the regional and national experts, AHPW and farmers. However, 739 out of the 801 participating farmers provided information on their professional experience.

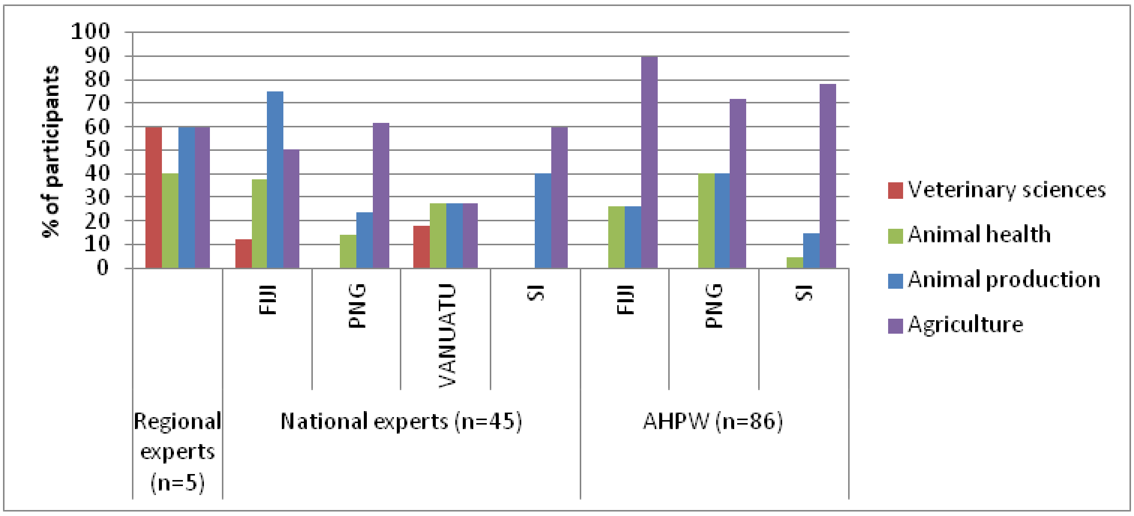


Figure 3-1: Distribution of disease prioritization participants according to their educational background

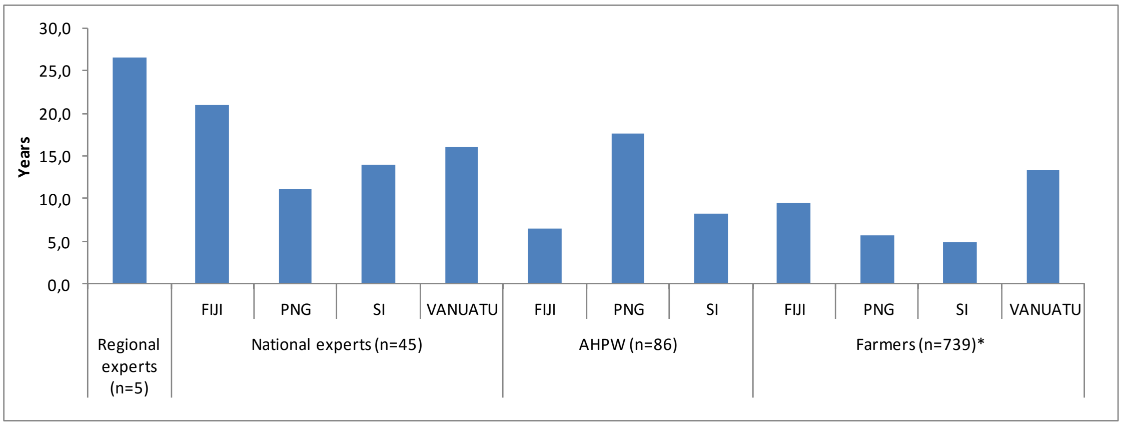


Figure 3-2: Distribution of disease prioritization participants according to their professional experience (* only 739 out of the 801 participating farmers answered this question)

Animal diseases rationally prioritized at the regional level

The final scores along with the ranking of each of the 132 animal diseases for this prioritization exercise are detailed in Table 3-1.

Animal diseases rationally prioritized at the national level

The scores and ranking of the prioritization process conducted in the four FABN countries are compiled in Table 3-2.

AHWP's animal disease knowledge assessment

Table 3-3 presents results regarding the AHWP's knowledge and ability to recognise the clinical signs of the top-twenty prioritized diseases.

Table 3-1: List of the 132 scored and ranked animal diseases at the regional level (Diseases presented in rank ascending order)

Animal diseases in the Pacific Islands region	Score	Rank
Leptospirosis	23,5	1
Highly pathogenic avian influenza	23	2
Brucellosis	22,5	3
Newcastle disease	21	4
Foot and Mouth disease	20,5	5
Tuberculosis	20	6-8
Infectious bursal disease (Gumboro)	20	6-8
Fowl pox	20	6-8
Salmonellosis	19,5	9-10
Rabies	19,5	9-10
Endoparasites	19	11-12
Classical swine fever	19	11-12
Marek's disease	18,5	13-14
Ectoparasites	18,5	13-14
Varroosis	18	15-19
Porcine reproductive respiratory syndrome	18	15-19
Infectious coryza	18	15-19
Avian infectious laryngotracheitis	18	15-19
Anthrax	18	15-19
Vibrionic dysentery	17,5	20
Parvovirus	17	21-22
Enzootic pneumonia	17	21-22
Avian infectious bronchitis	16,5	23
Trichomonosis	16	24-33
Toxoplasmosis	16	24-33
Nosemosis	16	24-33
Mycoplasmosis (M. Gallisepticum)	16	24-33
Hepatitis E virus	16	24-33
Fowl cholera	16	24-33
Fasciolosis	16	24-33
Contagious pustular dermatitis	16	24-33
Balantidium	16	24-33
American foulbrood	16	24-33
Tetanus	15,5	34-42
Swine erysipelas	15,5	34-42
Surra/Trypanosomosis	15,5	34-42
Q fever	15,5	34-42
Other avian salmonellosis	15,5	34-42
Johne's disease	15,5	34-42
Bovine ephemeral fever	15,5	34-42
Babesiosis	15,5	34-42
Avian mycoplasmosis (M. Synoviae)	15,5	34-42
Porcine rotavirus	15	43-54
Myxomatosis	15	43-54
Mycoplasma spp.	15	43-54
Low pathogenic avian influenza	15	43-54
Enzootic bovine leukosis	15	43-54
Dermatophilosis	15	43-54
Coccidiosis	15	43-54
Chalkbrood (fungus)	15	43-54
Caseous lymphadenitis	15	43-54
Bov. genital campylobacteriosis	15	43-54
Avian spirochaetosis	15	43-54
Aujeszky's disease	15	43-54

Animal diseases in the Pacific Islands region (Cont')	Score	Rank
Melioidosis	14,5	55-57
Filariosis	14,5	55-57
Botulism	14,5	55-57
Wax moth	14	58-66
Streptococcus suis type 1	14	58-66
Other pasteurelloses	14	58-66
Infectious bovine rhinotracheitis (IBR)	14	58-66
European foulbrood	14	58-66
Echinococcosis/hydatidosis	14	58-66
Bovine virus diarrhea (BVD)	14	58-66
Avian encephalomyelitis	14	58-66
Amoeba disease (Malpighamoeba)	14	58-66
Theileriosis	13,5	67-69
Japanese encephalitis virus	13,5	67-69
Bovine leukosis	13,5	67-69
Swine influenza	13	70-77
Small hive beetle infestation	13	70-77
Sheep mange	13	70-77
Pasteurella spp.	13	70-77
Inf. Bov. Rhinotracheit. (IBR/IPV)	13	70-77
Hendra virus[Henipavirus)	13	70-77
Enterovirus encephalomyelitis	13	70-77
Cysticercosis	13	70-77
Transmissible gastroenteritis (TGE)	12,5	78
Trichinellosis	12	79-90
Ross River virus	12	79-90
Henipavirus[Hendra and Nipah)	12	79-90
Equine Herpes virus	12	79-90
Enterotoxaemia	12	79-90
Chlamydiosis	12	79-90
Caprine arthritis/encephalitis	12	79-90
Blackleg	12	79-90
Avian malaria	12	79-90
Avian chlamydiosis	12	79-90
Anaplasmosis	12	79-90
Akabane virus	12	79-90
Clostridial infections	11,5	91
Shiga-like toxin I-producing E. Col	11	92-99
Bartonellae	11	92-99
Bluetongue	11	92-99
Commensal and opportunistic bacteria, including Salmonella spp.	11	92-99
Getah virus	11	92-99
Halfmoon disorder (nutritional /genetic?)disorder)	11	92-99
Plasmodium	11	92-99
Psittacosis	11	92-99
Avian leukosis	10,5	100-102
Equine infectious anaemia	10,5	100-102
Ovine epididymitis (B.ovis)	10,5	100-102
Actinomycosis	10	103-109
Black queen cell virus	10	103-109
Crocodylocapillaria longiovata	10	103-109
Kashmir bee virus	10	103-109
Sacbrood virus	10	103-109
Tropilaelaps infestation	10	103-109
Vesicular stomatitis	10	103-109
Canine distemper virus	9,5	110-111
Foot-rot	9,5	110-111
Heat-stable enterotoxin II-producing enterotoxigenic E. coli	9	112-114
Listeriosis	9	112-114
Murray Valley encephalitis virus	9	112-114

Animal diseases in the Pacific Islands region (Cont')	Score	Rank
Ehrlichia canis	7	115-116
Equine Influenza A	7	115-116
Dirofilariasis	6,5	117-118
Rabbit haemorrhagic disease	6,5	117-118
Equine leucoencephalomalacia	6	119
Equine rhinopneumonitis	5,5	120
Chronic paralysis virus	Not scored	Not scored
Contagious ophthalmia	Not scored	Not scored
Entamoeba polecki	Not scored	Not scored
Epizootic haemorrhagic disease	Not scored	Not scored
Equine coital exanthema	Not scored	Not scored
Equine viral arteritis	Not scored	Not scored
Leishmaniosis	Not scored	Not scored
Rubulavirus	Not scored	Not scored
Serpulina pilosicoli	Not scored	Not scored
Simbu serogroup	Not scored	Not scored
Strangles	Not scored	Not scored
Subcutaneous filarial worm	Not scored	Not scored

Table 3-2: List of prioritized animal diseases at the national level (diseases presented in alphabetical order)

Animal diseases	FIJI Scoring	FIJI Ranking	PNG Scoring	PNG Ranking	SOLOMON Scoring	SOLOMON Ranking	VANUATU Scoring	VANUATU Ranking
Anthrax	13	15	18	12	8	19	18,5	3
Avian infectious laryngotracheitis	12	19	24	2	19,5	4	17	5
Brucellosis	21	2	16,5	19	16,5	9	10	20
Classical swine fever	13	15	21	6	X	X	15	8
Ectoparasites	10	21	16	20	13,5	16	10,5	19
Endoparasites	19	6	19	10	16	12	12,5	14
Foot and Mouth disease	23	1	20,5	7	13,5	15	17,5	4
Fowl pox	9	22	17,5	15	11,5	18	8	22
Highly Pathogenic Avian influenza	15	12	21,5	3	16	11	20	2
Infectious bursal disease (Gumboro)	14	14	21,5	3	X	X	13	12
Infectious coryza	X	X	20,5	7	X	X	14	10
Leptospirosis	19	6	17,5	15	20,5	2	13	13
Marek's disease	15	12	17	17	19	5	8,5	21
Newcastle disease	13	15	21,5	3	17	8	21	1
Porcine reproductive respiratory syndrome	10,5	20	19	10	X	X	11	18
Rabies	13	15	16	20	13,5	14	16	7
Salmonellosis	16	9	25,5	1	14	13	11,5	15
Tuberculosis	20	3	20,5	7	13	17	17	6
Varroosis	16,5	8	17	17	X	X	11	17
Vibrionic dysentery	X	X	15,5	22	16	10	7,5	23
Extra: American Fool Brood	20	3						
Extra: Bacterial Disease	20	3	18	12	18	6		
Extra: Blindness	16	9			20	3	4	26
Extra: Bovine Venereal Campylobacteriosis					21	1	11	16
Extra: Coccidiosis			18	12	17	7	14,5	9
Extra: Enzootic pneumonia			12	23	18	6		
Extra: Foot Rot	16	9						
Extra: Infectious Bronchitis					20	3		
Extra: Kidney Worm							13	11
Extra: Mastitis							7	24
Extra: Swine Erysipelas					21	1		
Extra: Swine Flu			10	24	17	7		

X: Disease not scored by any participants

Extra: Refers to diseases that were not part of the regional top-twenty prioritized diseases but which were suggested for the prioritization process at the national level by experts.

Table 3-3: Animal health and production workers knowledge assessment on the top-twenty prioritised animal diseases

Animal diseases known by AHPW	Total FIJI (out of 19)	Total PNG (out of 25)	Total SI (out of 42)	Total for the 3 PICTs (out of 86)
Brucellosis	17	18	33	68
Tuberculosis	17	17	29	63
Fowl pox	6	19	30	55
Foot and Mouth disease	13	20	21	54
Newcastle disease	11	20	17	48
Leptospirosis	15	15	17	47
Classical swine fever	5	18	20	43
Rabies	8	18	15	41
Salmonellosis	6	17	10	33
Anthrax	3	19	9	31
Marek's disease	3	17	11	31
Ectoparasites	9	12	8	29
Endoparasites	10	12	7	29
Highly Path. Avian influenza (HPAI)	6	13	10	29
Avian infectious laryngotracheitis	2	11	10	23
Infec. bursal disease (Gumboro)	4	8	4	16
Infectious coryza	0	7	8	15
Porcine reproductive respiratory syndrome (PRRS)	2	4	7	13
Varroosis	0	4	9	13
Vibrionic dysentery	0	3	2	5
Animal diseases AHPW would clinically recognise				
Foot and Mouth disease	6	18	22	46
Tuberculosis	9	14	19	42
Brucellosis	13	11	13	37
Fowl pox	0	13	21	34
Rabies	2	14	13	29
Leptospirosis	8	9	9	26
Newcastle disease	1	14	9	24
Ectoparasites	7	9	7	23
Endoparasites	7	8	7	22
Classical swine fever	0	11	10	21
Anthrax	0	11	5	16
Marek's disease	1	8	7	16
Highly Path. Avian influenza (HPAI)	2	9	4	15
Salmonellosis	2	9	4	15
Avian infectious laryngotracheitis	0	6	6	12
Infectious coryza	0	3	7	10
Varroosis	0	2	6	8
Infec. bursal disease (Gumboro)	0	3	4	7
Porcine reproductive respiratory syndrome (PRRS)	0	2	4	6
Vibrionic dysentery	0	1	3	4

Farmers' and AHWP's animal disease perception

Access to villages in the countries proved to be more difficult than expected because of their remoteness or in some cases security and none of the countries were able to survey the percentage of villages originally specified in the materials and methods. In particular, there was a poor return rate from the Western province of Solomon Islands, which led to the exclusion of the data from that province. In total, 491 poultry farmers (72 from Fiji, 273 from PNG, 93 from Solomon Islands and 53 from Vanuatu) and 310 pig farmers (60 from Fiji, 110 from PNG, 91 from Solomon Islands and 49 from Solomon Islands) finally participated in this survey.

Pig farmers were interviewed in eight provinces of Fiji, two of PNG and Vanuatu and one of Solomon Island. By the end of the survey, 3.1% (n=36) of the villages with pig farmers interviewed in the selected provinces had been surveyed in Fiji, 0.8% (n=60) of villages in PNG, 1.9% (n=46) of villages in Solomon Islands and 7.3% (n=29) of villages in Vanuatu.

With respect to poultry farmers, nine provinces were surveyed in Fiji and two in PNG and Vanuatu and one in Solomon Islands. By the end of the survey, 3.8% (n=44) of the villages with poultry farmers in the selected provinces had been surveyed in Fiji, 1% (n=74) of villages in PNG, 2% (n=47) of villages in Solomon Islands and 7.8% (n=31) of villages in Vanuatu.

Provinces surveyed for pig farmers in Fiji were Ba, Bua, Cakaudrove, Kadavu, Macuata, Nadroga/Navosa, Serua and Tailevu. Provinces surveyed for poultry farmers in Fiji were Ba, Bua, Cakaudrove, Kadavu, Macuata, Nadroga/Navosa, Namosi, Rewa and Tailevu. Pig and poultry farmers were interviewed in the provinces of Morobe and Eastern Highlands Province (EHP) in PNG, Guadalcanal in Solomon Islands and Shefa (Efate Island) and Sanma (Santo Island) in Vanuatu.

The difference in the number of villages (n= 171) with pig farmers compared to villages (n=196) with poultry farmers is a reflection of the Seventh-day Adventist communities. The Seventh-day Adventist communities consider pork as unclean and thus don't have pig farmers in them. This resulted in fewer villages with pig farmers being included in the survey. To make up for this, interviewers in PNG interviewed more poultry farmers in the visited villages with on average 3.7 poultry farmers interviewed per village. The inability of interviewers to meet the desired sample sizes put forward in the methods was also due to the fact that in some small villages there was only one poultry farmer and/or one pig farmer and in a few of the villages interviewers could not find a second pig or poultry farmer willing to participate in the survey, thus highlighting the challenges of working in these countries.

Opinions of farmers and AHWP on the most important animal diseases are listed in Table 3-4. When interviewees didn't know the name of the disease, clinical signs were given instead and are also included in this table.

Correlation between the top-twenty priority diseases identified at the regional level and Farmer' perception

Table 3-5 shows which clinical signs enumerated by farmers match with each of the top-twenty prioritized animal diseases to demonstrate the potential correlation between the two sets of opinions.

Table 3-4: Animal health and production workers' and farmers' perception on diseases and clinical signs the most at risk

Animal health and production workers' perception

Diseases at risk	Frequency	Proportion
Brucellosis	22	11,96%
Tuberculosis	18	9,78%
Fowl pox	15	8,15%
Scabies	14	7,61%
Endoparasites	9	4,89%
Avian Influenza	8	4,35%
Ectoparasites	8	4,35%
Foot and Mouth Disease	8	4,35%
Newcastle Disease	8	4,35%
Pneumonia	8	4,35%
Anthrax	7	3,80%
Coccidiosis	7	3,80%
Leptospirosis	7	3,80%
Parasites	6	3,26%
Rabies	6	3,26%
Round worms	6	3,26%
Flu/Cold	4	2,17%
Classical Swine Fever	3	1,63%
HPAI	3	1,63%
Swine fever	3	1,63%
American Foulbrood	2	1,09%
Bacterial infections	2	1,09%
Chronic Respiratory Diseases	2	1,09%
Salmonellosis	2	1,09%
Asthma	1	0,54%
Avian Infectious Laryngotracheitis	1	0,54%
Mites	1	0,54%
Parvovirus	1	0,54%
Trichinosis	1	0,54%
Varroa mites	1	0,54%

Clinical signs at risk	Frequency	Proportion
Diarrhea	36	33,03%
Skin issue	9	8,26%
Cough	7	6,42%
Weak	7	6,42%
Eye issue	5	4,59%
Growth Issue	5	4,59%
Fever	3	2,75%
Lameness	3	2,75%
Respiratory issue	3	2,75%
Anaemia	2	1,83%
Blood in stool	2	1,83%
Injuries/wounds	2	1,83%
Loss appetite	2	1,83%
Loss of weight	2	1,83%
Mastitis	2	1,83%
Mortality	2	1,83%
Nutrition issue	2	1,83%
Poor condition	2	1,83%
Swollen body	2	1,83%
Blindness	1	0,92%
Constipation	1	0,92%
Fluid in the joints/in the body	1	0,92%
Hair falling off	1	0,92%
Itchiness	1	0,92%
Nose discharge	1	0,92%
Paralysis	1	0,92%
Pecking	1	0,92%
Salivary mouth	1	0,92%
Sore body	1	0,92%
Vomiting	1	0,92%

Farmers' perception

Diseases at risk	Frequency	Proportion
Parasites	37	24,03%
Flu/Cold	20	12,99%
Coccidiosis	20	12,99%
Scabies	18	11,69%
Fowl pox	13	8,44%
Round worms	7	4,55%
Footrot	7	4,55%
Coryza	7	4,55%
Lice	5	3,25%
Anthrax	5	3,25%
Bacterial infections	3	1,95%
Tetanus	2	1,30%
Mites	2	1,30%
Iron deficiency	2	1,30%
Clostridium	2	1,30%
Asthma	2	1,30%
Parvovirus	1	0,65%
Marek's disease	1	0,65%

Clinical signs at risk	Frequency	Proportion
Diarrhoea	221	28,37%
Fluid in the joints/in the body	117	15,02%
Paralysis	71	9,11%
Respiratory issue	41	5,26%
Loss of weight	37	4,75%
Mortality	36	4,62%
Swollen body	30	3,85%
Itchiness	28	3,59%
Poor condition	27	3,47%
Weak	17	2,18%
Skin issue	17	2,18%
Conjunctivitis	17	2,18%
White spots	11	1,41%
Loss appetite	11	1,41%
Injuries/wounds	11	1,41%
Blindness	11	1,41%
Pecking	9	1,16%
Nutrition issue	8	1,03%
Red body	7	0,90%
Locomotion issue	7	0,90%
Growth Issue	6	0,77%
Scaly legs	5	0,64%
Vomiting	4	0,51%
Lameness	4	0,51%
Eggs/laying issue	4	0,51%
Lumps' head	3	0,39%
Hair falling off	3	0,39%
Caught	3	0,39%
Still birth	2	0,26%
Salivary mouth	2	0,26%
Fever	2	0,26%
Eye issue	2	0,26%
Stress	1	0,13%
Straight neck/legs	1	0,13%
Sun burnt	1	0,13%
Cryptorchidism	1	0,13%
Blood in stool	1	0,13%

Table 3-5: Correlation between the twenty top-priority diseases ranked by regional experts and the symptoms reported by farmers

Top ranked diseases (columns) / Symptoms reported by Farmers (rows)	Leptospirosis[a]	HPAI[a]	Brucellosis[a]	Newcastle disease[a]	FMD[a]	Tuberculosis[a]	IBD (Gumboro)[a]	Fowl pox[a]	Salmonellosis[a]	Rabies[ab]	Endoparasites[a]	Classical swine fever[a]	Marek's disease[a]	Ectoparasites[c]	Varroosis[a]	PRRS[a]	Infectious coryza[a]	Avian infect. Laryngo.[a]	Anthrax[a]	Vibrionic dysentery[d]
Anaemia														x						
Blindness	x																			
Blood in stool									x											x
Conjunctivitis												x								
Constipation												x								
Cough		x				x												x		
Cryptorchidism																				
Diarrhoea		x				x			x			x					x			x
Eggs/laying issue		x						x									x	x		
Eye issue	x																x			
Fever									x			x				x			x	
Fluid in the body																				
Growth Issue								x			x	x		x						x
Hair falling off																				
Injuries/wounds																				
Itchiness																				
Lameness																				
Locomotion issue																				
Loss of appetite		x				x						x				x	x			x
Loss of weight						x					x									
Lumps' head								x												
Mastitis					x															
Mortality		x		x	x	x	x	x		x	x	x	x		x	x		x	x	x
Nasal discharge		x															x	x		
Nutrition issue																				
Overweight																				
Paralysis										x			x							
Pecking		x																		
Poor condition																				
Red body														x						
Respiratory issue		x		x		x		x	x							x	x	x		
Salivary mouth																				
Scaly legs																				
Skin issue								x						x						
Sore body																				
Still birth/abortion	x		x						x							x				
Straight neck/legs																		x		
Stress																				
Sun burnt																				
Swollen body		x															x		x	
Vomiting																				
Weak	x	x				x						x				x	x		x	
White nodules								x												

[a] (OIE, 2014)
[b] (Ballweber, 2006)
[c] (Hopla, A., & Keirans, 1994)
[d] (Duhamel, Hogg, & Straw, 1991)

DISCUSSION

Methodology limitations

The expert opinion elicitation procedure

By using an expert opinion elicitation procedure with a semi-quantitative approach for the scoring of the diseases, the methodology of this study faced similar limitations to those pointed out in previous studies (IFAH-Europe, 2009; Krause, 2008). The final results could be biased by the list of criteria that was ultimately selected, by the simple 4-tiered scoring system used, and by the choice of the regional experts not to apply any weighting. Also, as anticipated, it was a challenge for the participating experts to score each and every single eligible disease because of the complexity of scoring 10 criteria for 132 diseases at the regional level and 20 diseases at the national level; and secondly, because of the extensive workload that this prioritization process represents in terms of time needed for the Delphi technique.

The protocol originally planned for a multidisciplinary panel of experts and public health experts based in Suva, who were invited to participate in the regional priority setting. This format created a high level of interest in the study. However, despite numerous attempts that included postponement and date shifting of the workshops organized in Suva and in the targeted PICTs, no public health experts joined the workshop. This unfortunately reflects the difficulty of gathering veterinary and public health experts around the same table.

While all regional experts had an education in veterinary sciences and / or in animal health, national experts had mostly an animal production or agricultural background with limited or no background in animal health. This represents a serious limitation for the national animal disease prioritization exercise. Nevertheless, they had on average from 11 to 21 years of working experience in their country and therefore had valuable knowledge of what is currently happening in their country. To limit the impact on the accuracy of the scoring of the criteria, which requires a high level of expertise in veterinary / epidemiology sciences, the scoring system included the option “no scoring”.

This was a precaution against random scoring of the criteria by experts when they did not know enough about a particular disease. The consequence is that for some diseases the total ranking was the result of the scoring of very few experts.

The Mode function was originally chosen for compiling the scores attributed to each criterion in order to reflect the “majority opinion” i.e. what the majority thinks, and therefore reflecting the experts’ consensus. However, due to the limited number of experts involved at the regional level and the limited number of experts having scored some of the listed diseases, the compilation of scores with this function was providing aberrant and inconsistent results. It was thus replaced by the Median function that gives instead an “overall opinion”, i.e. it takes into account minorities’ opinion. With this data analysis approach, peer-pressure is thus less likely to bias the results.

Although the Pacific Islands region has a critical shortage of veterinarian and animal health workers (Yarrow, 2008), it was intentional to exclusively involve experts at the regional and national levels that are from and / or working in the Pacific Islands region. Within the group of regional experts only one was not originally from the PICTs but had been working for SPC for the last five years and two within the group of experts in Papua New Guinea are Australian but working on projects implemented in the targeted PICTs. In fact, experts involved in the four FABN countries occupied key positions in the different local counterpart agencies and advised decision-makers at a higher level with regard to the disease prevention and control programmes.

The methodology used followed the standards developed in other international studies but had been purposively kept as simple as possible in order to fit the local context and to achieve practicality. Considering the critical lack of up-to-date information (and in particular the lack of quantitative data) (Brioudes, Warner, Hedlefs, & Gummow, 2014), and despite the methodology limitations described here above, expert opinion elicitation still appears to be the best tool for setting animal disease priorities within the Pacific Islands region.

The farmer's interviews

The lack of accurate data makes it difficult to quantify the extent of the livestock production in the region but some of the PICTs have the highest pig and chicken densities in the world. These densities reflect the importance of livestock cultivation in the Pacific region where pigs and poultry in particular play a major role in cultures and traditions of the Pacific communities (Manueli, 2005; Secretariat of the Pacific Community, 2007a, 2007b, 2009). Only pig and poultry farmers were targeted for the survey of animal disease perception at a community level. This was because these species were the most prevalent and economically important species within these communities and provided a better focused survey. No diseases specific to other species (such as cattle, sheep and goats for instance) were to be cited by the interviewed farmers. In hind site this made direct comparison with the regional and national experts less reliable as they were not limited to pig and poultry diseases. However it could be argued that diseases that affect these species should have higher priority at a village level because of that importance in village economy and culture.

Emerging infectious disease threats versus endemic tropical diseases of the Pacific Islands region

The Pacific Islands region presents the unique status of being free of the most severe trans-boundary animal diseases such as highly pathogenic avian influenza (HPAI), foot and mouth disease (FMD) and rabies. In contrast these diseases are officially reported in South East Asia, a neighbouring region of the PICTs with, in particular, Papua New Guinea sharing a common land border with Indonesia (noting though that Indonesia itself is currently free of FMD). The results of this study reflect the concern for the potential of emergence of new infectious diseases within the Pacific Islands region with HPAI ranked second, FMD ranked fifth and rabies ranked ninth.

But the results also demonstrate the high importance of some tropical diseases that are endemic in the region such as leptospirosis, ranked as the top priority disease; brucellosis ranked third; tuberculosis ranked sixth and endoparasites and ectoparasites ranked respectively at eleventh and thirteenth place.

With this mix of exotic and endemic animal diseases among the top-twenty priority list, results show evidence of the complexity of discriminating between diseases. Decision-makers have to make this very sensitive choice. On the one hand there are chronic infectious diseases that are affecting their country and generally do not cause drastic or immediate losses but can heavily affect communities from an economic and social perspective. On the other hand, there are the emerging diseases that are not present in the country but if they were to be introduced, would most likely have a very high economic impact among livestock producers. And in the particular case of zoonoses like HPAI and rabies, the emergence of such diseases within the Pacific Islands region could also impact drastically on tourism which is a key economic sector for a number of PICTs.

The differences in disease ranking between the four FABN countries confirms that despite their similarity and their commonality of belonging to the Melanesian sub-region, they have different societies and different livestock production systems with different animal disease priorities. Our results allow a better focused sharing of resources and training at regional and in-country level.

Based on the results of the regional prioritization, leptospirosis is ranked first and is thus considered to be the most important disease within the Pacific Islands region. Many studies have demonstrated its endemicity among domestic animal populations of the PICTs (Desvars, Cardinale, & Michault, 2011; Lupo, 2003; Martin, 1999a, 1999b, 1999c; Martin & Epstein, 1999; Perolat & P.A., 1992; Saville, 1994, 1996a, 1996b, 1996c, 1996d, 1999; Simms, 1997, 1998; Thevenon, Lambert, Desouter, Costa, & Domenech, 1990). Recent studies conducted in American Samoa have demonstrated the link between the number of piggeries near homes and human cases of leptospirosis (Lau, Clements, et al., 2012; Lau, Dobson, et al., 2012). However, an interesting point is that none of the pig farmers interviewed have mentioned this disease. Despite its endemicity within the PICTs, a majority of farmers may plausibly not know the name of that disease. But the fact that only one farmer in the survey cited one of the typical symptoms (i.e. stillbirth) of that disease tends to show that it might not be a production limiting disease for pig farmers. Recent studies on leptospirosis in the western Indian Ocean islands confirm the role of rats as the major reservoir host for the bacteria on all islands, but asserts also that all mammals can be a source of contamination (Desvars, Michault, & Bourhy, 2013). Leptospirosis was ranked 7th on the prioritization list of human infectious diseases of the Federated States of Micronesia (Pavlin, Kool, Samo, & Gerstel, 2010). In light of the results presented in this study, further research on leptospirosis within the PICTs would be required in order to provide more up-to-date data on the level of infection among the domestic animal population. Such further research would enable assessment of its real impact on livestock production and thus its financial impact on farmers and local communities.

Not surprisingly, farmers didn’t name any transboundary animal diseases when they were asked about the diseases representing the highest risk in their area. Instead, the majority identified some endemic tropical disease (parasites, flu/cold, coccidiosis and scabies). Parasites and flu are quite generic terms that could match with the top-prioritized ecto and endoparasites and HPAI from the regional priority setting. However, coccidiosis and mange are ranked in the middle-bottom part of the experts’ regional priority list.

Therefore, results from this study show that farmers’ perception varies from the expert opinion and that targeted surveillance programmes resulting from the rationalised veterinary public health approach may not match the expectation of the local communities.

Implication for the disease prevention and control programmes within the PICTs

Most of the Pacific Islands are developing countries, with only limited resources allocated to their disease prevention and control programmes. Few active disease surveillance programmes are currently being conducted within these countries, such as tuberculosis and brucellosis testing in infected zones of Fiji (Secretariat of the Pacific Community, 2013). Therefore animal disease detection in these countries relies mostly on a passive surveillance system. Farmers and AHPWs (as an extension of private veterinarians in the PICTs) are defined by OIE as two of the main actors of the “key tripod” for effective surveillance (OIE, 2013) and are thus at the front line in the field of disease detection. The results of the disease perception survey show that only four diseases out of the top-twenty list (i.e. brucellosis, tuberculosis, FMD, fowl pox and Newcastle Disease) are known by at least half of the interviewed AHPW. Furthermore, only FMD would be clinically recognised by a majority of interviewed AHPW (51%) if it was to emerge within the FABN countries. These results are coherent with the fact that a majority of AHPW do not actually have an animal health background and confirms the need for more capacity building in animal disease awareness with a particular focus on these prioritized top-twenty diseases.

Results obtained from this study reflect only the animal disease priorities at the time of the study. The disease priority setting is intended to be repeated as often as required; usually whenever there is a change in animal health status within the studied area.

The framework developed for this prioritization process could also benefit the remaining 18 PICTs, with further adjustments as required.

CONCLUSION

Leptospirosis, HPAI and Brucellosis are the top three prioritized diseases of economic and human health significance for the Pacific Islands region. However, the same disease scoring process conducted in four pilot countries of this region resulted in significantly different disease ranking lists. Therefore, these results show that a regional approach should take into account country specific needs.

Farmers did not name any emerging infectious diseases as priorities but identified instead endemic diseases (parasites, flu, coccidiosis and scabies) as the most important. This study therefore demonstrates that the consensus reached through expert opinion does not agree with the farmers' perspective. Therefore, better targeted surveillance programmes may result in more rational and transparent allocations of resources for enhancing food security but might not directly match the needs of the local communities.

Interviewed Animal Health and Production Workers were unfamiliar with most of the top-twenty prioritised diseases and a majority acknowledged that they would not be able to recognise clinical signs if outbreaks were to occur in their area. This highlights the need for further capacity building for improving the animal disease knowledge in this region.

ACKNOWLEDGEMENTS

This research work was conducted in partnership between the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC) and the School of Veterinary and Biomedical Sciences of James Cook University (JCU), Townsville, Queensland, Australia as part of the Food Animal Biosecurity Network. The project received funding support under the Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government.

We are most grateful to the regional and national experts and to the field animal health and production workers and the farmers who agreed to participate in this study.

REFERENCES

Balabanova, Y., Gilsdorf, A., Buda, S., Burger, R., Eckmanns, T., Gartner, B., Gross, U., Haas, W., Hamouda, O., Hubner, J., Janisch, T., Kist, M., Kramer, M.H., Ledig, T., Mielke, M., Pulz, M., Stark, K., Suttorp, N., Ulbrich, U., Wichmann, O., Krause, G., 2011. Communicable diseases prioritized for surveillance and epidemiological research: results of a standardized prioritization procedure in Germany, 2011. PLoS One 6, e25691.

Ballweber, L.R., 2006. Endoparasite Control. Vet. Clin. North Am. Food Anim. Pract. 22, 451-461.

Brioudes, A., Gummow, B., 2013. Domestic animal diseases within the Pacific Islands region. Bibliography. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.

Brioudes, A., Warner, J., Hedlefs, R., Gummow, B., 2014. A review of domestic animal diseases within the Pacific Islands region. Acta Trop. 132, 23-38.

Cardoen, S., Van Huffel, X., Berkvens, D., Quoilin, S., Ducoffre, G., Saegerman, C., Speybroeck, N., Imberechts, H., Herman, L., Ducatelle, R., Dierick, K., 2009. Evidence-based semiquantitative methodology for prioritization of foodborne zoonoses. Foodborne Pathog. Dis. 6, 1083-1096.

Desvars, A., Cardinale, E., Michault, A., 2011. Animal leptospirosis in small tropical areas. Epidemiol. Infect. 139, 167-188.

Desvars, A., Michault, A., Bourhy, P., 2013. Leptospirosis in the western Indian Ocean islands: what is known so far? Vet. Res. 44, 80.

Doherty, J.A., 2000. Establishing priorities for national communicable disease surveillance. The Canadian journal of infectious diseases 11, 21-24.

Duhamel, G.E., Hogg, A., Straw, B.E., 1991. Prevention and control of swine dysentery, in: Lincoln, U.o.N.-. (Ed.), NebGuide, Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Gibson, J.M., 2011. A burden of disease approach to prioritizing environmental policy initiatives: a case study in the Middle East. N. C. Med. J. 72, 136-140.

Gilsdorf, A., Krause, G., 2011. Prioritisation of infectious diseases in public health: feedback on the prioritisation methodology, 15 July 2008 to 15 January 2009. Euro Surveill. 16.

Havelaar, A.H., van Rosse, F., Bucura, C., Toetenel, M.A., Haagsma, J.A., Kurowicka, D., Heesterbeek, J.H., Speybroeck, N., Langelaar, M.F., van der Giessen, J.W., Cooke, R.M., Braks, M.A., 2010. Prioritizing emerging zoonoses in the Netherlands. PLoS One 5, e13965.

Hopla, C.E., A., D.L., Keirans, J.E., 1994. Ectoparasites and classification. Rev. sci. tech. Off. int. Epiz. 13, 985-1017.

Humblet, M.F., Vandeputte, S., Albert, A., Gosset, C., Kirschvink, N., Haubruge, E., Fecher-Bourgeois, F., Pastoret, P.P., Saegerman, C., 2012. Multidisciplinary and evidence-based method for prioritizing diseases of food-producing animals and zoonoses. Emerg. Infect. Dis. 18 (4), e1. doi: 10.3201/eid1804.111151.

IFAH-Europe, 2009. Approaches to the prioritisation of diseases to focus and prioritise research in animal health: A worldwide review of existing methodologies. DISCONTOOLS Project. http://www.discontools.eu/upl/1/default/doc/WP%202%20Prioritisation%20Review%20Paper%20Final%2020120930.docx (accessed 01/03/2014).

Kline, K., McCarthy, J.S., Pearson, M., Loukas, A., Hotez, P.J., 2013. Neglected tropical diseases of Oceania: review of their prevalence, distribution, and opportunities for control. PLoS Negl. Trop. Dis. 7, e1755.

Krause, G., 2008. How can infectious diseases be prioritized in public health? A standardized prioritization scheme for discussion. EMBO reports 9 Suppl 1, S22-27.

Kurowicka, D., Bucura, C., Cooke, R., Havelaar, A., 2010. Probabilistic inversion in priority setting of emerging zoonoses. Risk analysis : an official publication of the Society for Risk Analysis 30, 715-723.

Lau, C.L., Clements, A.C., Skelly, C., Dobson, A.J., Smythe, L.D., Weinstein, P., 2012a. Leptospirosis in American Samoa--estimating and mapping risk using environmental data. PLoS Negl. Trop. Dis. 6, e1669.

Lau, C.L., Dobson, A.J., Smythe, L.D., Fearnley, E.J., Skelly, C., Clements, A.C., Craig, S.B., Fuimaono, S.D., Weinstein, P., 2012b. Leptospirosis in American Samoa 2010: epidemiology, environmental drivers, and the management of emergence. The American journal of tropical medicine and hygiene 86, 309-319.

Lupo, C., 2003. Epidemiological study of animal Leptospirosis in Fiji Islands. Thèse d'exercice, Ecole Nationale Vétérinaire de Toulouse - ENVT, 2003, 151 p.

Manueli, P., 2005. Report on the Workshop on Pacific Heads of Veterinary & Animal Production Services (PHOVAPS) - First regional meeting, p. 76p.

Martin, T., 1999a. The Animal Health Status of Samoa. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 42.

Martin, T., 1999b. The Animal Health Status of Tokelau. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 23.

Martin, T., 1999c. The Animal Health Status of Wallis & Futuna. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 29.

Martin, T., Epstein, V., 1999. The animal health status of the Salomon Islands. Secretariat of the Pacific Community, p. 44.

McAnulty, J., Stewart, K., Network, N.S.W.P.H., 2003. Priorities for communicable disease control in New South Wales, 2003. N S W Public Health Bull 14, 200-205.

McKenzie, J., Simpson, H., Langstaff, I., 2007. Development of methodology to prioritise wildlife pathogens for surveillance. Prev. Vet. Med. 81, 194-210.

Newman, S., McKenzie, A., 1991. Organisation of veterinary public health in Australasia and the Pacific Islands. Rev. Sci. Tech. 10, 1159-1184.

Ng, V., Sargeant, J.M., 2012a. A quantitative and novel approach to the prioritization of zoonotic diseases in North America: a public perspective. PLoS One 7, e48519.

Ng, V., Sargeant, J.M., 2012b. A stakeholder-informed approach to the identification of criteria for the prioritization of zoonoses in Canada. PLoS One 7, e29752.

Ng, V., Sargeant, J.M., 2013. A quantitative approach to the prioritization of zoonotic diseases in North America: a health professionals' perspective. PLoS One 8, e72172.

OIE, 2013. Fact sheets - Good veterinary governance, http://www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/Fact_sheets/GOUV_EN.pdf (accessed 10/03/2014). OIE, Paris, France.

OIE, 2014a. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals 2013, http://www.oie.int/international-standard-setting/terrestrial-manual/access-online/ (accessed 07/03/2014), in: OIE (Ed.), Paris, France.

OIE, 2014b. World Animal Health Information Database (WAHID) Interface - Information by Country/territory - Animal health situation. http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Animalsituation (accessed 14/03/2015), OIE, 12, rue de Prony, 75017 Paris, France.

Osborne, H.G., 1974. Animal quarantine in the South Pacific commission area. University of Queensland, Brisbane, Queensland, Australia, p. 56.

Owen, I.L., 2005. Parasitic zoonoses in Papua New Guinea. J. Helminthol. 79, 1-14.

Owen, I.L., 2011. Parasites of animals in Papua New Guinea recorded at the National Veterinary Laboratory: a catalogue, historical review and zoogeographical affiliations. Zootaxa, 1-163.

Pavlin, B.I., Kool, J.L., Samo, M.H., Gerstel, L., 2010. A standardized process for developing a national notifiable diseases list in a pacific island setting. Asia Pac. J. Public Health 22, 279-288.

Perolat, P., P.A., R., 1992. First evidence of leptospirosis in Vanuatu. Trans. R. Soc. Trop. Med. Hyg. 86, 557-559.

Phylum, 2009. Listing and Categorisation of Priority Animal Diseases, including those Transmissible to Humans - Methodological Manual. Phylum, 9 allée Charles CROS – ZAC des Ramassiers – 31770 Colomiers - France.

Saville, P., 1994. The Animal Health Status of the Cook Islands. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 14.

Saville, P., 1996a. The Animal Health Status of Kiribati. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 13.

Saville, P., 1996b. The Animal Health Status of Niue. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 18.

Saville, P., 1996c. The animal health status of the Pacific islands countries and territories - 1994. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 17.

Saville, P., 1996d. The Animal Health Status of Tonga. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 20.

Saville, P., 1999. The Animal Health Status of Palau. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 21.

Secretariat of the Pacific Community, 2006. The paravet training manual for the Pacific Islands - Introductory course, 2nd edition ed. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.

Secretariat of the Pacific Community, 2007a. The importance of the Pig in Pacific Island Culture - A literature review. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 38.

Secretariat of the Pacific Community, 2007b. The importance of the Pig in Pacific Island Culture - An annoted bibliography. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 44.

Secretariat of the Pacific Community, 2009a. Livestock in the Pacific. Policy brief 9/2009, 4.

Secretariat of the Pacific Community, 2009b. Report of the first FAO/OIE subregional meeting of GF-TADs for the Pacific Community region in collaboration with SPC, 25-26 June 2009, Nadi, Fiji, Secretariat of the Pacific Community, Suva Regional Office, Private Mail Bag, Suva, Fiji Islands.

Secretariat of the Pacific Community, 2013. GFTAD Meeting, March 4-8 2013, Nadi, FIJI. Secretariat of the Pacific Community, Nadi, Fiji, p. 77.

Simms, J.R., 1997. Federate States of Micronesia - Survey of Leptospirosis in Animals, A disease transmitted to Humans from Animals, College of Micronesia Agricultural Experiment Station, p. 27.

Simms, J.R., 1998. Animal leptospirosis in the Federated States of Micronesia. Pacific Health Dialog 5, 30-37.

Simoes, E.J., Mariotti, S., Rossi, A., Heim, A., Lobello, F., Mokdad, A.H., Scafato, E., 2012. The Italian health surveillance (SiVeAS) prioritization approach to reduce chronic disease risk factors. Int J Public Health 57, 719-733.

Thevenon, J.G., Lambert, C., Desouter, D., Costa, R., Domenech, J., 1990. Epidemiologic-study of bovine leptospirosis in New Caledonia. Recueil De Medecine Veterinaire 166, 903-909.

Uzochukwu, B.S., Onwujekwe, O.E., Nwobi, E.A., Ndu, A.C., Onoka, C., 2007. Households' perceptions and prioritization of tropical endemic diseases in Nigeria: implications for priority setting for resource allocation. World Health Popul 9, 36-47.

Van der Fels-Klerx, I.H., Goossens, L.H., Saatkamp, H.W., Horst, S.H., 2002. Elicitation of quantitative data from a heterogeneous expert panel: formal process and application in animal health. Risk analysis : an official publication of the Society for Risk Analysis 22, 67-81.

Williams, V., 2008. Critical veterinary shortage in Pacific islands, Biosecurity Magazine. MAF Biosecurity New Zealand, PO Box 2526, Pastoral House, 25 The Terrace, Wellington, New Zealand.

Woolhouse, M.E.J., Fevre, E.M., Handel, I., Heller, J., Tildesley, M.J., Parkin, T., Reid, S.W.J., 2011. Guide to Good Practice for Quantitative Veterinary Epidemiology, http://www.qve-goodpracticeguide.org.uk/ (accessed 21/05/2011).

World Health Organization, 2006. Setting priorities in communicable disease surveillance. http://www.who.int/csr/resources/publications/surveillance/WHO_CDS_EPR_LYO_2006_3.pdf (Accessed 01/03/2012).

Yarrow, R., 2008. Increasing veterinary capacity in the Pacific, Third regional meeting of Heads of Agriculture and Forestry Services (HOAFS), 3-5 September 2008, Apia, Samoa. Secretariat of the Pacific Community, Suva, Fiji, p. 4.

CHAPTER 4

UNDERSTANDING PIG AND POULTRY TRADE NETWORKS AND FARMING PRACTICES WITHIN THE PACIFIC ISLANDS AS A BASIS FOR SURVEILLANCE

A. Brioudes[1] and B. Gummow[1, 2]

[1] *Discipline of Veterinary Sciences, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville 4811, Queensland, Australia*

[2] *Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa*

Published in Transboundary and Emerging Diseases Journal (2015)
doi:10.1111/tbed.12370

ABSTRACT

Pacific Island countries have large pig and poultry populations. Yet little is known about patterns of contact between animals and how this influences disease spread in these islands. The objectives of this study were to examine farmer practices and the movements of pig and poultry within the Pacific Islands using questionnaires and social network analysis (SNA) tools to understand disease spread in the region. Questionnaire-based surveys were conducted in Fiji, Papua New Guinea (PNG), Solomon Islands and Vanuatu with interviews of 310 pig farmers and 491 poultry farmers. Pacific Island farmers were found to have few animals (median=7 pigs/farm, IQR 4-12); (median=50 chicken/farm, IQR 23-52); (median=10 ducks/farm, IQR 4-25); (median=12 Muscovy ducks/farm, IQR 7-28) and a diversified number of species. A large proportion of farmers (44.6 to 61.3%) do not implement any preventive or control measures, yet, the majority (80.6 to 88%) did not experience any animal diseases over the past twelve-months. Most farmers never ask for veterinary care, never engage in laboratory testing and do not report when their animals show clinical signs. Many pig farmers (31.8%) trade within their communities only and sell (24.5%) directly to consumers which reduces the risk of diseases spreading. Our results show an association between farmers that report having had disease on their farm in the past twelve-months and movements of animals on and off their farms. The capitals of the studied provinces in PNG, Vanuatu and Solomon Islands were identified as the most connected nodes of both pig and poultry trade while Fiji networks appeared much less connected. Our study found that farmer practices increased the risk of disease spread but this was currently limited by trading practices. The SNA results serve as a basis for more targeted disease surveillance and better use of available resources for disease prevention and control.

KEYWORDS

Pacific Island countries; livestock movement; targeted surveillance; pig; poultry; food animal biosecurity.

INTRODUCTION

Livestock play a major role in the social, cultural and economic environment of the Pacific Islands region and makes a significant contribution to many islander households' income and food security. The husbandry of pigs and poultry in particular is of primary importance for the Pacific communities and pigs and poultry products feature in most traditional ceremonies (FAO, 1998; Guerrier, Foster, Metge, Chouvin, & Tui, 2013; Secretariat of the Pacific Community, 2007, 2009b). There are however few studies detailing farmer practices with respect to disease reporting and management (A. Brioudes & Gummow, 2013).

Currently, the Pacific Island countries and territories (PICTs) are free from most serious transboundary animal diseases such as highly pathogenic avian influenza (HPAI), foot-and-mouth disease (FMD) or rabies (A. Brioudes, Warner, Hedlefs, & Gummow, 2014; Aurélie Brioudes, Warner, Hedlefs, & Gummow, 2015; Secretariat of the Pacific Community, 2009c; Yarrow, 2008) but the risk of these diseases being introduced into the region is highly likely and could heavily impact the livestock industry and threaten food security (Brioudes and Gummow, unpublished data) (Senne, 2003; Swallow, 2012) .

In most PICTs, animal disease detection is mainly dependent on passive surveillance (i.e. on the reporting of farmers). PICTs that are members of the World Animal Health Organisation (OIE), namely the Federate States of Micronesia, Fiji, New Caledonia, Papua New Guinea and Vanuatu, have the obligation to report twice a year on their animal disease status. These PICTS must be proactive in animal disease surveillance to be able to declare confidently which diseases are suspected or present in the country. PICTs interested in engaging in livestock product export markets also need to meet international requirements to demonstrate freedom from animal diseases such as bovine spongiform encephalopathy (Secretariat of the Pacific Community, 2009a, 2010). Therefore, despite their favourable animal disease status, the PICTs cannot rely only on their passive surveillance system and have to also undertake active surveillance programmes. Deciding how to prioritize these surveillance programmes and where to implement them remains a challenge.

Animal health authorities are in charge of animal disease surveillance but the PICTs face a critical shortage of veterinarians and animal health and production workers (Williams, 2008; Yarrow, 2008). Despite the external aid for building capacity, with for instance the on-going paravet training being conducted in some PICTs (Secretariat of the Pacific Community, 2012), there is a need for a rationalisation of the scarce financial and human resources for animal disease prevention. A targeted approach is thus required for focussing the surveillance activities as well as for the containment of disease spread in the event of a major disease outbreak.

Previous studies have demonstrated the significance of contact between livestock within a trading network in the spread of contagious diseases among animal populations (Chen et al., 2014; Christley et al., 2005; Gilbert et al., 2005; Kao, Green, Johnson, & Kiss, 2007; Kiss, Green, & Kao, 2006; Ortiz-Pelaez, Pfeiffer, Soares-Magalhaes, & Guitian, 2006). Interactions between individuals within a group can be characterised and analysed through Social Network Analysis (SNA) techniques. In preventive veterinary medicine, SNA allows a description of the contacts between animals and/or farms and leads to a better understanding of the potential risks of livestock disease transmission and dissemination among susceptible animal populations. By understanding the network, the key elements that play a role in disease dissemination can be targeted to create more efficient surveillance and control programmes (Martinez-Lopez, Perez, & Sanchez-Vizcaino, 2009).

A comprehensive study was therefore conducted in the PICTs to: (i) describe the pig and poultry movements within the PICTs and identify the key trade hubs where infectious disease may be disseminated among these livestock sectors in the Pacific Island region; (ii) evaluate the relationship between movements of live animals or animal products and presence of animal diseases in pig and poultry farms and (iii) better understand the pig and poultry farmer practices with regard to disease reporting and disease management.

METHODS

Data collection

Because there is neither formal nor informal information on the trading patterns of live animal and animal products within the PICTs, data had to be purposively collected for this study. In 2010, a Food Animal Biosecurity Network (FABN) was established between Fiji, Papua New Guinea (PNG), Vanuatu and Solomon Islands (hereafter defined as “FABN countries”), with the aim of “delivering enhanced animal health field and laboratory capability to the Pacific islands, particularly in the area of animal disease surveillance, to allow assessment under OIE guidelines for trade in animals and animal products” (Gummow, 2014). These four countries account, along with New Caledonia, for 90% of the total Pacific Island area and for more than 85% of its population (Secretariat of the Pacific Community, 2008). This paper therefore focuses on the FABN countries which can be viewed as a well-defined cluster of Pacific Island countries representative of the PICTs.

A cross-sectional survey of pig and poultry farmers was conducted in the four FABN countries from July 2012 to July 2013 (2015) with methods and selection process previously described in Chapter 3.

Data was collected by means of a standardized questionnaire structured into three main sections. Firstly, it included a description of the farm structure (number, category and breed of animals, description of the farm raising system, presence of other species on the farm and potential mix with animals from another farm). Secondly, the trading practices were characterised by the type and the frequency of on-farm and off-farm movements of live pigs or poultry and pig or poultry products over the past twelve-month period. “Pig products” referred to material derived from the body of a pig and “poultry products” referred to material derived from the body of poultry. Questions about the seasonality of the trade and the use or not of a middleman for these trading activities were also asked. Thirdly, the last section covered the farmer’s disease reporting and disease management practices (Did their flock/herd experience any diseases over the past twelve-months? Have they had any mortality among their flock/herd? Do they seek external assistance when their animals are sick? If yes, from who? How do they handle the animal carcasses?). Farmers who reported the presence of diseases on their farms in the past twelve-months were asked to name these diseases and if they were not able to name them, they were asked to list the symptoms observed.

Preceding the launching of the field survey, the questionnaire was tested by interviewing 10 pig farmers and 10 poultry farmers located within the central division of Fiji and revised based on their feed-back before implementation. After consultation with SPC and local counterparts, a translation of the questionnaire in the respective local languages of the four FABN countries was judged to be unnecessary and would not affect the quality of the research as interviews were conducted by local native speaker staff able to read in English and to provide further verbal explanations in local language if needed.

Ethical approval was granted for this survey from the James Cook University ethics committee (application H4421). As part of a bigger project, this study was developed and implemented with the approval and the collaboration of SPC and the following institutions (named hereafter as “local counterparts”): the Department of Animal Health and Production of Fiji’s Ministry of Primary Industries; the National Agriculture Quarantine and Inspection Authority (NAQIA) and the National Agricultural Research Institute (NARI) of PNG and the Departments of Livestock and Quarantine of Solomon Islands and of Vanuatu.

Operatives from the local counterpart agencies in each FABN country were trained to perform face-to-face interviews with the farmers and fill in the questionnaires. Prior to the interview, an information sheet was distributed to farmers (and read to illiterate ones) to explain the aim and the extent of the study and their written informed consent was obtained for participating in the study.

Data management and analysis

All data from the completed questionnaires were entered into Epi Info™ 7 software for statistical analysis (CDC, 2013). Network data were exported to UCINET 6 software (S.P.; Borgatti, Everett, & Freeman, 2002) and analysed using SNA techniques while network graphs were produced with NetDraw 2.097 (S.P. Borgatti, 2002).

Because the identity of the person selling to or buying from the farmer was considered sensitive and confidential when the questionnaire was piloted, it was decided to confine the origin and the destination of live pig or poultry and their products to village level rather than farm level. Villages were therefore chosen as the nodes of the pig and poultry movement networks. Movements of live pigs and poultry or pig and poultry products between two villages represented the ties connecting two nodes. The village locations where pigs and poultry were purchased and sold were reformatted into source-destination pairs and integrated into separate network adjacency matrices for pig and poultry movements. Directed networks of pig and poultry movements were constructed from the data on the origin of purchase and the destination of sale of live pigs and poultry and pig and poultry products. Degree represented the number of ties connected to a node within the directed network of this study; in-degree represented more specifically the movement of pigs and poultry to a node while the out-degree represented pig and poultry movements originating from a node. The node degree values were normalised to allow their comparison across the different island networks of this study. The normalised in-degree value was defined as the number of contacts going to a node divided by the maximum number of possible contacts and the normalised out-degree value corresponded to the number of contacts arising from a node divided by the maximum number of possible contacts. The degree centrality refers to the number of ties a node has to other nodes within the networks of this study. The in-degree centralisation expresses the deviation of the largest values of in-degree from the value computed for all other nodes and, similarly, the out-degree centralisation reflects the deviation of the largest values of out-degree from the value computed for all other nodes in the studied networks.

The open-access geographic information system software DIVA-GIS, version 7.5 (Hijmans, 2005) was used for mapping. Graphs representing the pig and the poultry networks were produced for each of the four FABN countries with NetDraw 2.097 (S.P. Borgatti, 2002). On these graphs, each node represents a location (capital, village, settlement, etc.) and arrows indicate the direction of the animal movement between two locations. The size of the nodes and their labels are proportional to the degree (i.e. number of connections to and from a node) and the thickness of the arrows is proportional to the number of movements between two locations. Movements originating from a node and ending at the exact same node are represented by an ellipsoidal arrow above that node (“self-loop”). Because the exact geographic position of the different locations where interviews were conducted could not always be retrieved the “group by attribute” function was first used for gathering the nodes belonging to the same islands (Fiji, Solomon Islands and Vanuatu) or to the same province (for PNG) in the different quadrants of the graph. Different node shapes were used to distinguish locations from the different islands or provinces. In the second stage, a “drag and drop” method was used to relocate the nodes for an optimal display of the different components (i.e. sets of connected nodes) and node connections of the networks.

Descriptive statistics were used to describe the disease reporting and disease management data. Univariable and multivariable analyses were conducted using Epi Info^{TM} 7 and NCSS software (Hintze, 2013). The univariate analysis using odds ratios (ORs) was first carried out to look for associations between farms having had animal disease in the past twelve-months and movement of pig/poultry or related products on or off the same farm. Ninety five percent confidence intervals were calculated to determine if the ORs were statistically significant or not. Since interaction between variables was not accounted for in the univariate analysis, hierarchical multivariate models were developed using logistic regression with the dependant variable being farms having had animal disease in the past twelve-months. The model was run using a hierarchical forward switching process. The forward switching process was based on log likelihood values. Independent variables were on and off-farm movements of live pigs/poultry and related products. Non significant variables based on the Wald test ($p<0.05$) were not included in the final model.

RESULTS

Survey implementation

Access to villages in the countries proved to be more difficult than expected because of their remoteness or in some cases lack of security. When a selected village could not be reached, the operatives were asked to go to the nearest accessible village instead. By the end of the study none of the countries were able to survey the percentage of villages originally specified in the materials and methods. The main reason for this being insufficient resources or geographical areas that were difficult to access. In total, 491 poultry farmers from 196 villages and 310 pig farmers from 171 villages participated in this survey.

Poultry farmers were interviewed in nine provinces of Fiji and two of PNG and Vanuatu and one of Solomon Islands. By the end of the survey, 3.8% (n=44) of the villages with poultry farmers in the selected provinces had been surveyed in Fiji, 1% (n=74) of villages in PNG, 2% (n=47) of villages in Solomon Islands and 7.8% (n=31) of villages in Vanuatu. With respect to pig farmers, eight provinces were surveyed in Fiji, two in PNG and Vanuatu and one in Solomon Island. By the end of the survey, 3.1% (n=36) of the villages with pig farmers had been surveyed in Fiji, 0.8% (n=60) of villages in PNG, 1.9% (n=46) of villages in Solomon Islands and 7.3% (n=29) of villages in Vanuatu.

Provinces surveyed for pig farmers in Fiji were Ba, Bua, Cakaudrove, Kadavu, Macuata, Nadroga/Navosa, Serua and Tailevu. Provinces surveyed for poultry farmers in Fiji were Ba, Bua, Cakaudrove, Kadavu, Macuata, Nadroga/Navosa, Namosi, Rewa and Tailevu. Pig and poultry farmers were interviewed in the provinces of Morobe and Eastern Highlands Province (EHP) in PNG, Guadalcanal in Solomon Islands and Shefa (Efate Island) and Sanma (Santo Island) in Vanuatu (Figure 4-1).

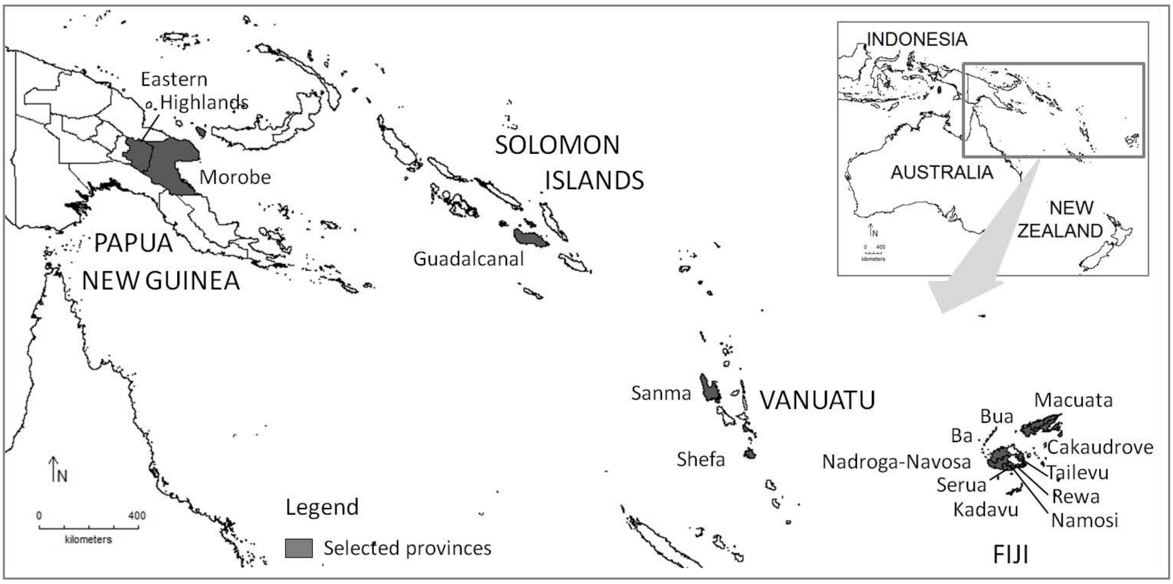


Figure 4-1: Map of the four Food Animal Biosecurity Network countries with the provinces selected for the study

Characteristics of selected farms

Of the 491 interviewed poultry farmers, 72 (14.7%) were from Fiji, 273 (55.6%) from PNG, 93 (18.9%) from Solomon Islands and 53 (10.8%) from Vanuatu. A vast majority (74.5%) were men and the median number of years of working as a farmer was four (IQR 2-10, max=50). The proportion of the different species, breeds and categories of poultry raised are presented in Figure 4-2 along with the farm raising systems. Almost all (97.8%) interviewed poultry farmers raised chickens with a median number of chickens per farm of 50 (IQR 23-52, max=42,000) and 7.9% raised ducks with a median number of ducks per farm of 10 (IQR 4-25, max=70). Six farmers were also raising Muscovy ducks but only three of these gave information on the number of Muscovy ducks farmed (median=12, IQR 7-28, max=28). Approximately half of the farmers (46.8%) had other species apart from poultry, these included dogs (22.8%), cats (14.3%), goats (12.6%), pigs (11%), cattle (8.2%), horses (3.7%), sheep (2.4%), rabbits (0.2%) and fish (0.2%). Thirteen percent reported mixing their poultry with animals from other farms.

Sixty (19.4%) of the interviewed pig farmers were from Fiji, 110 (35.9%) from PNG, 91 (29.4%) from Solomon Islands and 49 (15.8%) from Vanuatu. They were predominately men (77.7%) and had been raising pigs for about 5 years (median, IQR 2-10, max= 65). The median number of pigs per farm was 7 (IQR 4-12, max=

6000). Figure 4-2 displays the proportion of the different breeds and category of pigs farmed as well as the diverse kind of raising systems used by farmers. A large number of farmers (45.8%) raised other animals (27.1% raising also poultry, 26.1% dogs, 11.6% cattle, 11.6% cats, 7.4% goats, 6.1% horses, 1.6% sheep, 0.3% bees and 0.3% parrots). Twenty four percent of interviewed farmers mixed their pigs with animals from other farmers.

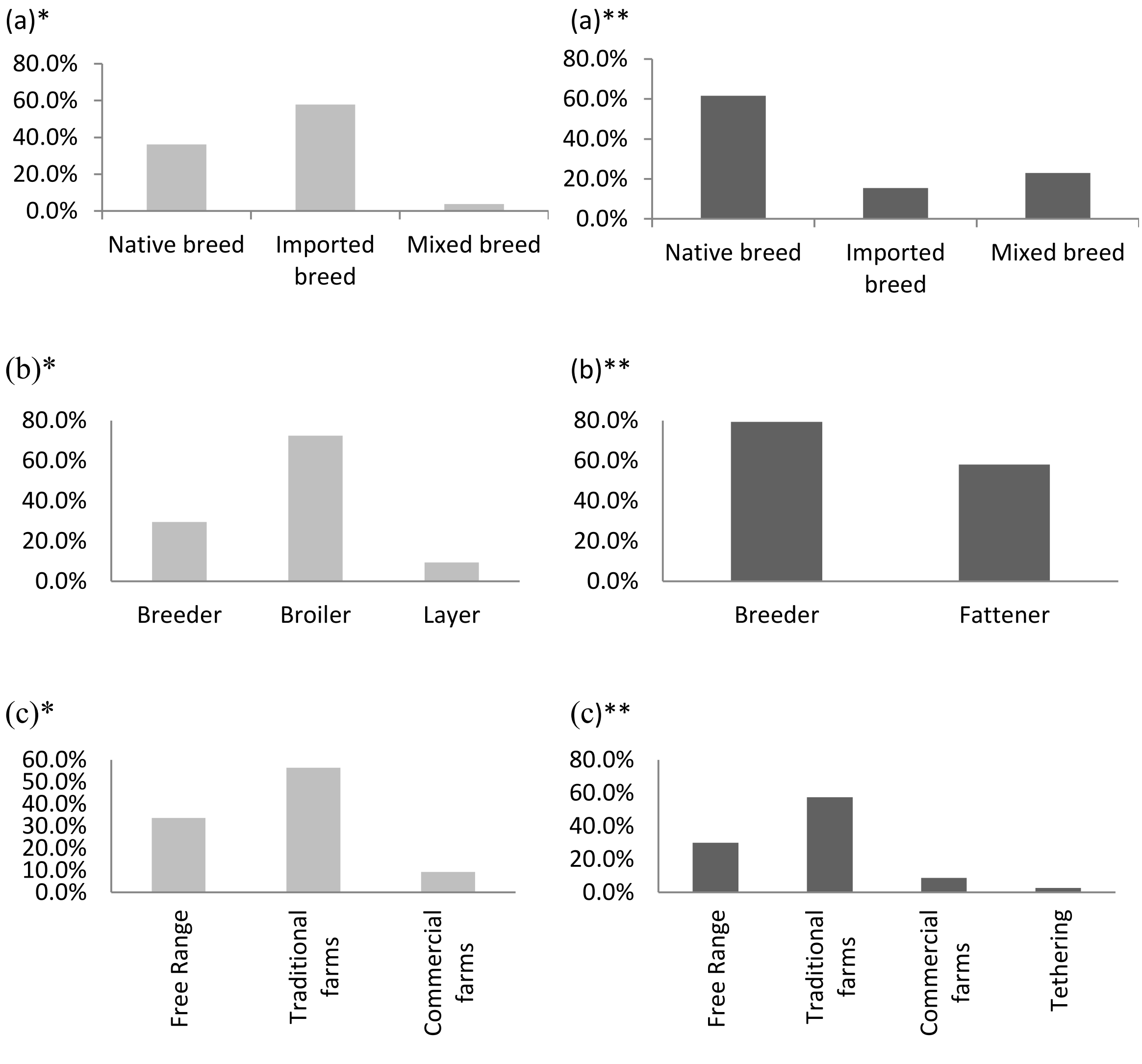


Figure 4-2: Poultry* and pig farm demographics (a) breed; (b) production categories; (c) husbandry settings for FABN Countries in 2012/13**

Disease reporting and management

A total of 108 poultry farmers (22.0%) and 60 pig farmers (19.4%) responded having had disease(s) in their flock or herd over the past twelve-month period. The list of diseases and symptoms reported by these farmers is summarised in Figure 5-3 and is based on the answers of the interviewed farmers to an open question about the diseases experienced by their flock/herd over the past twelve-months. It is not clear how farmers diagnosed these diseases as only two poultry farmers (1.98%) and one pig farmer (1.85%) reported asking for laboratory tests to confirm a diagnosis. Many farmers did however report asking for assistance (see below) and this may provide an avenue for making a diagnosis.

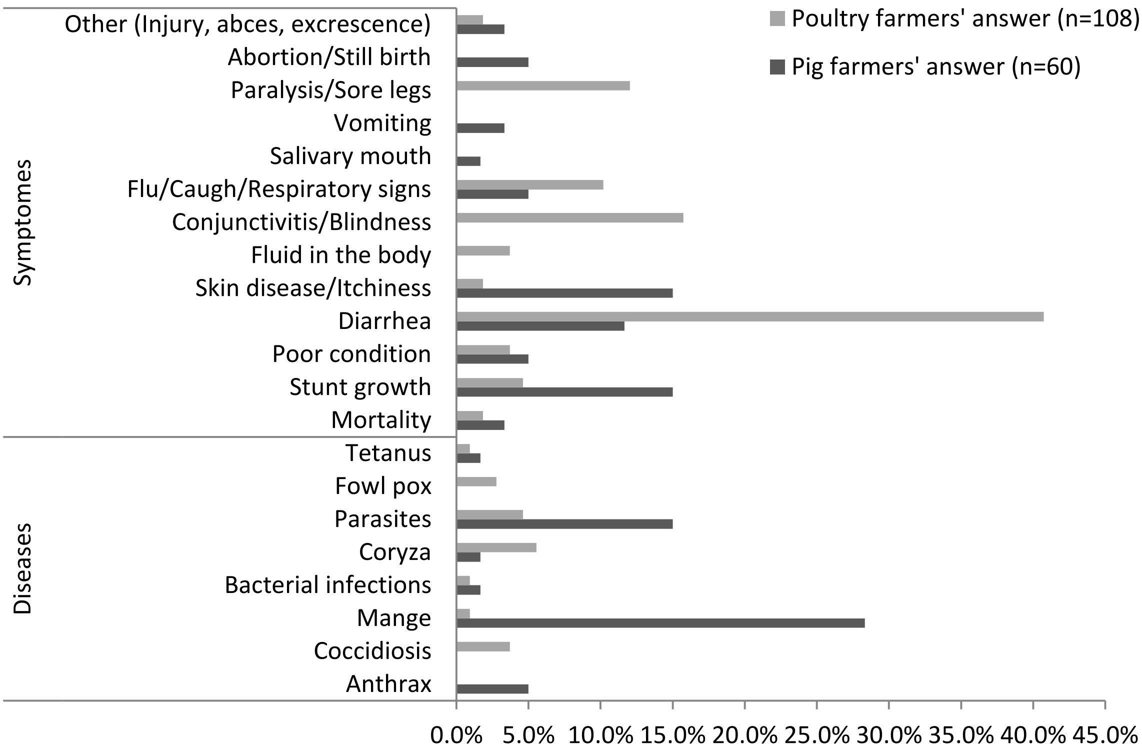


Figure 4-3: Diseases and symptoms listed by FABN farmers over the past twelve-month period (Jul. 2012-Jul. 2013) in their pigs and poultry, as a proportion of the total number of responses to this question

Results of the univariate analysis and multivariate logistic regression are presented in Table 4-1. The univariate analysis showed an association between the presence of diseases and movement of live poultry on or off the farms in the past twelve-month period. The same association applied to live pig movement. However, with respect to movement of poultry and pig products, only on farm movement of pig products showed a significant association to disease presence in the past twelve-months. Similar results were observed with the multivariate logistic regression except that on-farm movement of live poultry was no longer significant. The final logistic regression model for poultry was “Model for the presence of disease = - 0.79+0.98*(Off-farm movements of live poultry)” and for pigs “Model for the presence of disease = 1.32+1.11*(Off-farm movement of pig products) + 1.39 * (Off-farm movements of live pigs) + 0.96* (On-farm movements of pig products)”. The percentage of observed values correctly classified by each model was 41.3% in the case of poultry model and 55.5% in the case of the pig model, implying other risk factors are probably also playing a role.

When asked about actions taken for avoiding or controlling diseases on their farm, 55.4% of the poultry farmers and 38.7% of pig farmers reported putting in place preventive or control measures (Figure 4-4). If animals get sick or present abnormal signs, 34.4% of poultry farmers and 41.0% of the pig farmers look for external assistance (Figure 4-5) while the remaining declared never asking for assistance from anyone. Considering the past twelve-month period only 4.6% of poultry farmers and 10.4% of the pig farmers asked for assistance, which represents respectively 20.4% (22/108) and 53.3% (32/60) of the poultry and pig farmers who had sick animals over that period of time. According to interviewed farmers, 27.0% of them had some mortalities in their poultry flocks over the past twelve-month period and 68.4% in their pig herds. The different ways in which pig and poultry farmers handle carcasses on their properties are detailed in Figure 4-6.

Table 4-1: Results of the univariate analysis (a) and multivariate logistic regression with poultry variables (b) and pig variables (c) for the association between the presence of diseases on a farm in the past twelve-months and the movement of pigs/poultry or related products on or off that farm

(a) Univariate analysis

Networks	Presence of diseases in poultry farms	Presence of diseases in pig farms
On-farm movement of live animals	**OR=1.74 (95% CI: 1.10 – 2.73)**	OR=1.73 (95% CI: 0.94 – 3.20)
On-farm movement of animal products	OR=1.14 (95% CI: 0.47 – 2.74)	**OR=2.87 (95% CI: 1.35 – 6.09)**
Off-farm movement of live animals	**OR=2.67 (95% CI: 1.46 – 4.89)**	**OR=5.23 (95% CI: 2.47 – 11.08)**
Off-farm movement of animal products	OR=1.40 (95% CI: 0.82 – 2.42)	**OR=4.23 (95% CI: 2.10 – 8.51)**

(b) Multivariate analysis poultry

Independent variables	Regression coefficient	Odds ratios	Lower 95% confidence	Upper 95% confidence	Wald prob level
Off-farm movement of live poultry	0.98	2.67	1.46	4.89	0.0027

(c) Multivariate analysis pigs

Independent variables	Regression coefficient	Odds ratios	Lower 95% confidence	Upper 95% confidence	Wald prob level
On-farm movement of pig products	0.96	2.60	1.17	5.79	0.01866
Off-farm movement of live pig	1.39	4.03	1.86	8.74	0.00042
Off-farm movement of pig products	1.11	3.04	1.46	6.32	0.00294

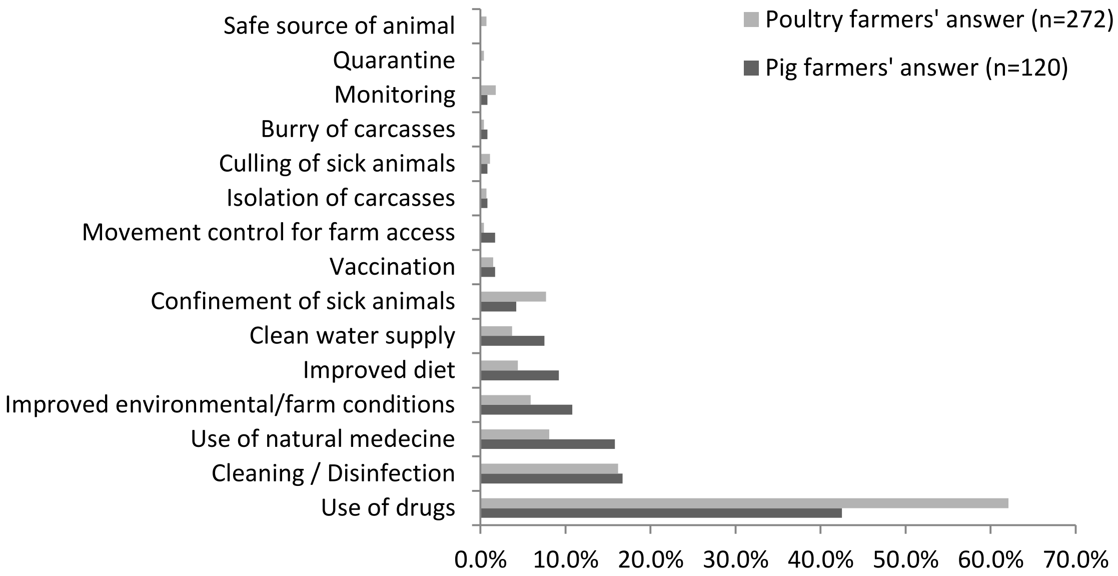


Figure 4-4: Preventive and disease control measures put in place by 38.7% of pig and 55.4% of poultry farmers, shown as a proportion of these farmers

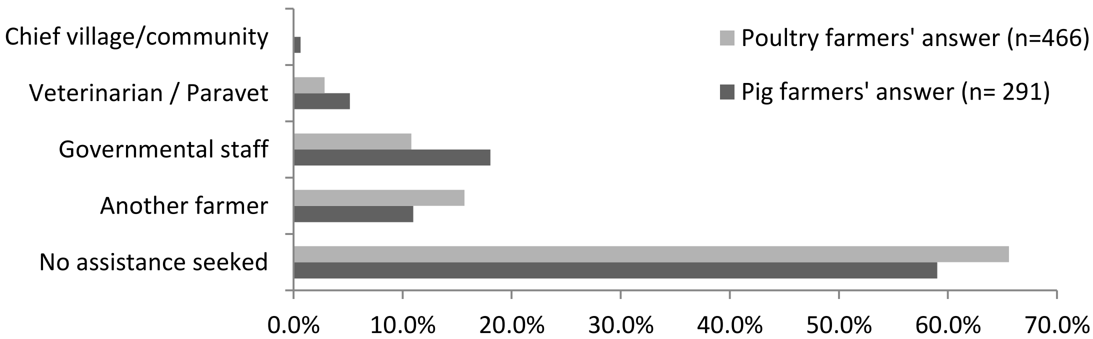


Figure 4-5: List of persons contacted by pig and poultry farmers when seeking assistance, shown as a proportion of the farmers that answered this question

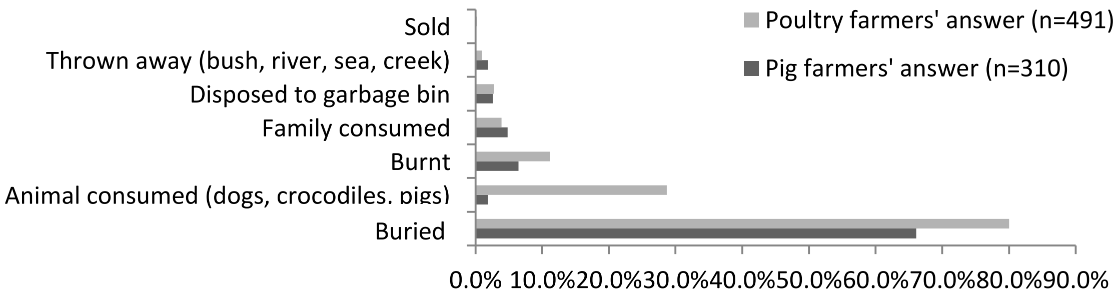
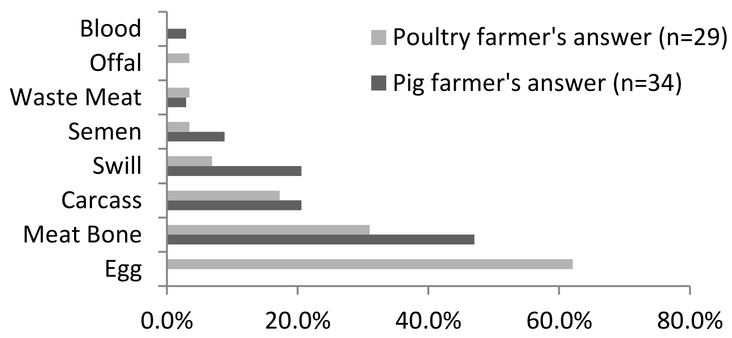


Figure 4-6: Farmer's habits for handling carcasses shown as a proportion of the farmers that answered this question (all farmers answered this question)

Characteristics of pig and poultry movements

Among the interviewed pig farmers, 24.5% had live pigs and 11.0% had pig products on-farm movements over the past twelve-month period. During that same period of time, 58.1% had live pigs and 13.2% had pig products off-farm movements. Similarly, 58.7% and 5.9% of poultry farmers had on-farm movements of live poultry and poultry products respectively over the past twelve-month period, and 75.0% and 16.7% of them had off-farm movements of respectively live poultry and poultry products during that same period. Figure 4-7 details the proportions of the different categories of animal products being moved to and out of the pig and poultry farms. A total of 28.1% of pig farmers and 17.1% poultry farmers did not move any pigs or poultry to or from their farm over the past twelve-month period. Among those farmers who declared some movement of pig or poultry to or out of their farms, 31.8% of pig farmers and 7.1% of poultry farmers traded only within their home locality and 24.5% of pig farmers and 23.0% of poultry farmers who had off-farm movements sold their live animals or animal products directly to local consumers (on farm-site or within their community).

(a)



(b)

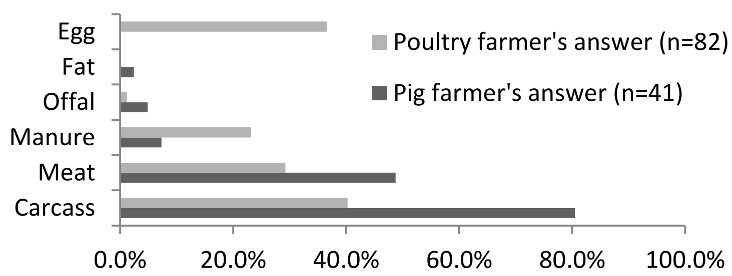


Figure 4-7: The types of animal products moved (a) on-farm and (b) off-farm as a proportion of the total movements of products

Directed networks of poultry and pig movements in each of the four FABN countries are respectively illustrated in Figures 4-8 and 4-9. The key parameters of these networks are presented in Table 4-2.

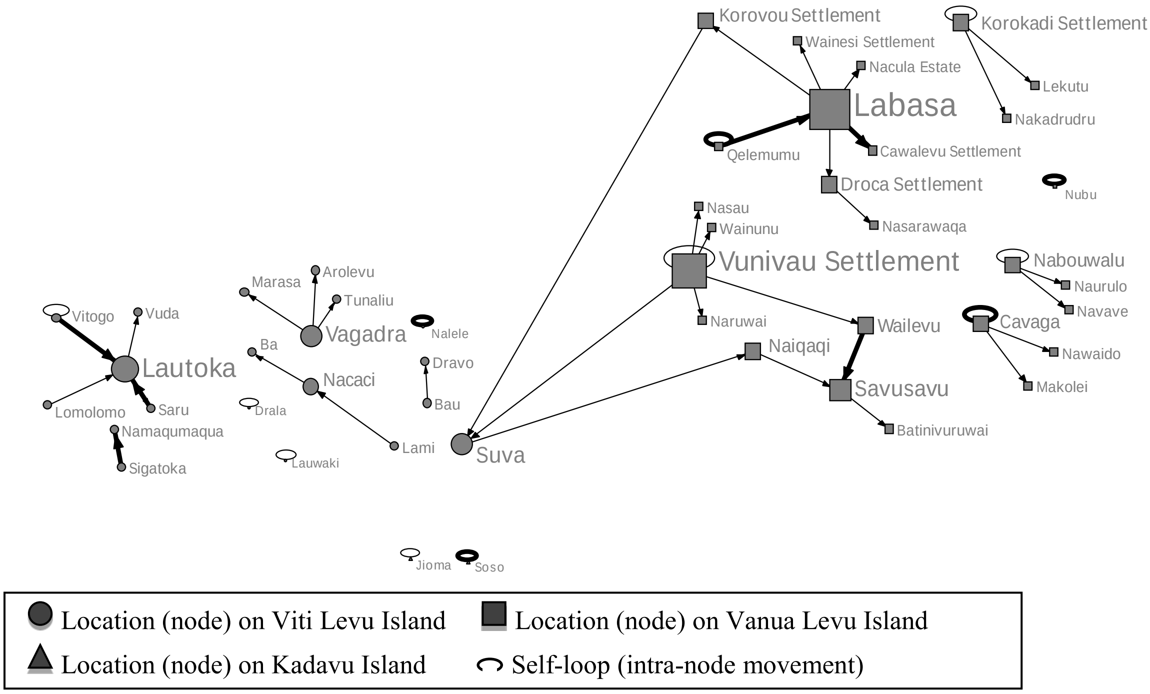
Table 4-2: Social network parameters of pig and poultry networks in the four FABN countries

Poultry network parameters	Fiji	PNG	Solomon Islands	Vanuatu
Network size				
Number of nodes	48	82	31	37
Number of ties	35	184	37	24
Number of components	10	3	3	9
Proportion of nodes in the main component	35.4% (n=17)	92.7% (n=76)	56.8% (n=21)	27% (n=10)
Number of nodes with self-loop only	6	4	7	8
Measures of centrality				
Normalised mean in-degree (min, max)	1.55 (0-6.38)	0.47 (0-3.50)	1.41(0-16.13)	1.80(0-19.44)
Normalised mean out-degree (min, max)	1.55 (0-10.64)	0.47(0-14.71)	1.41(0-25.81)	1.80(0-8.33)
In-degree centralisation	4.93%	3.07%	15.19%	18.13%
Out-degree centralisation	9.28%	14.42%	25.18%	6.71%
Pig network parameters	**Fiji**	**PNG**	**Solomon Islands**	**Vanuatu**
Network size				
Number of nodes	48	53	24	35
Number of ties (active ties)	35	37	18	27
Number of components	14	10	2	4
Proportion of nodes in the main component	20.8% (n=10)	45.2% (n=24)	70.8% (n=17)	54.2% (n=19)
Number of nodes with self-loop only	4	10	7	8
Measures of centrality				
Normalised mean in-degree (min, max)	1.55 (0-4.26)	0.42 (0-5.29)	3.26(0-34.78)	2.27(0-17.65)
Normalised mean out-degree (min, max)	1.55 (0-10.64)	0.42(0-3.37)	3.26(0-30.44)	2.27(0-11.77)
In-degree centralisation	2.76%	3.01%	32.89%	15.83%
Out-degree centralisation	9.28%	4.97%	28.35%	9.78%

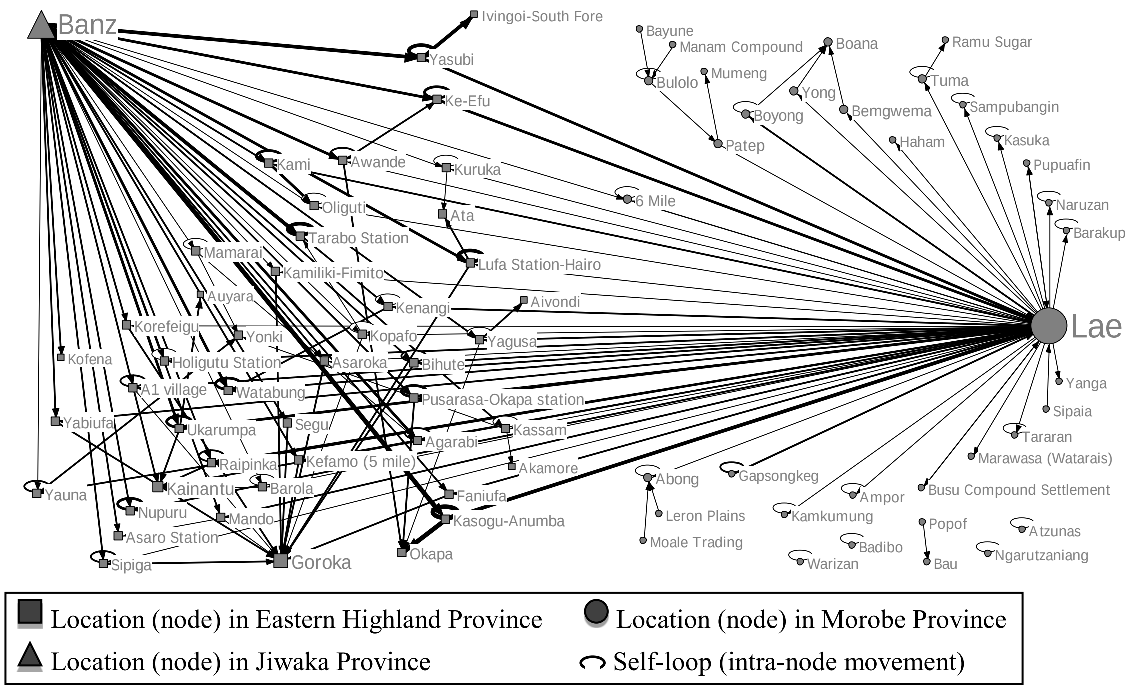
The poultry network in PNG appeared highly connected with a giant component of 92.8% of the total number of nodes composing this network. In the Solomon Islands the poultry network is also highly connected with a main component composed of 65.6% of nodes and other components with no ties or two ties only. Lae (capital of Morobe province) and Banz (capital of Jiwaka province, neighbouring Eastern Highland Province) in PNG were the nodes with the highest out-degree values of this network, which is to be attributed to the presence in these localities to the biggest day-old chick (DOC) suppliers in PNG. With a total of 26 ties out of the total numbers of 29 ties of the network, Honiara (capital) was a central node with the highest in-degree and out-degree values of the strongly connected Solomon Island poultry network. In Fiji and in Vanuatu the poultry networks appeared less connected with several small components. But Port Vila (capital) in Vanuatu and Labasa and Vunivau settlement in Fiji were identified as the locations with the highest degree values (Figure 4-8 and Table 4-2). A common point of these four networks is the presence of some nodes not connected with any other nodes which reflects the absence of any kind of movement for some of the interviewed farmers and the intra-village poultry movements for others.

The pig networks of Solomon Islands and Vanuatu show a great connectivity with respectively 54.2% and 70.8% of the nodes within the main component, and the capitals (Honiara and Port Vila) as the locations with the highest degree of trade (Figure 4-9 and Table 4-2). The pig network of PNG is less connected with10 different components but Lae lies again in a central position with the highest in-degree and out-degree values of the network. Similar to the poultry network, Goroka has the highest in-degree value which is linked to the presence of important livestock markets and slaughterhouses. The pig network in Fiji is composed of 10 different components with a limited number of connections, except for the Northern division (composed of Bua, Macuata and Cakaudrove provinces) where the two nodes with the highest in-degree values are Togalevu Estate and Nacaracara Estate. Isolated nodes were also identified in each of these four pig networks, reflecting the absence of pig movement to and from these nodes.

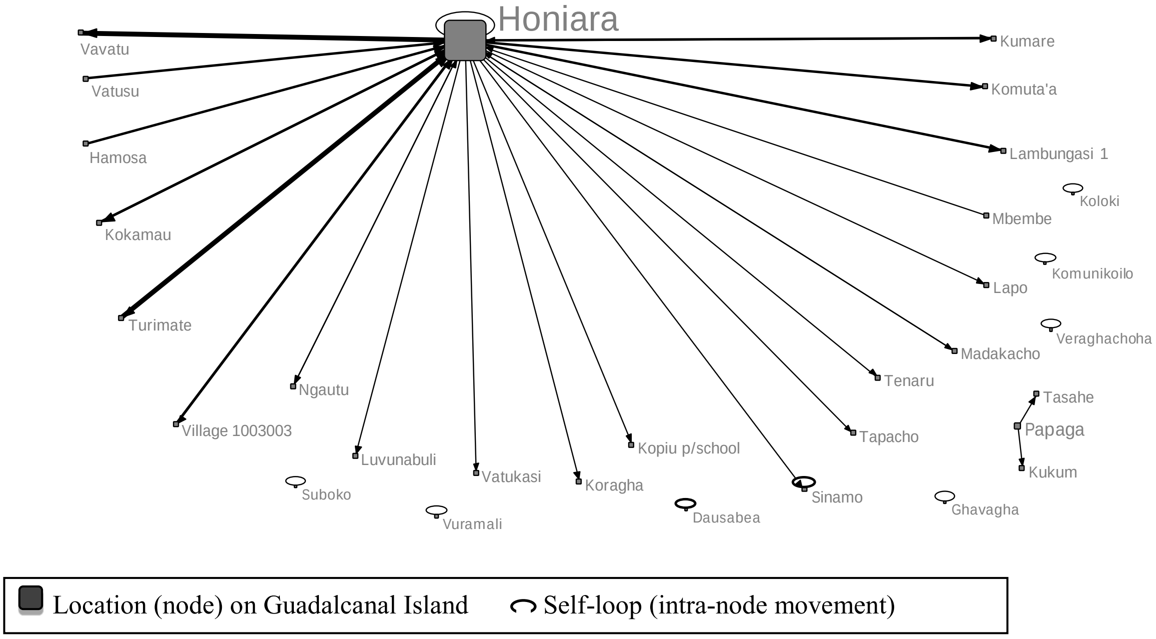
(a)


Korovou Settlement
Korokadi Settlement
Wainesi Settlement
Nacula Estate
Lekutu
Labasa
Nakadrudru
Qelemumu
Cawalevu Settlement
Droca Settlement
Nubu
Nasau
Nasarawaqa
Wainunu
Vunivau Settlement
Nabouwalu
Naurulo
Navave
Arolevu
Marasa
Tunaliu
Vitogo
Vuda
Vagadra
Nalele
Naruwai
Wailevu
Cavaga
Ba
Dravo
Naiqaqi
Nawaido
Lautoka
Nacaci
Makolei
Savusavu
Lomolomo
Saru
Drala
Bau
Namaqumaqua
Lami
Batinivuruwai
Suva
Sigatoka
Lauwaki
Jioma
Soso
Location (node) on Viti Levu Island
Location (node) on Vanua Levu Island
Location (node) on Kadavu Island
Self-loop (intra-node movement)

(b)


Banz
Ivingoi-South Fore
Yasubi
Ke-Efu
Bayune
Manam Compound
Boana
Ramu Sugar
Bulolo
Mumeng
Yong
Tuma
Boyong
Bemgwema
Sampubangin
Patep
Haham
Kasuka
Pupuafin
Kami
Awande
Kuruka
6 Mile
Naruzan
Barakup
Oliguti
Ata
Tarabo Station
Mamarai
Kamiliki-Fimito
Lufa Station-Hairo
Auyara
Aivondi
Kenangi
Korefeigu
Yonki
Kopafo
Yagusa
Lae
Kofena
Holigutu Station
Asaroka
Bihute
Yanga
A1 village
Watabung
Pusarasa-Okapa station
Sipaia
Yabiufa
Ukarumpa
Segu
Kassam
Tararan
Agarabi
Marawasa (Watarais)
Raipinka
Kefamo (5 mile)
Akamore
Abong
Gapsongkeg
Yauna
Kainantu
Barola
Ampor
Busu Compound Settlement
Faniufa
Nupuru
Mando
Kasogu-Anumba
Leron Plains
Kamkumung
Popof
Atzunas
Asaro Station
Badibo
Moale Trading
Sipiga
Goroka
Okapa
Warizan
Bau
Ngarutzaniang
Location (node) in Eastern Highland Province
Location (node) in Morobe Province
Location (node) in Jiwaka Province
Self-loop (intra-node movement)

(c)



(d)

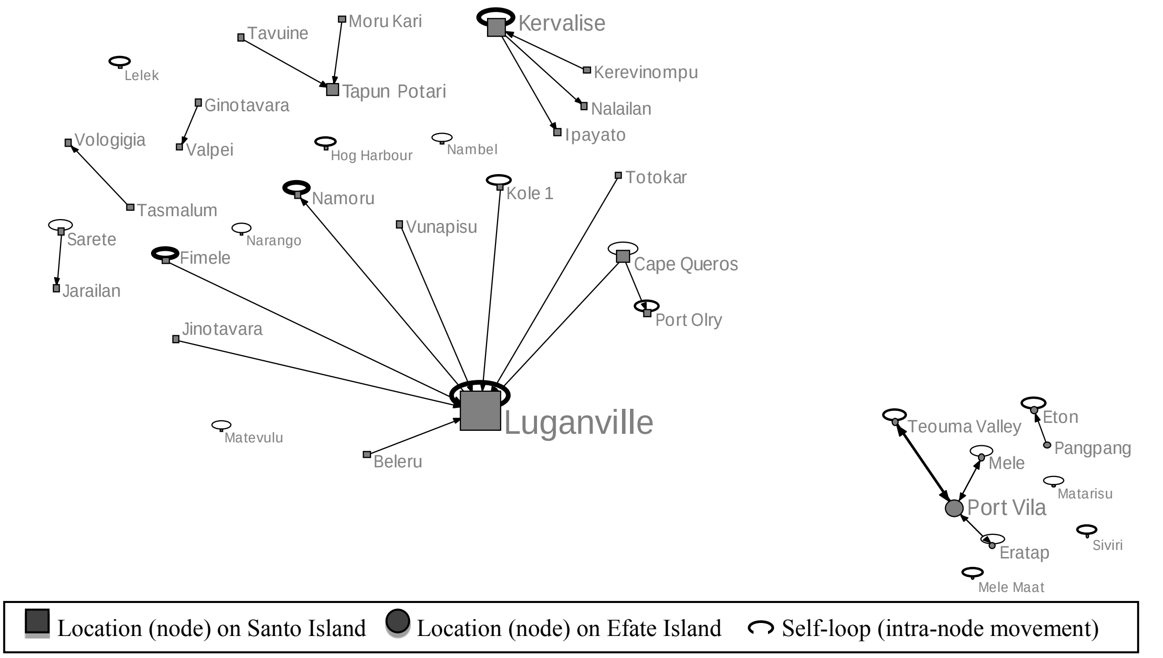
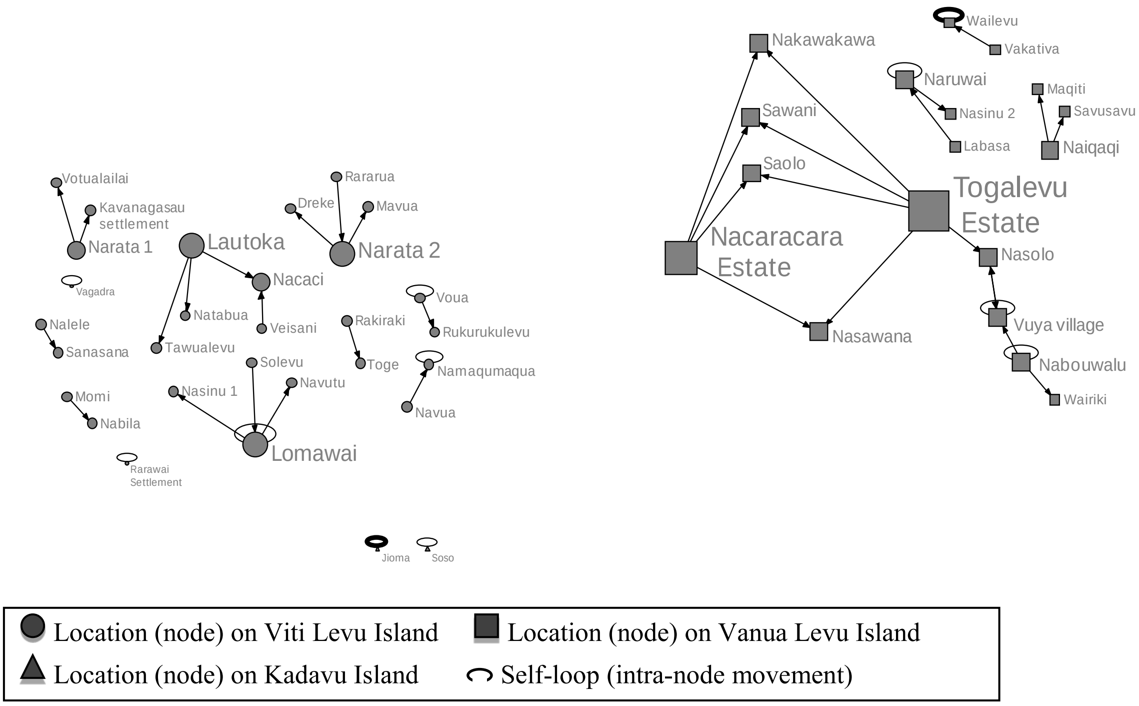
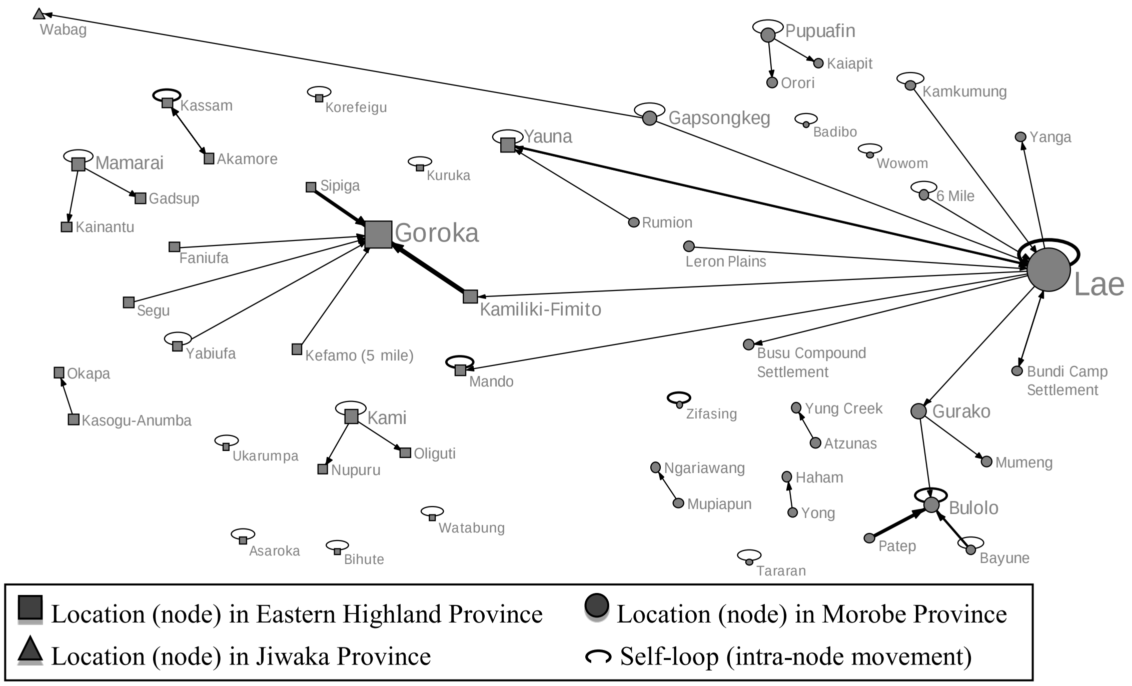


Figure 4-8: Poultry trade networks in the four FABN countries in 2012/13: (a) Fiji, (b) PNG, (c) Solomon Islands and (d) Vanuatu, with node size and labels being proportional to the degree of the node; edges representing the animal movements between two locations and the self-loops indicating movements originating from a node and ending at the exact same node

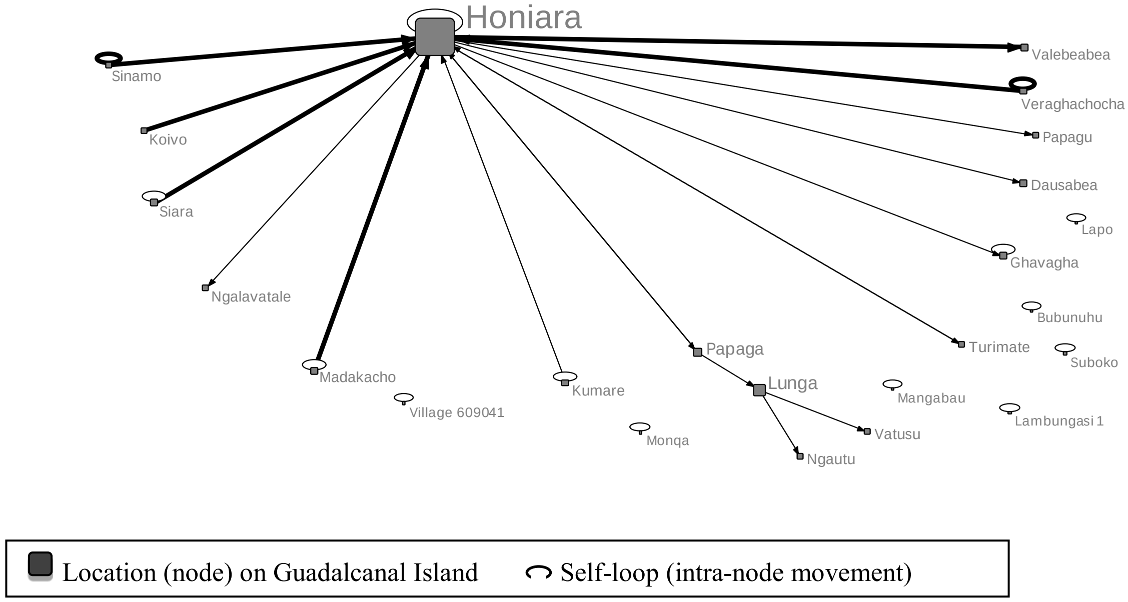
(a)


Wailevu
Vakativa
Nakawakawa
Naruwai
Maqiti
Savusavu
Sawani
Nasinu 2
Labasa
Naiqaqi
Saolo
Togalevu Estate
Nacaracara Estate
Nasolo
Vuya village
Nasawana
Nabouwalu
Wairiki
Votualailai
Kavanagasau settlement
Narata 1
Lautoka
Rararua
Dreke
Mavua
Narata 2
Nacaci
Vagadra
Natabua
Veisani
Voua
Nalele
Rakiraki
Rukurukulevu
Sanasana
Tawualevu
Solevu
Toge
Namaqumaqua
Navutu
Momi
Nasinu 1
Nabila
Navua
Lomawai
Rarawai Settlement
Jioma
Soso
Location (node) on Viti Levu Island
Location (node) on Vanua Levu Island
Location (node) on Kadavu Island
Self-loop (intra-node movement)

(b)


Wabag
Pupuafin
Kaiapit
Orori
Kamkumung
Kassam
Korefeigu
Gapsongkeg
Badibo
Yanga
Akamore
Yauna
Wowom
Mamarai
Kuruka
6 Mile
Gadsup
Sipiga
Kainantu
Goroka
Rumion
Faniufa
Leron Plains
Lae
Segu
Kamiliki-Fimito
Yabiufa
Kefamo (5 mile)
Busu Compound Settlement
Bundi Camp Settlement
Okapa
Mando
Zifasing
Yung Creek
Gurako
Kasogu-Anumba
Kami
Atzunas
Oliguti
Ukarumpa
Mumeng
Nupuru
Ngariawang
Haham
Mupiapun
Bulolo
Yong
Watabung
Patep
Asaroka
Bihute
Bayune
Tararan
Location (node) in Eastern Highland Province
Location (node) in Morobe Province
Location (node) in Jiwaka Province
Self-loop (intra-node movement)

(c)



(d)

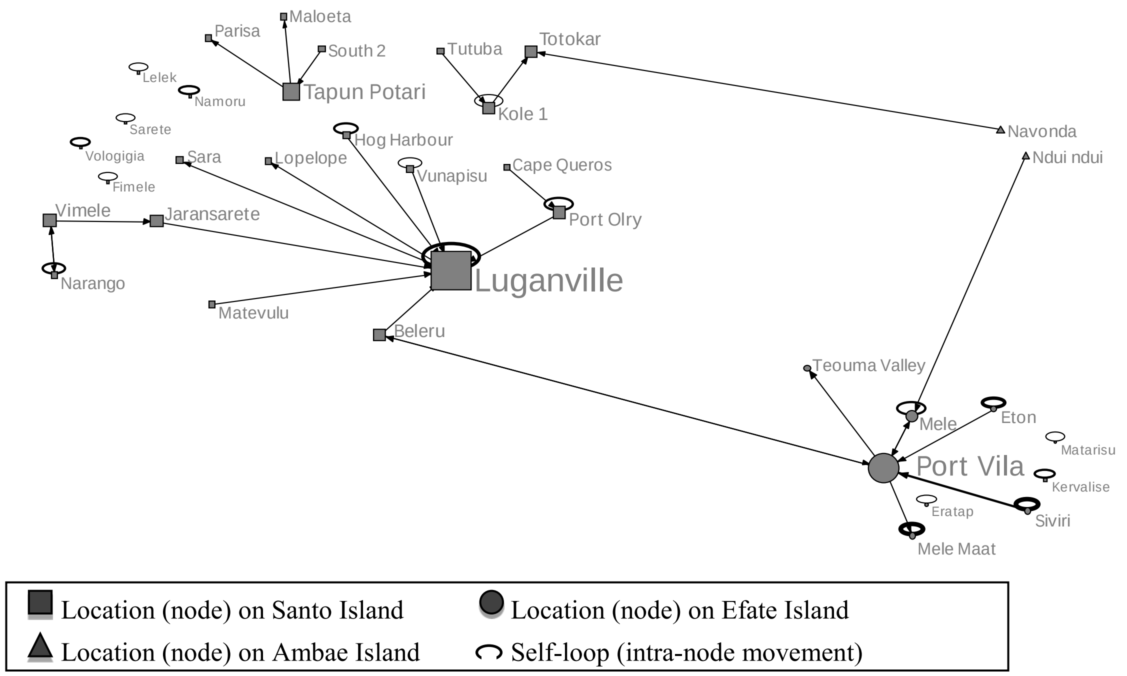


Figure 4-9: Pig trade networks in the four FABN countries in 2012/13: (a) Fiji, (b) PNG, (c) Solomon Islands and (d) Vanuatu, with node size and labels being proportional to the degree of the node; edges representing the animal movements between two locations and the self-loops indicating movements originating from a node and ending at the exact same node.

Seasonality of pig and poultry movements

Regarding the seasonality of trade, 66.6% of poultry farmers (n=327) and 52.3% of pig farmers (n=162) observed an increase in sales over certain periods of the year. Pig farmers across the four FABN countries observe similar patterns of seasonal trading whereas poultry farmers in PNG have an increase in trade from April/May to October/November, which is not observed in the three other FABN countries. This increase is related to the Coffee season and is associated with festivities organised around this activity that involves increased poultry consumption. The highest increase in trade reported by pig farmers of the four FABN countries is associated with Christmas and New Year celebrations in December and January. This is also observed by the majority of poultry farmers, except in Fiji where the poultry trade seems to have only limited variations over the year. The different occasions linked to these increases in trade are listed in Figure 4-10. In addition to events occurring at fixed periods of the year (like Christmas, Easter, Coffee season, school holidays), social events happening all year long (like traditional ceremonies, weddings, funerals) were also cited by farmers as reasons for an increase in their trade.

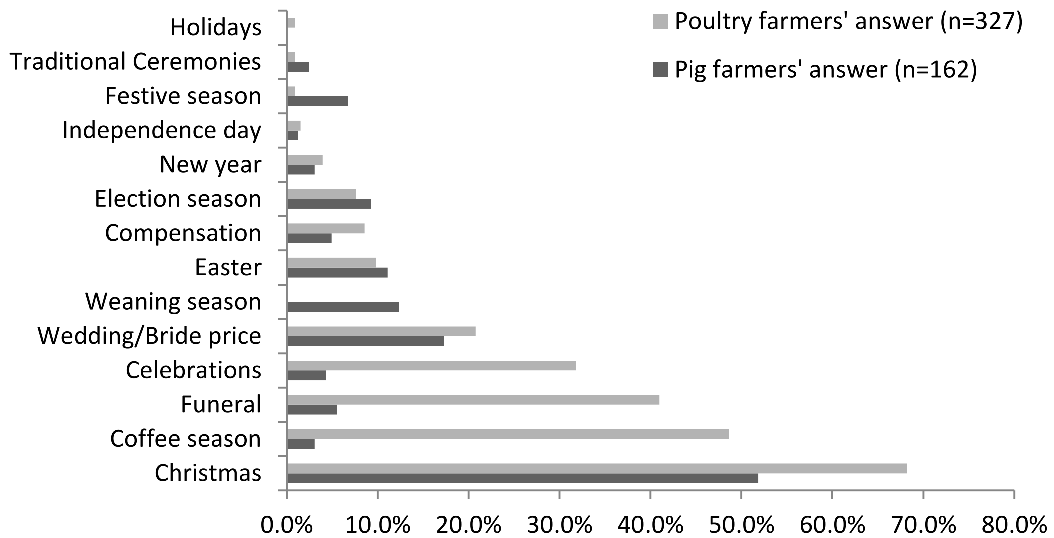


Figure 4-10: Proportion of farmers who declared increased trade of pig or poultry during the occasions listed

DISCUSSION

With a median of 50 poultry per farm and seven pigs per farm, the sampling frame of this study was composed mostly of small households with predominantly free range animals or animals raised in a traditional small housing system with limited biosecurity measures. Almost half of the farmers also raised other animals apart from pigs or poultry. This is consistent with farmers of the Pacific Island region who tend to have small-scale subsistence-based farms with small numbers of animals but a diversified number of species (FAO, 1998; Guerrier, Foster, Metge, Chouvin, & Tui, 2013; Secretariat of the Pacific Community, 2009a). This local context produces potentially favourable conditions for the introduction and the dissemination of diseases across species within a farm such as for example leptospirosis, which is endemic in the region, (Brioudes, Warner, Hedlefs, & Gummow, 2014) or foot-and-mouth disease if it was to be introduced (Swallow, 2012). Our study also showed that about a quarter of pig farmers and 12% of poultry farmers mix their animals with animals of other farmers within their village, which increases the risk of disease dissemination between villages as well.

What is interesting is that despite the favourable conditions for spread of disease and even though a large proportion of pig and poultry farmers (61.3% and 44.6% respectively) do not implement any preventive or control measures to avoid or limit the impact of animal diseases, the majority didn't experience any animal diseases over the extended retrospective period covered within this study (i.e. the past twelve-month). This finding is confirmed by others (Brioudes et al., 2014; Newman & McKenzie, 1991; Secretariat of the Pacific Community, 2009b; Yarrow, 2008) and reasons for this apparent anomaly are discussed further below.

Our results indicate that the use of laboratory testing for confirming the presence of animal diseases in pig and poultry is poor in the surveyed countries. The availability and the maintenance of laboratory diagnostic capacities are known to be a challenge in the Pacific as it is in many developing countries (Bhatia & Narain, 2010; Jeggo, 2000). Currently, only two of the FABN countries (i.e. Fiji and PNG) have adequate laboratory facilities for a basic animal disease diagnostic capacity. The cost-benefit of a laboratory confirmation may not be perceived as positive by farmers and the shortage of animal health staff makes sample collection a challenge, especially in remote areas. The results of this study show that a large proportion of pig and poultry farmers never ask for assistance when diseases occur on their farm and do not report diseases. This finding is consistent with a previous study on swine brucellosis awareness in Polynesia (Guerrier et al., 2013) in which pig farmers declared being afraid of losing their respectability if they were to ask for veterinary care and feeling embarrassed if they were no longer able to offer pigs for traditional ceremonies because their pigs had been slaughtered. This finding is particularly of concern considering that for most of these countries, there is minimal to no active surveillance and therefore the detection of new animal disease outbreaks relies mostly on farmer reporting (i.e. passive surveillance).

With a total absence of movement over the past twelve-month period for 28.1% of pig farmers and 17% of poultry farmers, external trading is not a primary source of income for many of these Pacific Islanders but rather a more traditional practice of securing food for the family. A third of pig farmers (31.8%) also trade within their communities only and this helps reduce the risk of spreading pig diseases. In addition, about a quarter of pig and poultry farmers sell directly to consumers, at the farm gate or within their neighbouring community, which further reduces the risk of diseases spreading. These practices combined partially explain the apparent lack of disease present in their animal populations despite the high risks noted above.

The results of the multivariate analysis show an association between the movement of live animals or animal products and the presence of diseases (Table 4-1). This trend has been observed by others when looking at specific diseases (Nicolas, Durand, Duboz, Rakotondravao, & Chevalier, 2013; Poolkhet, Chairatanayuth, Thongratsakul, Kasemsuwan, & Rukkwamsuk, 2013; Rasamoelina-Andriamanivo et al., 2014; Soares Magalhaes et al., 2010; Van Kerkhove et al., 2009). The implication is that as the transport networks expand in the FABN countries due to current development goals, one can anticipate an increase in movement of animals with consequent increase in disease frequency (Ministry of Agriculture and Livestock of the Independent State of

Papua New Guinea, 2006; National Strategic Plan Taskforce of the Independent State of Papua New Guinea, 2010).

This can be countered by raising awareness among farmers about disease prevention practices to avoid the introduction of pathogens when they trade animals. The significant association observed between disease occurrence and off-farm movement of live animals for both pig and poultry is hard to explain but may be because farmers and their animals come into contact with other animals carrying diseases when trading at the trading hubs identified in this study. If animals are not sold at the market, it is common practice to return with these animals back to their farms and because of poor biosecurity and lack of quarantine they may be inadvertently introducing diseases back into their farms as a consequence (personal communication, Andy K Yombo, Principle Epidemiologist and OIE Focal Point for Disease Notification, NAQIA, PNG, March 2015). These results confirm the need to implement adequate biosecurity measures within pig and poultry farms to prevent animal diseases being introduced onto their farms.

The capitals of the studied provinces of PNG (i.e Lae, Goroka and Banz), Solomon Islands (i.e. Honiara) and Vanuatu (i.e. Port Vila and Luganville) were identified as the most connected nodes of both pig and poultry networks (Figure 4-8 and 4-9). This is to be linked with the presence in these locations of key husbandry actors and infrastructures such as markets (selling both live animals and animal products), slaughterhouses, DOC suppliers and pig breeder companies. They are thus potential hubs for incursion and/or spread of pig and poultry diseases and are therefore ideal locations for targeting surveillance activities. The fact that the critical control points for disease surveillance are the capitals should ease the actual implementation of surveillance activities for local animal health authorities in these countries. Knowing this is important because traditional surveillance activities are difficult due to insufficient manpower, large distances to cover and poor road quality.

The fact that the most central nodes identified within the pig and poultry networks are the same is also important as it identifies the potential for cross-species transmission of diseases such as Influenza A, which affects both pigs and poultry. It is common in some PICTs to see live pigs and poultry for sale in the same markets. It would therefore be most cost-effective for the local animal health authorities to focus their animal surveillance activities on mixed markets in the capital cities. Our study also identified specific periods of the year when more trade occurs (such as Christmas and New Year celebrations). This can also be taken into account when rationalising the limited resources of these PICTs for active surveillance interventions.

In Fiji, the pig and poultry networks were composed of many small components with a limited number of ties. This suggests a lower level of connectivity and thus a lower risk of pig and poultry disease dissemination in this country. However, the survey did not capture the entire pig and poultry farmer networks and it is possible that some central nodes may exist but may not have been captured. Therefore, further research is required in this country to confirm the apparent low connectivity of the pig and poultry networks.

Over the last few years, PNG has been piloting a syndromic surveillance programme in some pilot areas and Vanuatu has shown an interest in following suite (Mr Lonny Bong, Acting Director of the Livestock Department, Vanuatu, personal communication, 2014). The results of this study are therefore of particular interest for targeting these surveillance activities in the identified hubs and thereby increase the probability of an early detection of unusual pig or poultry disease trends within these PICTs.

Considering the extent of the targeted population (i.e. all the pig and the poultry farmers of the four FABN countries), the entire movement network could not be practically captured and a sampling strategy was designed instead for this study. As a result, several SNA parameters such as the betweenness and the measures of cohesion (density, geodesic distance and clustering coefficient) were impacted and were excluded from the data analysis. The networks presented in this paper are therefore not complete but the image captured provides useful information for decision makers. For example degree, which is considered a good indicator for predicting risk of infection (Christley et al., 2005), can be calculated out of this data set (Table 4-2). In addition, the present survey enabled the identification of key nodes within the trade network that will assist the local animal health authorities to better target future surveillance activities (Figures 4-8 and 4-9).

Thanks to the strong commitment of the Fijian counterparts from the Department of Animal Health and Production, more provinces (n=10) were included in Fiji than in the three other FABN countries where only two provinces were selected on the basis of their extended level of pig and poultry trade (Brioudes and Gummow, unpublished results). In particular, it would have been of interest to include the Province of Sandaun, in the North West of PNG because of its shared border with the Irian Jaya province of Indonesia and of the animal trade taking place between these two countries. But unfortunately, the local authorities were not in a position to conduct the survey in this province within the timeframe imposed by the project. In Solomon Islands, two provinces where originally selected for this study but an insufficient number of questionnaires were returned from the Western province which led to the exclusion of the data from that province from the analysis. Thus highlighting the challenges of working in these countries. The smaller number of pig farmers interviewed in the study compared to poultry farmers is a reflection of the villages inhabited by Seventh-day Adventist communities who consider pork as unclean and thus don't have pig farmers in them.

CONCLUSION

The traditional Pacific Islanders husbandry practices and limited biosecurity measures provide favourable conditions for the potential introduction and spreading of animal diseases. The barriers and/or the lack of incentive for farmers to ask for external assistance and to report disease events is particularly of concern since most of the Pacific Island countries have no or limited active surveillance and the detection of new animal disease outbreaks relies mostly on passive surveillance. Based on farmer feedback, it appears that there is a higher risk of occurrence of diseases when farmers move live animals or animal products to or from their farms. However a significant proportion of farmers trade within their own village or with neighbouring villages only, which helps minimise the risk of spreading of animal disease within the region. PNG and to a lesser extent Vanuatu and Solomon Islands have highly connected pig and poultry networks with the capital cities of the studied provinces being the nodes with the highest degree values. This could increase the impact of contagious diseases like avian influenza should they break out. Fiji however has a lower level of connectivity for pig and poultry networks thus a lower risk of disease dissemination but this would need to be confirmed. The Coffee season in PNG and Christmas and New Year festivities in the four studies countries were identified as periods of more intensive trade and therefore of potentially higher risk for disease spread. The results of this study can be used by the countries to implement a more targeted approach to pig and poultry disease surveillance. This would allow a better use of available resources and manpower for disease prevention and control.

ACKOWLEDGEMENTS

This research work was conducted in partnership between the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC) and the School of Veterinary and Biomedical Sciences of James Cook University (JCU), Townsville, Queensland, Australia as part of the Food Animal Biosecurity Network. The project received funding support under the Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government.

We are most grateful to the Operatives from the local counterpart agencies who conducted the field interviews, to the farmers who participated in this study and to the Animal Health and Production team of SPC for its assistance during the field implementation of this study. We also acknowledge Robert Hedlefs and Jeffrey Warner for their advice and assistance. We finally thank Ms Elenoa Salele and Ms Nguyen Thi Thanh Hang for the data entry into EpiInfo.

REFERENCES

Bhatia, R., Narain, J.P., 2010. Review paper: the challenge of emerging zoonoses in Asia pacific. Asia-Pac. J. Public Health 22, 388-394.

Borgatti, S.P., 2002. Netdraw Network Visualisation. Analytic Technologies : Harvard, MA, USA.

Borgatti, S.P., Everett, M.G., Freeman, L.C., 2002. Ucinet for Windows: software for social network analysis. Analytic Technologies, Harvard, MA, USA.

Brioudes, A., Gummow, B., 2013. Domestic animal diseases within the Pacific Islands region. Bibliography. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.

Brioudes, A., Warner, J., Hedlefs, R., Gummow, B., 2014. A review of domestic animal diseases within the Pacific Islands region. Acta Trop. 132, 23-38.

Brioudes, A., Warner, J., Hedlefs, R., Gummow, B., 2015. Diseases of livestock in the Pacific Islands region: Setting priorities for food animal biosecurity. Acta Trop. 143, 66-76.

CDC, 2013. Epi Info™ 7.1.3.0, Centers for Disease Control and Prevention (CDC), 1600 Clifton Road Atlanta, GA 30329-4027, USA.

Chen, S., White, B.J., Sanderson, M.W., Amrine, D.E., Ilany, A., Lanzas, C., 2014. Highly dynamic animal contact network and implications on disease transmission. Sci. Rep. 4, 4472.

Christley, R.M., Pinchbeck, G.L., Bowers, R.G., Clancy, D., French, N.P., Bennett, R., Turner, J., 2005. Infection in social networks: using network analysis to identify high-risk individuals. Am. J. Epidemiol. 162, 1024-1031.

FAO, 1998. Grazing Livestock in the Southwest Pacific., in: FAO (Ed.), FAO Sub-Regional Office for the Pacific, Apia. Samoa.

Gilbert, M., Mitchell, A., Bourn, D., Mawdsley, J., Clifton-Hadley, R., Wint, W., 2005. Cattle movements and bovine tuberculosis in Great Britain. Nature 435, 491-496.

Guerrier, G., Foster, H., Metge, O., Chouvin, C., Tui, M., 2013. Cultural contexts of swine-related infections in Polynesia. Clin. Microbiol. Infect. 19, 595-599.

Gummow, B., 2014. Establishing a Food Animal Biosecurity Network, Australian Government - AusAID, Public sector linkages program - Activity completion report. James Cook University, Townsville, 4811, QLD, Australia.

Hijmans, R.J., 2005. DIVA-GIS, version 7.5. Available at: http://www.diva-gis.org (accessed 16 October 2014).

Hintze, J., 2013. NCSS 9. NCSS, LLC. Kaysville, Utah, USA. Available at: www.ncss.com (accessed 11 March 2015).

Jeggo, M.H., 2000. An International Approach to Laboratory Diagnosis of Animal Diseases. Ann. N. Y. Acad. Sci. 916, 213-221.

Kao, R.R., Green, D.M., Johnson, J., Kiss, I.Z., 2007. Disease dynamics over very different time-scales: foot-and-mouth disease and scrapie on the network of livestock movements in the UK. J. R. Soc. Interface 4, 907-916.

Kiss, I.Z., Green, D.M., Kao, R.R., 2006. The network of sheep movements within Great Britain: Network properties and their implications for infectious disease spread. J. R. Soc. Interface 3, 669-677.

Martinez-Lopez, B., Perez, A.M., Sanchez-Vizcaino, J.M., 2009. Social network analysis. Review of general concepts and use in preventive veterinary medicine. Transbound. Emerg. Dis. 56, 109-120.

Ministry of Agriculture and Livestock of the Independent State of Papua New Guinea, 2006. National Agriculture Development Plan 2007–2016: policies and strategies, Ministry of Agriculture and Livestock of the Independent State of Papua New Guinea. MAL, Port Moresby, p. 155.

National Strategic Plan Taskforce of the Independent State of Papua New Guinea, 2010. Papua New Guinea Vision 2050, National Strategic Plan Taskforce of the Independent State of Papua New Guinea, Port Moresby, p. 63.

Newman, S., McKenzie, A., 1991. Organisation of veterinary public health in Australasia and the Pacific Islands. Rev. Sci. Tech. 10, 1159-1184.

Nicolas, G., Durand, B., Duboz, R., Rakotondravao, R., Chevalier, V., 2013. Description and analysis of the cattle trade network in the Madagascar highlands: potential role in the diffusion of Rift Valley fever virus. Acta Trop. 126, 19-27.

Ortiz-Pelaez, A., Pfeiffer, D.U., Soares-Magalhaes, R.J., Guitian, F.J., 2006. Use of social network analysis to characterize the pattern of animal movements in the initial phases of the 2001 foot and mouth disease (FMD) epidemic in the UK. Prev. Vet. Med. 76, 40-55.

Poolkhet, C., Chairatanayuth, P., Thongratsakul, S., Kasemsuwan, S., Rukkwamsuk, T., 2013. Social network analysis used to assess the relationship between the spread of avian influenza and movement patterns of backyard chickens in Ratchaburi, Thailand. Res. Vet. Sci. 95, 82-86.

Rasamoelina-Andriamanivo, H., Duboz, R., Lancelot, R., Maminiaina, O.F., Jourdan, M., Rakotondramaro, T.M., Rakotonjanahary, S.N., de Almeida, R.S., Rakotondravao, Durand, B., Chevalier, V., 2014. Description and analysis of the poultry trading network in the Lake Alaotra region, Madagascar: implications for the surveillance and control of Newcastle disease. Acta Trop. 135, 10-18.

Secretariat of the Pacific Community, 2007. The importance of the Pig in Pacific Island Culture - A literature review. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 38.

Secretariat of the Pacific Community, 2008. Land Ressources Division Strategic Plan 2009-2012. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 40p.

Secretariat of the Pacific Community, 2009a. Annual Report 2009, Part 1 - Annual overview, Secretariat of the Pacific Community, Noumea, New Caledonia, p. 70.

Secretariat of the Pacific Community, 2009b. Livestock in the Pacific, Policy Brief. Secretariat of the Pacific Community, BP DS, 98848 Noumea Cedex, New Caledonia.

Secretariat of the Pacific Community, 2009c. Report of the first FAO/OIE subregional meeting of GF-TADs for the Pacific Community region in collaboration with SPC, 25-26 June 2009, Nadi, Fiji, Secretariat of the Pacific Community, Suva Regional Office, Private Mail Bag, Suva, Fiji Islands.

Secretariat of the Pacific Community, 2010. SPC Regional Terrestrial and Aquatic Animal Disease Reporting Workshop, Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 26.

Secretariat of the Pacific Community, 2012. Paravet Training Project. Available at: http://www.spc.int/lrd/regional-projects/paravet (accessed 09 October

2014). Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.

Senne, D.A., 2003. Avian influenza in the Western Hemisphere including the Pacific Islands and Australia. Avian Dis. 47, 798-805.

Soares Magalhaes, R.J., Ortiz-Pelaez, A., Thi, K.L., Dinh, Q.H., Otte, J., Pfeiffer, D.U., 2010. Associations between attributes of live poultry trade and HPAI H5N1 outbreaks: a descriptive and network analysis study in northern Vietnam. BMC Vet. Res. 6, 10.

Swallow, R., 2012. Risk of Foot-and-Mouth Disease for the Pacific NorthWest Economic Region. Transbound. Emerg. Dis. 59, 344-352.

Van Kerkhove, M.D., Vong, S., Guitian, J., Holl, D., Mangtani, P., San, S., Ghani, A.C., 2009. Poultry movement networks in Cambodia: implications for surveillance and control of highly pathogenic avian influenza (HPAI/H5N1). Vaccine 27, 6345-6352.

Williams, V., 2008. Critical veterinary shortage in Pacific islands, Biosecurity Magazine. MAF Biosecurity New Zealand, PO Box 2526, Pastoral House, 25 The Terrace, Wellington, New Zealand.

Yarrow, R., 2008. Increasing veterinary capacity in the Pacific, Third regional meeting of Heads of Agriculture and Forestry Services (HOAFS), 3-5 September 2008, Apia, Samoa. Secretariat of the Pacific Community, Suva, Fiji, p. 4.

CHAPTER 5

FIELD APPLICATION OF A COMBINED PIG AND POULTRY MARKET CHAIN AND RISK PATHWAY ANALYSIS WITHIN THE PACIFIC ISLANDS REGION AS A TOOL FOR TARGETED DISEASE SURVEILLANCE AND BIOSECURITY

A. Brioudes[1] and B. Gummow[1, 2]

[1] *Discipline of Veterinary Sciences, College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville 4811, Queensland, Australia*

[2] *Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa*

Published in Preventive Veterinary Medicine Journal (2016)

doi:10.1016/j.prevetmed.2016.05.004

ABSTRACT

Limited resources are one of the major constraints in effective disease monitoring and control in developing countries. This paper examines the pig and poultry market chains of four targeted Pacific Island countries and territories (PICTs): Fiji, Papua New Guinea, Solomon Islands and Vanuatu and combines them with a risk pathway analysis to identify the highest risk areas (risk hotspots) and risky practices and behaviours (risk factors) of animal disease introduction and/or spread, using highly pathogenic avian influenza (HPAI) and foot-and-mouth disease (FMD) as model diseases because of their importance in the region. The results show that combining a market chain analysis with risk pathways is a practical way of communicating risk to animal health officials and improving biosecurity. It provides a participatory approach that helps officials to better understand the trading regulations in place in their country and to better evaluate their role as part of the control system. Common risk patterns were found to play a role in all four PICTs. Legal trade pathways rely essentially on preventive measures put in place in the exporting countries while no or only limited control measures are undertaken by the importing countries. Legal importations of animals and animal products are done mainly by commercial farms which then supply local smallholders. Targeting surveillance on these potential hotspots would limit the risk of introduction and spread of animal diseases within the pig and poultry industry and better rationalize use of skilled manpower. Swill feeding is identified as a common practice in the region that represents a recognized risk factor for dissemination of pathogens to susceptible species. Illegal introduction of animals and animal products is suspected, but appears restricted to small holder farms in remote areas, limiting the risk of spread of transboundary animal diseases along the market chain. Introduction of undeclared goods hidden within a legal trade activity was identified as a major risk pathway. Activities such as awareness campaigns for pig and poultry farmers regarding disease reporting, biosecurity measures or danger of swill feeding and training of biosecurity officers in basic animal health and import-associated risks are recommended to prevent and limit the spread of pathogens within the PICTs.

KEYWORDS

Pacific Island countries and territories; Risk hotspot; Pig/poultry market chain; Legal/illegal trade; Highly pathogenic avian influenza; Foot-and-mouth disease.

INTRODUCTION

The Pacific Island countries and territories (PICTs) are composed of 22 countries or territories scattered across the largest ocean in the world and host about 9 million inhabitants. Agriculture plays an important role in most PICTs' economies with, in some Pacific states, up to 30% of national GDP attributed to this sector (Secretariat of the Pacific Community, 2009a). The agricultural contribution to the local economy is attributed to the production of crops and livestock. The livestock sector contributes to the local food security needs and to the supply of vital protein to local communities and provides export revenue for the larger countries such as Papua New Guinea (PNG) (FAO Statistic Division, 2014). Livestock also plays a crucial role in traditions and cultures with most of the important social and cultural events in island life featuring livestock (Guerrier, Foster, Metge, Chouvin, & Tui, 2013; Secretariat of the Pacific Community, 2009b, 2011; Yarrow, 2008).

According to data from the trade statistics department of the Secretariat for the Pacific Community (SPC), the meat product imports for nine PICTS in 2007 were almost 68,000 tonnes, worth USD 159 million. This figure confirms the strong demand for livestock products and the potential market for increased local production and exportations. Currently, this demand for livestock products is met from both local production and importations. The consumption of meat products over the last 30 years has been increasing steadily and this trend is expected to continue in the future. It represents a major opportunity for the development of the livestock sector in the Pacific (Secretariat of the Pacific Community, 2009a).

Pig and poultry production systems have a particular importance within the PICTs (Table 5-1) as beside their contribution to the local economy, they are part of the traditional way of living in the Pacific communities (Secretariat of the Pacific Community, 2009a). Ten of the 22 PICTs are in the top-25 list of countries with the highest number of pigs per hectare of agricultural area and 13 of the 22 PICTs are in the top half of the poultry density ranking of countries with poultry (FAO Statistic Division, 2014).

Table 5-1: Livestock numbers in the Food Animal Biosecurity Network (FABN) countries (FAO Statistic Division, 2014).

PICTs	Livestock	Livestock numbers	Import quantity (Head)	Import value (1000 US$)
Fiji	Pigs	147,000	2	1
	Chickens	4,900,000	1,000	4
	Ducks	100,000	301,000	1,474
Papua New Guinea	Pigs	2,000,000	Data not available	Data not available
	Chickens	4,400,000	103,000	804
	Ducks	17,000	Data not available	Data not available
Solomon Islands	Pigs	54,500	Data not available	Data not available
	Chickens	240,000	Data not available	Data not available
	Ducks	Data not available	Data not available	Data not available
Vanuatu	Pigs	94,000	0	0
	Chickens	750,000	62,000	112
	Ducks	Data not available	0	0

The Pacific Islands region has a favorable animal health situation and is free of the most contagious infectious diseases (Brioudes, Warner, Hedlefs, & Gummow, 2014; OIE, 2014c). However, the extent of its 25,000 islands' borders and the vastness of its surface area represent a real challenge for avoiding the incursions of transboundary animal diseases (Secretariat of the Pacific Community, 2009a; Yarrow, 2008). The tropical environment of the PICTs combined with the inter-island movements of people and goods are also favorable factors for the potential emergence of such diseases at the human, livestock and wild animal interface (Gummow, 2010).

Transmission by migratory waterfowl has been responsible for significant transfer of H5 group type A influenza viruses throughout Asia, Europe, Africa and North America in 2014-2016. To date there have been no reports of H5 group type A influenza viruses from the PICTs. This may be because they are not on major flyways of waterfowl. The main birds on the East Asia flyways are not waterfowl and this is the reason why transmission to Australia and New Zealand has not occured. This study focusses on the other routes of transmission.

The introduction and spread of infectious diseases within a country could have severe consequences to the largely naïve livestock production sector, national economy and international trade. Disease introduction would also represent an important threat to the biodiversity of these islands, which host a large variety of indigenous animal and plant species. Therefore, countries are encouraged to invest in veterinary surveillance systems to prevent and/or control animal diseases (Forman et al., 2012). But human and financial resources are limited in PICTs and countries need to rationalize their resource allocation and need methods to identify their priorities for surveillance.

Based on the prioritization of livestock diseases conducted in the Pacific Islands region in 2012, highly pathogenic avian influenza (HPAI) and food-and-mouth disease (FMD) were ranked as the top priority poultry and pig diseases after leptospirosis and brucellosis (Brioudes, Warner, Hedlefs, & Gummow, 2015), based on a list of six categories of criteria (disease epidemiology, animal health impact, public health impact, economic impact, social impact, and availability of preventive and control measures).

HPAI is a highly contagious disease usually carried asymptomatically by wild birds but that can impact the poultry industry when it spreads to domestic poultry, resulting in 90 to 100% mortality among flocks and generating drastic trade restrictions. Some strains can also infect mammals and humans causing severe symptoms or leading to death. Aerosols or fecal-oral route are the main means of infection for animals. Humans usually get infected by close contact with infected birds or their tissues and transmission by indirect contact is also thought to be possible by the ingestion of virus-infected raw poultry products.

HPAI viruses are thought to persist for short periods in tropical environments and can spread through fomites (OIE, 2014a).

FMD is a highly contagious viral disease affecting cloven-hoofed animals (such as pigs, cattle, sheep and goats) which causes important economic losses. Susceptible animals are infected by direct contact with infected animals or contaminated fomites. Consumption of untreated contaminated meat products (swill feeding), inhalation of aerosols or artificial insemination represent a risk of transmission. The virus can also be airborne spread up to 60 km overland and 300 km by sea, depending on the serotype. However, airborne spread is more likely to occur in temperate regions areas than tropical regions (OIE, 2014a).

The PICTs are currently free of these two transboundary animal diseases. However, most countries of the neighboring East and South-East Asia regions reported HPAI events in the recent past (i.e. Bangladesh, Bhutan, Nepal, Chinese Taipei, Hong Kong, People's Rep. of China, Democratic People's Rep. of Korea, Vietnam, Cambodia, Myanmar, Indonesia) and FMD events (i.e. Bangladesh, Cambodia, People's Rep. of China, Hong Kong, Democratic People's Rep. of Korea, Laos, Myanmar, Nepal, Thailand, Vietnam, Malaysia, Mongolia) (OIE, 2014b) over the last few years (2012-2013). It is to be noted that Indonesia has been an OIE free zone without vaccination for FMD for more than 30 years. Similarly Singapore, Brunei, the Philippines and Timor Leste, Australia and New Zealand are all free of FMD.

Within this context, the study aimed to (i) use market chains in combination with risk pathways as a tool for identifying the highest risk areas (risk hotspots) and the risky practices and behaviours of market chain stakeholders (risk factors) with regards to animal disease introduction and/or spread. HPAI and FMD were used as model diseases because of their importance in the region. Identification of the risk hotspots and risk factors would enable the PICTs to better target their resources at specific high risk areas; and (ii) demonstrate the application of a practical framework combining a descriptive market chain mapping with risk pathways promoted by FAO to model disease risk in the region (FAO, 2011). A "market chain" or "value chain" is a group of people interacting with the goal being to supply a specific commodity (see Chapter 1). The term "market chain" was preferred for this study because there isn't any economic component to the assessment conducted.

METHODS

Study design

This study was conducted as part of a Food Animal Biosecurity Network (FABN) project that aimed at "delivering enhanced animal health field and laboratory capability to the Pacific Islands, particularly in the area of animal disease surveillance, to allow assessment under OIE guidelines for trade in animals and animal products". This work was carried out in four targeted PICTs selected for this project namely Fiji, PNG, Solomon Islands and Vanuatu (Fig. 5-1).

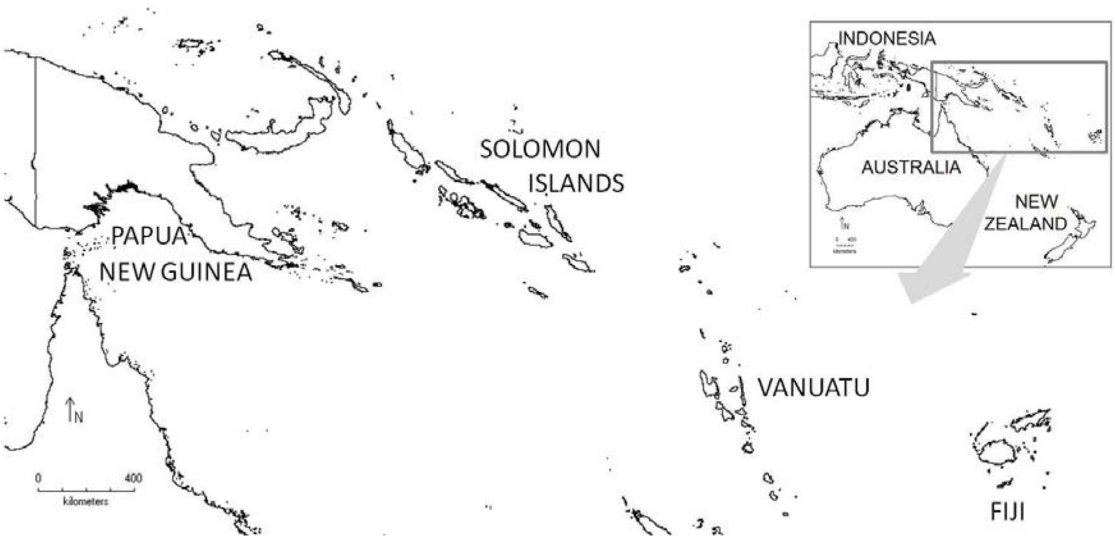


Figure 5-1: Map of the four targeted Pacific Island countries and territories (Fiji, PNG, Solomon Islands and Vanuatu).

In consultation with the local project partners, invitations were made to the Animal Health and Production Department of Fiji's Ministry of Primary

Industries, the National Agriculture Quarantine and Inspection Authority (NAQIA) of PNG, the Department of Livestock and Quarantine of Solomon Islands and the National Department of Livestock and Quarantine of Vanuatu to identify and invite the relevant local experts within the national governmental agencies involved in livestock production and livestock trade control to participate in multi-disciplinary consultative panels aimed at evaluating regional animal health surveillance.

Using the practical framework for field application “A value chain approach to animal diseases risk management” (FAO, 2011) as a basis, a participatory stepwise approach (Fig. 5-2) was set up involving the identified veterinary and livestock production authorities from the studied countries. The stepwise approach combined a market chain assessment with risk pathways for disease introduction and spread to identify key risk hotspots and risk factors in the market chain.

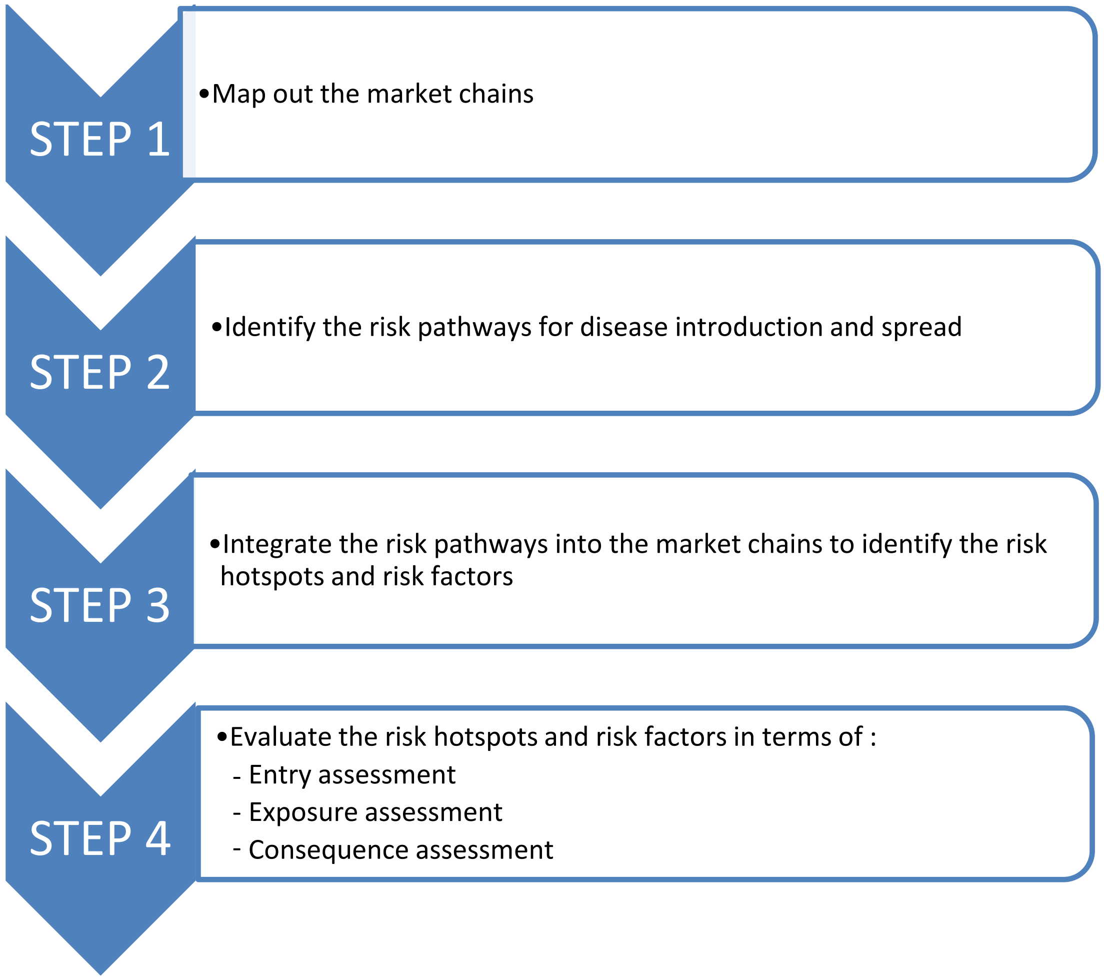


Figure 5-2: Stepwise approach used for this study in the four targeted Pacific Island countries and territories.

Consultative workshops, including group discussions, were conducted to enable simultaneous data collection from groups of stakeholders and to encourage interactions and exchange of opinions among participants (FAO, 2011; Pavlin, Kool, Samo, & Gerstel, 2010; Valenciano, 2001). A series of two workshops were implemented in each of these four targeted PICTs to gather experts' opinion with regards to first the market chain (first workshop) and then the risk pathways for introduction of HPAI and FMD in their country (second workshop).

The group discussions in each workshop were led by a study coordinator who was in charge of facilitating the group discussions through semi-structured interviews and recording the answers of the participants on a consensus basis. To ensure equal participation by all participants, participants were asked individually by the study coordinator at each key step in the market chain analysis and risk pathways for their opinion to ensure all opinions were heard by the group. Careful group management by the study coordinator countered any biases brought into the discussion by dominant individuals.

Pig and poultry market chain analysis

The first series of workshops was held between July to November 2012 to map out the pig and poultry production systems in each of the four FABN countries and understand how stakeholders interact along these livestock market chains (Fig. 5-2, Step 1). Participants were drawn from the panel of national experts.

Pig and poultry market chains within the four targeted countries were analyzed with market chains being defined as a group of people interacting with an activity to supply a specific commodity (from the producer to the final consumer). This analysis allowed the mapping of the different potential or existing routes for livestock marketing and the assessment of how well these market chains are working. Specifically, the various key stakeholders of the pig and poultry industries within the four studied countries were identified in consultation with the workshop participants and their trading practices were characterized. Information about legal and illegal importations of animal and animal products was collected and trading exchanges with movement of animal and animal products between the different stakeholders of the market chains were sketched within each of the studied PICTs. At the end of the first workshop, pig and poultry market chains were developed. By going through this market chain analysis, participants were stimulated to think about where there might be a risk of disease introduction and spread.

Identification of risk pathways for HPAI and FMD

A second round of workshops was conducted between March and May 2013 to identify the segments of the market chains that present the highest risk for animal disease introduction and/or spread (risk hotspots) and the risky practices and behaviours of stakeholders (risk factors), using HPAI and FMD in poultry and pig as model diseases because of their importance. To do this, participants were consulted to identify risk pathways that could potentially lead to the introduction of HPAI and FMD in the PICTs (Fig. 5-2, Step 2). The pathways identified were: legal importation of live animals or animal products; illegal introduction of live animals or animal products; introduction of infected wild animals; introduction of virus-contaminated vehicles/fomite and, for FMD only, airborne transmission.

Identification of risk hotspots and risk factors

While the purpose of a livestock market chain analysis is to improve the production efficiency, it also allows the identification of the most critical areas of potential disease transmission (“risk hotspots”) when integrated with disease risk pathways (Fig. 5-2, Step 3). These risk hotspots were characterized by their localization within the market chain, their geographic position within the studied countries or their temporality (FAO, 2011). Risky practices or behaviours of stakeholders (“risk factors”) can similarly be identified in the process of mapping the market chain (Fig. 5-2, Step 3). To do this participants at the second workshop were asked to consider the three key steps defined for risk assessment under the OIE framework for the import of animals and animal products (FAO, 2011; Murray et al., 2004) (Fig. 5-2, Step 4) i.e. entry assessment, exposure assessment and consequence assessment. The first step in risk assessment was previously called “release” assessment and is this now referred to as “entry” assessment (OIE, 2010) (see Chapter 1).’

Entry assessment is the estimation of the probability of entry of a pathogen along the risk pathways tracing the way by which a pathogen reaches a production site. In this context, entry scenario diagrams were sketched (based on an adaptation from FAO (2011)) to detail the chain of events potentially leading to the introduction of HPAI and FMD within each targeted PICT and identify the related risk hotspots and risk factors.

Exposure assessment is the estimation of the degree of exposure based on relevant factors (biological factors, country factors and commodity factors). In this context, it was used to identify the risk hotspots and risk factors that could be involved in the exposure of pig and poultry along the market chains once a pathogen (HPAI or FMD virus) has been introduced within the PICTs.

Consequence assessment is the estimation of the potential impact of the disease introduction based on direct consequences, economic losses and environmental impacts and spreading of animal disease. In this context, it was used to identify the risk hotspots and risk factors involved in the pathogen introduction and/or in the pig and poultry exposure leading to the highest impact with the view of identifying the risk-reduction interventions of priority.

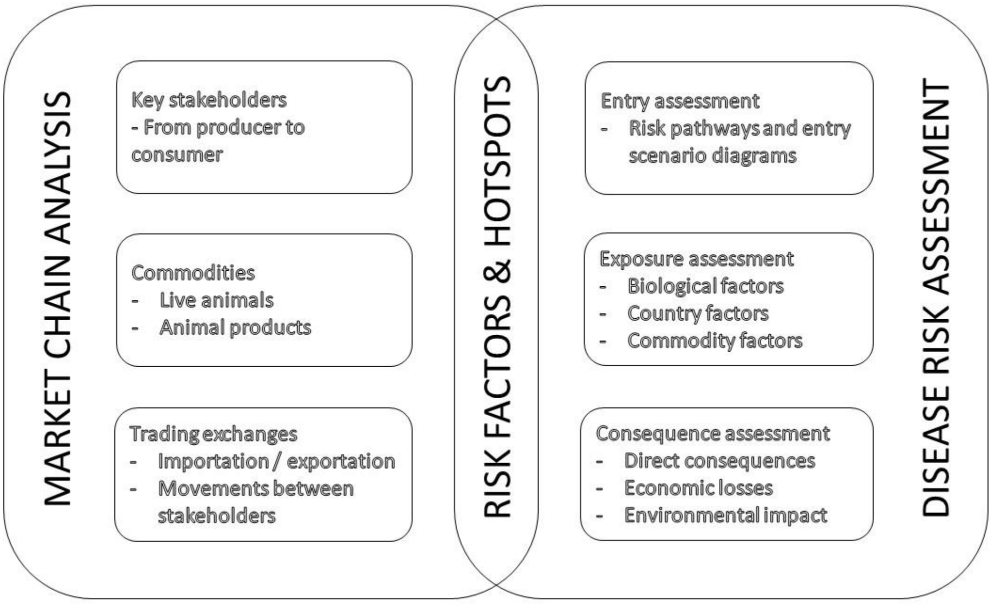


Figure 5-3: Identification of disease risk factors and hotspots through a combined market chain analysis and disease risk assessment.

Hence, for each risk pathway identified, participants' opinions were elicited through group discussion facilitated by the study coordinator to identify the risk hotspots and risk factors within the market chains created during the first round of workshops that would potentially enable the introduction and spread of HPAI and FMD using the OIE three step approach. To assist participants in these exercises, copies of the OIE technical disease cards (OIE, 2014a) and of the most up-to-date OIE distribution maps of HPAI and FMD in the Asia-Pacific region (OIE, 2013) were distributed to them at the beginning of the workshop. A semi-structured template was used to capture the key risk hotspots and risk factors for each of the risk pathways along the market chain that had been identified by participants through facilitated group discussions.

RESULTS

Study implementation

Cross-disciplinary panels of experts were formed in the four selected PICTs. In total, the first series of workshops held for the pig and poultry market chain analysis comprised 24 national experts from Fiji (all from the Animal Health and Production Department), 10 from PNG (2 staff from the National Agriculture Quarantine and Inspection Authority; 2 staff from the National Agriculture Quarantine and Inspection Authority; 1 staff from the National Agriculture Research Institute; 2 staff from the Livestock Development Corporation; 1 staff from the Department of Agriculture and Livestock and 1 staff from Rhado Piggery Limited Company), 5 from Solomon Islands (all from the Livestock Department) and 4 from Vanuatu (2 staff from the Livestock Department and 2 from the Biosecurity Department).

The second series of workshops held for the disease risk pathway analysis involved a total of 10 national experts from Fiji (7 staff from the Animal Health and Production Department and 3 from the Biosecurity Department), 14 from PNG (7 Animal Health officers and 7 Quarantine officers from NAQIA), 9 from Solomon Islands (all from the Livestock Department) and 6 from Vanuatu (3 staff from the Livestock Department and 3 from the Biosecurity Department).

Participants of the two workshops were not necessarily the same as they were selected on the basis of their expertise on the market chain and risk pathway respectively. Only one participant from Fiji, two from PNG, five from Solomon Islands and four from Vanuatu attended both workshops, which provided some continuity between the two workshops.

Pig and poultry market chain analysis

Figures 5-4 and 5-5 display the key data collected with regard to the main stakeholders among the pig and poultry market chains and their trading patterns in the four studied countries.

Risk pathways for HPAI and FMD

The risk pathways and entry scenario diagrams that were designed and validated through expert consultation for the legal and illegal trade of pigs and poultry in the case of HPAI and FMD are shown in Figures 5-6 and 5-7. The other risk pathways were essentially the same but referred to the introduction of wild animals, the introduction of virus-contaminated vehicles and/or fomites and the airborne transmission.

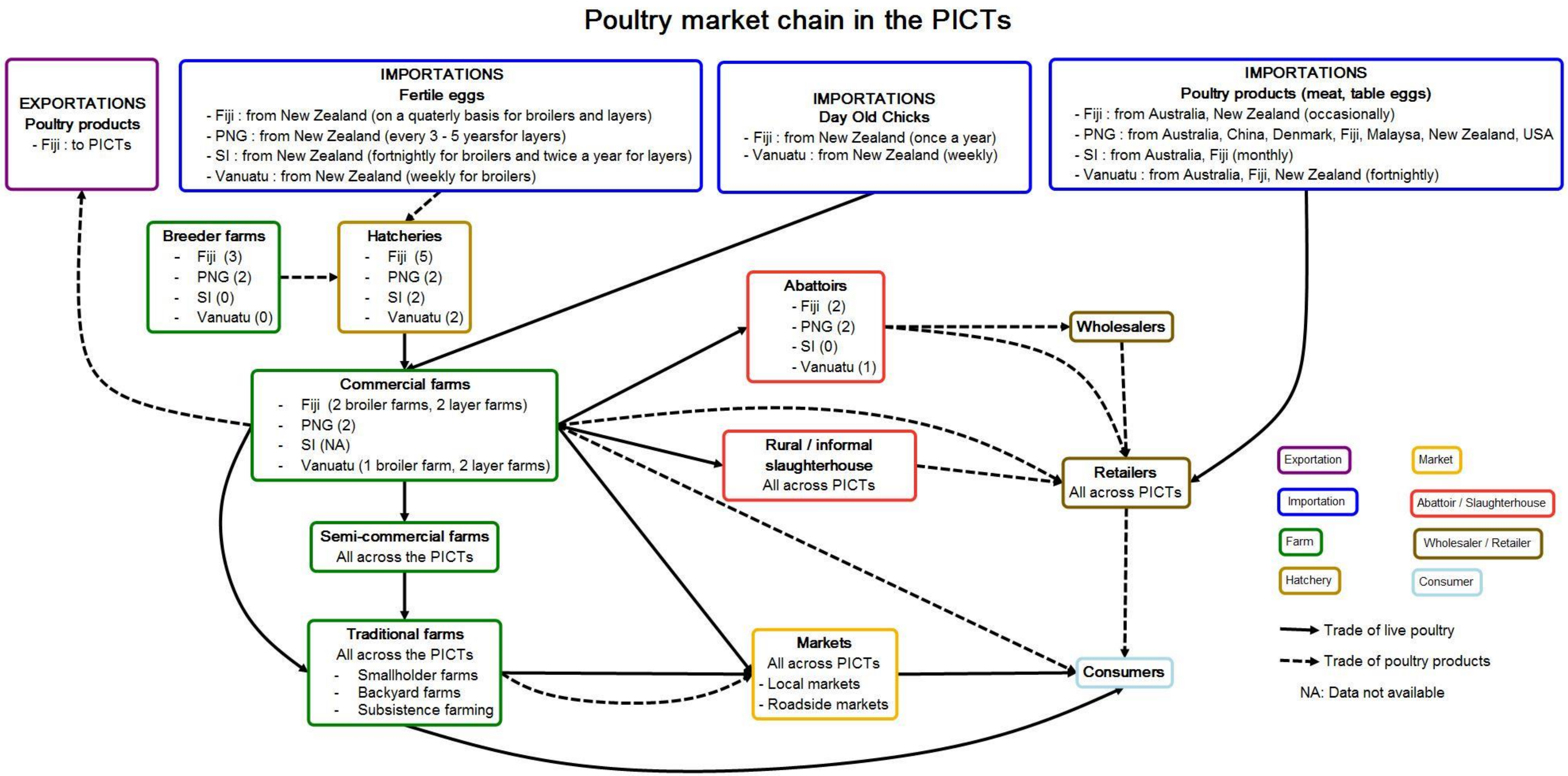


Figure 5-4: Diagram of the poultry market chain in the four targeted Pacific Island countries and territories (PICTs) (Fiji; Papua New Guinea (PNG); Solomon Islands (SI) and Vanuatu), 2013

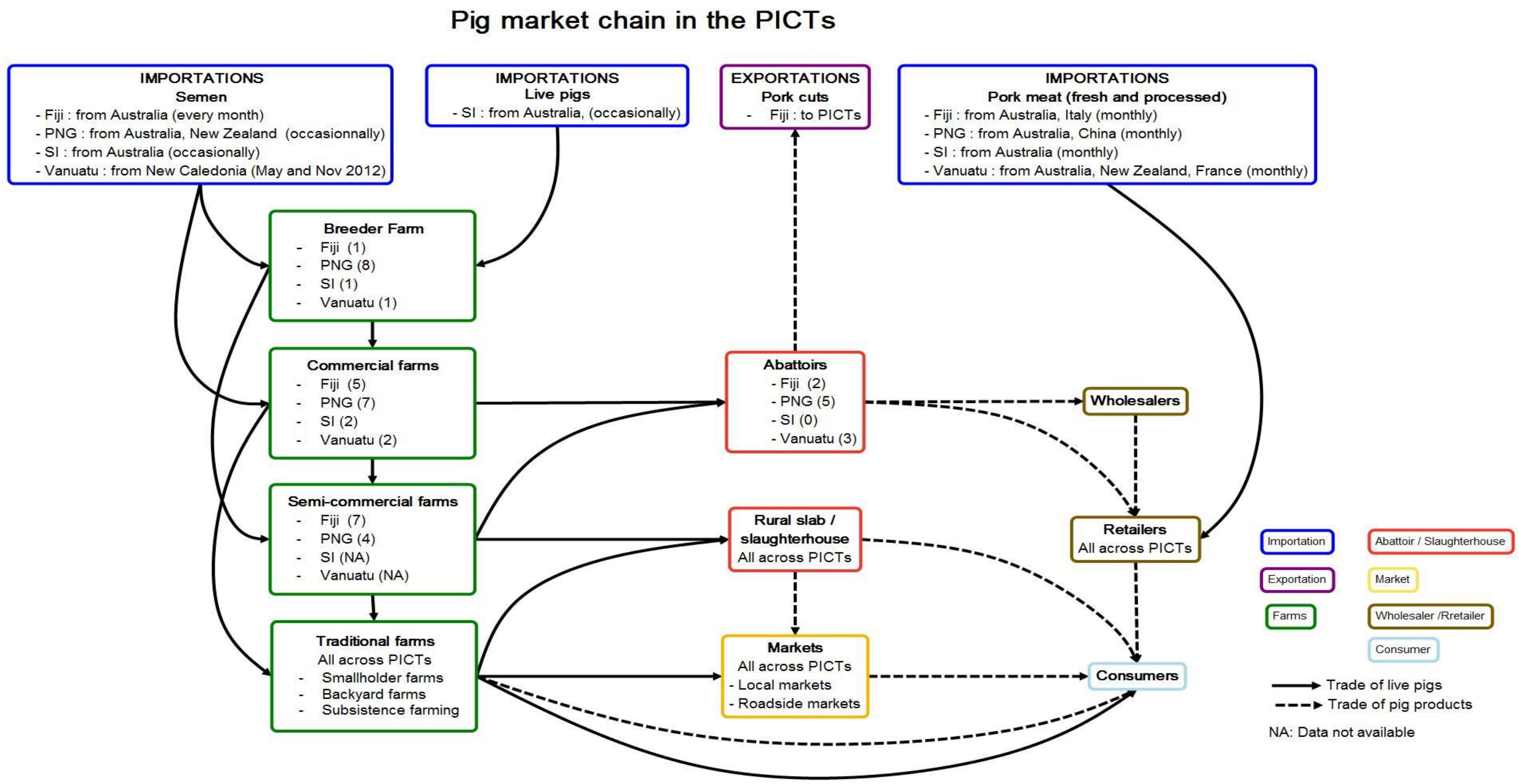


Figure 5-5: Diagram of the pig market chain in the four targeted Pacific Island countries and territories (PICTs) (Fiji; Papua New Guinea (PNG); Solomon Islands (SI) and Vanuatu), 2013

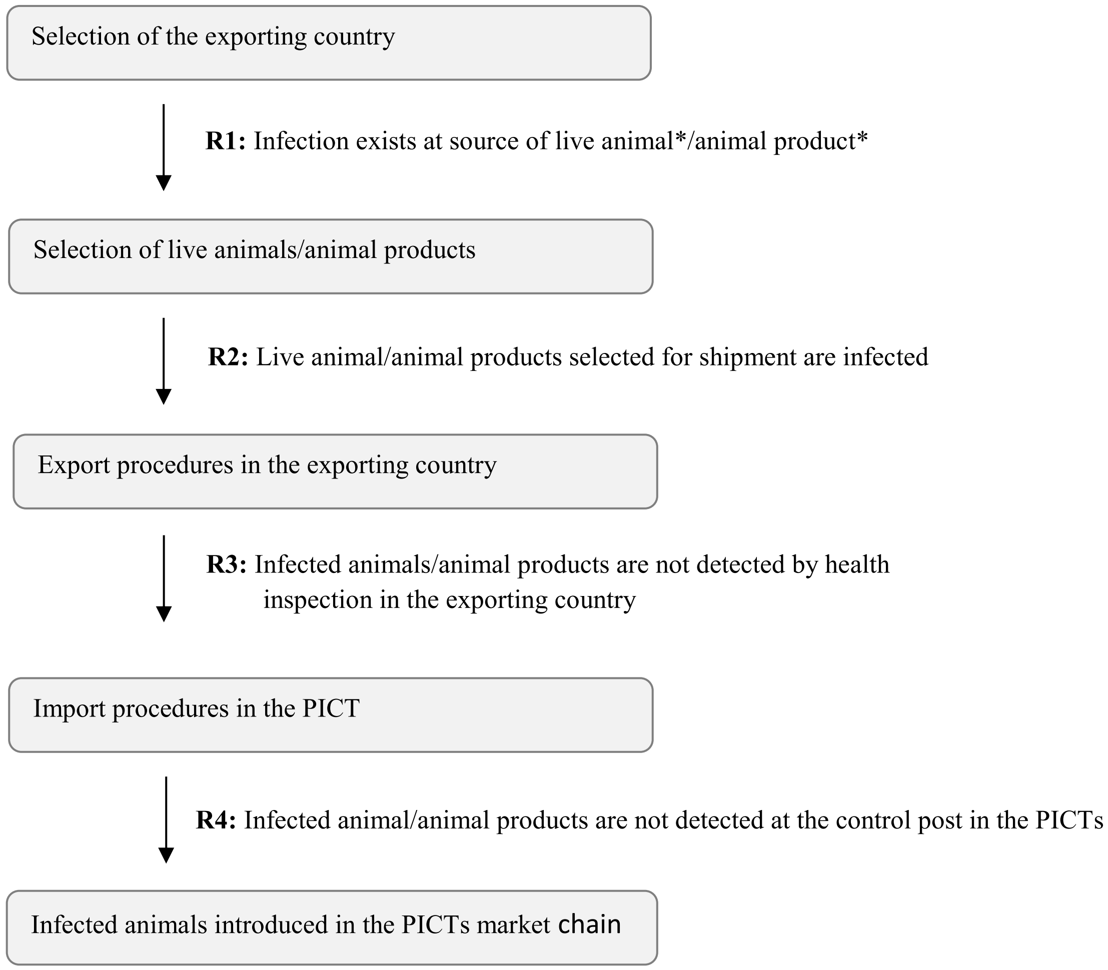


Figure 5-6: Risk pathways and entry scenario diagram for legal trade (*the term ”animal” stands for “poultry” or for “pigs” in case of HPAI or FMD risk assessment respectively), adapted from FAO (2011). PICT = Pacific Island countries and territories.

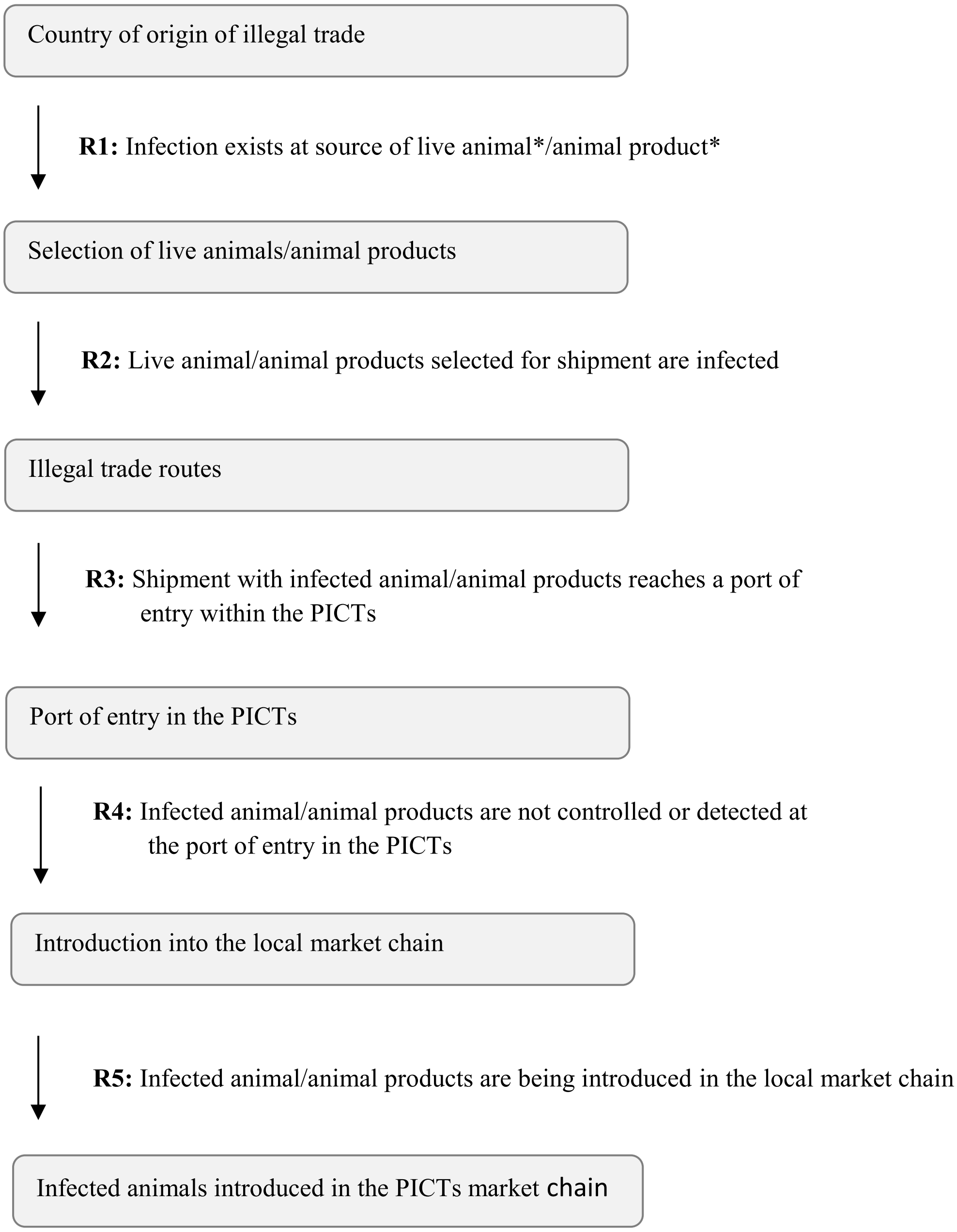


Figure 5-7: Risk pathways and entry scenario diagram for illegal trade (*the term ”animal” stands for “poultry” or for “pigs” in case of HPAI or FMD risk assessment respectively), adapted from FAO (2011). PICT = Pacific Island countries and territories.

Identification of risk hotspots and risk factors

The risk of introducing FMD through airborne transmission had been considered by study participants but considering the tropical climate of the PICTs and their scattered distribution over the Pacific Ocean, this risk pathway was assessed as not being important for the 4 studied PICTs and therefore didn't lead to the identification of any risk hotspots or risk factors.

Combining the data from the two series of workshops lead to the identification of the key risk hotspots and risk factors for the introduction and spread of FMD and HPAI along the pig and poultry market chains which could be used to target surveillance within the four countries comprising the FABN. The outcomes of this is shown in Tables 5-2 and 5-3. Key risk factors (practices and behaviours) are shown in bold italics while risk areas (hotspots) are shown in bold. This is done for all of the risk pathways identified.

In addition to the common risk factors and risk hotspots identified for the four PICTs and presented in Tables 5-2 and 5-3, some specific risk factors and hotspots were identified for PNG and the Solomon Islands due to the closeness of their respective borders and due to the shared border of PNG with West Papua (noting that boats (including logging boats) come from all part of Indonesia and other parts of the region (Brookes & Ward, (2016)). These were 1. the risk pathway "Illegal introduction", which referred to illegal trade of domestic poultry and swine for breeding purposes or social events, taking place across the border between (i) Bougainville in PNG and Shortland Island in Solomon Islands and (ii) West Papua and PNG. This was possible because the distances are very short and there is only limited capacity for control on either side of the border. Free ranging village poultry and swine would quickly have opportunity for contact with infected poultry and swine illegally introduced; 2. the risk pathway "Introduction of infected wild pigs", which referred to wild pigs crossing the West Papua-PNG border and the border between the Solomon Islands and PNG and 3. the risk pathway "Introduction of virus-contaminated vehicles/fomites", which referred to no control of vehicles at the West Papua-PNG border.

Table 5-2: HPAI risk hotspots and risk factors identified along the poultry market chain within in the four targeted Pacific Island countries and territories (PICTs) (Fiji; Papua New Guinea; Solomon Islands and Vanuatu).

Risk Pathways	*Key* ***risk factors (bold italics)*** and **hotspots (bold)** identified within the region
Legal importation	- No or limited random testing of imported commodity. ***Importation controls*** rely mostly on a documentary check of the approved import permits based on health certificate from the exporting country. - Control officers have mainly an agriculture background and have ***limited diagnostic skills.*** - Live poultry and fertile eggs imports done by the **main commercial farms** which play a key role in the poultry industry in the country and supply most of the local poultry smallholders – high potential for disease spread across the country. - Hatchery usually separated from the poultry production unit but occasionally they could be in the same unit or there could be a breach in the ***biosecurity measures*** between the hatchery and production unit. - Poultry meat is usually cooked thoroughly but the risk comes from ***uncooked waste*** junked in a bin. Common practice of waste collection from restaurant (and would not be cooked) to feed pigs.
Illegal introduction	- **Official ports of entry without control stations** with full-time officers. - High suspicion and/or evidence of introduction of ***undeclared goods*** hidden within a legal trade activity such as: • Logging boats landing directly without going through official port of entry suspected of introducing not-declared poultry illegally on board mostly for their own consumption but also for trading with locals for other commodities (fruits, veggies...) and for fighting cocks in the camps. Many on- and off-movements taking place from these camps. • Regular illegal introductions of poultry products hidden in between other commodities within a container or in imported second hand cars. • Flight passengers entering the PICTs without officially declaring goods. - Illegal trade suspected to take place mostly in **remote areas, with small holder farms** only. Any abnormal situation among poultry flock would not be reported timely as a result of being illegally introduced so the disease would have time to spread within the area which could have direct consequences due to the ***limited disease containment measures*** in place.
Introduction of infected waterfowl	- Limited to ***no waterfowl surveillance*** ever conducted. - ***Under or no waterfowlmortality reporting*** by Pacific Islanders. Local population may even cook these birds for their own consumption. - Risk of indirect contact with **indigenous birds** and spread via scavenging birds.
Introduction of virus-contaminated vehicles / fomite	- Limited to ***no cleaning and disinfection*** procedure of imported crates/cartons which are going straight to the importing farms and then recycled and reused. - ***Customs procedure*** about passengers declaring having visited a farm in the departing country during the past 30 days ***not properly enforced***.

Table 5-3: FMD risk hotspots and risk factors identified along the pig market chain within in the four targeted Pacific Island countries and territories (PICTs) (Fiji; Papua New Guinea; Solomon Islands and Vanuatu).

Risk Pathways	*Key* ***risk factors (bold italics)*** and **hotspots (bold)** identified within the region
Legal importation	- No or limited random testing of imported commodity at the **official port of entr** ***Importation controls*** rely solely on a documentary check of the approved import permits based on health certificate from the exporting country. - **No quarantine station for pigs at the port of entry**; quarantine period implemented at the farm for about 3 months. - ***Swill feeding*** practiced in smallholder and backyard pig farms with the left over from restaurant not systematically boiled or cooked.
Illegal introduction	- High suspicion and/or evidence of introduction of ***undeclared goods*** hidden with a legal trade activity such as in logging boats from Asia, in containers, in importe second hand cars or by flight passengers entering **official ports of entry** of the PICTs without officially declaring goods. - Pig products are being illegally introduced for human consumption but could potential be ultimately used for ***swill feeding***.
Introduction of infected wild pigs	- Local population ***hunting*** for wild pig and try to ***domesticate*** them while limited bisosecurity measures are applied at village level. Domesticated ***free ranging village pigs*** roaming around in the bush would get in contact with wild pigs - Villages are isolated which limits the risk of spread but the disease may spread to ***other species*** in this area and control measures would still have to be implemente
Introduction of virus-contaminated vehicles / fomite	***Customs procedure*** about passengers declaring having visited a farm in the departing country during the past 30 days ***not properly enforced***.
Air borne transmission	Pathway not realistically active for any of the four pilot PICTs

DISCUSSION

Study implementation

This study consisted in an initial approach to identify the key risk hotspots and risk factors for the introduction and spread of HPAI and FMD into the pig and poultry market chains within selected PICTs, with the objective of getting stakeholders involved in the animal disease surveillance and biosecurity to critically think about the procedures in place and their role in potential risk-reduction interventions. However, considering the broad scope of this study with the assessment of 2 highly infectious diseases (HPAI and FMD) and the risk of introduction and spread into 2 market chains (pig and poultry) within 4 targeted PICTs, further studies would be required to do a detailed analysis of each and every risk pathway for each type of animal and animal product being imported into the PICTs.

Because of the specific focus of this study on the pig and the poultry sectors, the risk question for the occurrence of FMD did not include the other susceptible species (i.e. all domestic and wild cloven-hoofed animals such as cattle, sheep, goats and deer). This was justified because of the importance of these two species in these countries and the fact that these exercises had never previously been carried out before and an overly complex model may have disengaged participants. A more accurate assessment of the risk of importation of FMD in these countries would thus require extending the analysis of the risk pathways to these other cloven-hoofed animals.

The process of collecting information for the market chain and then building on this foundation using HPAI and FMD as models to identify risk hotspots and risk factors was in itself very informative and lead to the sharing of critical data. Breaking down the risk into the different risk pathways and looking at the different OIE steps of the risk pathways forced the participants to consider in detail all the different conditions in place in their country that could lead to the introduction and the spread of the disease in the country. By making this process more frequent it may serve to improve the biosecurity of these countries.

The participatory approach used in this study allowed for the collection of data from national experts in the four selected PICTs at the same time. This provided a forum for communication between the countries regarding their market chains and risk pathways and added transparency to the processes within each of the countries, thus building trust. It also provided an opportunity for better communication between animal health officials involved in disease surveillance and biosecurity within their own countries and clarification on how their roles fitted together with respect to surveillance and biosecurity. One potential weakness faced with this elicitation technique can be the influence of some of the experts over the other workshop participants during the group discussions which can potentially lead to a biased panel result. This can be countered by the study coordinator through careful group management and regular engagement of all participants' opinion.

At the end of the study, participants provided feedback acknowledging the value of combining a market chain analysis with a review of disease risk pathways to assist them in better understanding the trading regulations in place in their country and better evaluating the role of his/her duties as part of the control system. We therefore put forward this approach as a risk communication tool and a means of educating animal health officials about the risks of trade in animals and animal products in developing countries.

Market chain and risk pathways analysis

The analysis of the results from the four studied countries revealed common risk patterns among the Pacific Islands region. The four FABN countries import poultry and/or poultry products from neighbouring developed countries with high import-export standards (i.e. Australia, New Zealand). The fact that legal trade pathways rely essentially on preventive measures put in place in the exporting countries while no or only limited control measures are undertaken by the importing countries was perceived as an increased source of risk. Participants' confidence in the importers ability to detect diseases could result in these countries being less vigil in their monitoring of imports. However, the second workshop was conducted early in 2013, just after an outbreak of HPAI (H7N7) had occurred in November 2012 in New South Wales, Australia (OIE, 2012). This outbreak was actually a good example where disease incursion can happen even in developed countries with high biosecurity measures in place and strongly enforced import/export control systems. It served to heighten awareness in participants of their countries needs to take responsibility for monitoring of imports. Awareness of this outbreak stimulated participants to think more critically about additional control measures that could be put in place in the PICTs for preventing disease incursion from exporting countries.

Illegal trade was thought to happen occasionally between the Pacific Islands or to originate from South-East Asian countries where HPAI and FMD cases are reported, with very little random control along the various potential ports of entry on these islands. PNG faced an outbreak of Newcastle disease in March 2013 that occurred in Sandaun province and that is suspected to have originated from illegal cross-border trade. It has only recently been eradicated and it confirms expert opinion that the risks of disease incursion from illegal cross-border trade are probably high (Vallis, 2014). Despite the illegal practices, study participants assessed that their remoteness would limit the risk of spread of any contagious animal virus inadvertently introduced to the country.

With regards to illegal trade, the highest threat is perceived to come from illegal activities hidden within legal patterns such as logging boats imported second-hand cars or containers coming from Asia, with live animal and/or animal product being hidden within a legal trade activity. Study participants suspect these illegal introductions happen regularly and declared that, even though they follow an official import procedure, they are difficult to detect as the PICTs don’t have the means to examine every passenger, container, car and boat landing on these islands. These results are consistent with those from the Caribbean Islands that identified the legal trade of live animals and the uncontrolled introduction of animal products by boat passengers as the two most likely routes of introduction of exotic animal pathogens (Percedo Abreu et al., 2011). Therefore, despite the vastness of uncontrolled island coastal borders that represent an obvious threat with regard to illegal introduction of potentially contaminated goods, it appears that a major challenge for small developing islands is the control of undeclared commodities hidden within a legal trade activity.

The main risk identified with regards to wild animals lies in the potential contact with domesticated animals as about 30% of pig and poultry farms in the PICTs raise free ranging pigs and poultry (Brioudes & Gummow, 2015). Farmers would therefore probably benefit from awareness raising campaigns about the risk of introduction and spread of transmissible diseases through wild animals and the need for an early reporting of suspect clinical signs or mortality among domesticated and wild animals.

The results of the analysis also highlighted that the countries involved had limited import procedures for preventing the introduction of infectious diseases through virus-contaminated vehicles or fomites.

Identified risk hotspots and risk factors

It is acknowledged that conducting a market chain analysis and a disease risk assessment through stakeholder consultation leads to more transparent animal disease management and plays a central role in risk communication (FAO, 2011). Considering the limited financial and human resources available in the developing countries, choices have to be made as to where disease prevention and control measures should be targeted.

To increase the chances of detecting highly contagious transboundary animal disease, before the imported commodity is actually released, random checks of imported commodities should ideally be set up at the ports of entry together with random visual checks of live animals. In the PICTs, our study showed that most of the legal importation of live animals (day-old-chicks, live pigs) and animal products (fertile eggs, pig semen) was done by commercial farms who then supply most of the local smallholders. As such, they play a key role in the pig and poultry industry and it makes sense therefore to target them in a first line of surveillance. This is consistent with the findings of a previous study conducted in these 4 PICTs (Brioudes & Gummow, 2015) in which the capitals of the studied provinces of PNG, Solomon Islands and Vanuatu were identified as the most connected nodes of pig and poultry networks as a consequence of having key husbandry actors such as day-old-chick suppliers and pig breeder companies based in these locations. Targeting surveillance on these farms would thus potentially limit the risk of spread across the countries if some highly contagious pathogens were to be introduced through legal trade.

Since the introduction of undeclared goods hidden within a legal trade activity was identified as a major risk pathway in all studied PICTs, local authorities might consider targeting legal trade activities before considering illegal trade activities if resources are limited.

With the exception of Vanuatu where the import inspections were conducted by a veterinarian, control officers in charge in the three other PICTs had an agriculture background with only a minimal knowledge of animal health and a limited understanding of disease spread risks. This was identified as a risk factor that could potentially lead to an unnoticed introduction of animal pathogens within the PICTs through legal importation or illegal introduction of live animals. A solution may be more systematic and extended training of biosecurity officers in basic animal health and importation-associated risks. This would increase their awareness of animal disease risks relating to live animals and animal products and enhance their understanding of the role they play along the risk pathways when disease is detected.

Swill feeding was confirmed as a common practice within the Pacific Islands region that potentially increases the risk of spread of contagious viruses to susceptible species. This practice resulted in the introduction of FMD into South Africa in 2000 (Brückner et al., 2002) and the United Kingdom in 2001 (Valarcher et al., 2008) and the introduction of African swine fever into Mauritius in 2007 (Lubisi, Dwarka, Meenowa, & Jaumally, 2009). While banning this traditional practice is unrealistic in the PICTs and would deprive farms from a cheap source of stock feed, local authorities might consider raising awareness among farmers about the risk related to swill and inform them about good practices such as cooking food waste before distribution to animals.

CONCLUSION

Using market chain analysis in conjunction with risk pathways provided an opportunity for better communication between animal health officials involved in disease surveillance and biosecurity within their own countries and clarification on how their roles fitted together with respect to surveillance and biosecurity. It also provides a practical framework that developing countries can use to identify the key risk hotspots and risk factors within their animal disease surveillance systems. Legal trade of animals and animal products appear to rely essentially on preventive measures put in place in the exporting countries while no or only limited control measures are undertaken in-country. Illegal introduction of hidden goods within a legal trade was unanimously perceived as the highest risk for the PICTs. Commercial farms play a key role in the legal importations of animal and animal products and supplying the majority of the local poultry smallholders. They should therefore be incorporated into any disease monitoring and control system. Activities such as awareness campaigns for pig and poultry farmers regarding disease reporting, biosecurity measures or danger of swill feeding should be implemented to prevent and limit the spread of pathogens. Training of national staff involved in import control on animal diseases and their potential impact if they were to be introduced should be implemented.

ACKNOWLEDGEMENTS

This research work was conducted in partnership between the Animal Health and Production Team, Land and Resources Department of the Secretariat for the Pacific Community (SPC) and the School of Veterinary and Biomedical Sciences of James Cook University (JCU), Townsville, Queensland, Australia as part of the Food Animal Biosecurity Network. The project received funding support under the Public Sector Linkages Program, Department of Foreign Affairs and Trade of the Australian government (AUSAID agreement 54828/16).

We are most grateful to the national animal health and production experts and biosecurity experts who agreed to participate in this study and to the Animal Health and Production team of SPC for its assistance in the conducting of the expert consultations. We also acknowledge Robert Hedlefs and Jeffrey Warner for their advice and assistance.

REFERENCES

Brioudes, A., Gummow, B., 2015. Understanding Pig and Poultry Trade Networks and Farming Practices Within the Pacific Islands as a Basis for Surveillance. Transbound. Emerg. Dis. doi:10.1111/tbed.12370.

Brioudes, A., Warner, J., Hedlefs, R., Gummow, B., 2014. A review of domestic animal diseases within the Pacific Islands region. Acta Trop. 132, 23-38.

Brioudes, A., Warner, J., Hedlefs, R., Gummow, B., 2015. Diseases of livestock in the Pacific Islands region: setting priorities for food animal biosecurity. Acta Trop. 143, 66-76.

Brookes, V., Ward, M., 2016. Expert Opinion to Identify High-Risk Entry Routes of Canine Rabies into Papua New Guinea. Zoonoses Public Health, 1-5.

Brückner, G.K., Vosloo, W., Du Plessis, B.J.A., Kloeck, P.E.L.G., Connoway, L., Ekron, M.D., Weaver, D.B., Dickason, C.J., Schreuder, F.J., Marais, T., Mogajane, M.E., 2002. Foot and mouth disease: the experience of South Africa. Rev. Sci. Tech. 21, 751.

FAO, 2011. A value chain approach to animal diseases risk management - Technical foundations and practical framework for field application, Animal Production and Health Guidelines. No. 4. Rome, Italy.

FAO Statistic Division, 2014. FAOSTAT, http://faostat3.fao.org/download/Q/QA/E (accessed 20/10/2014).

Forman, S., Plante, C., Murray, G., Rey, B., Belton, D., Evans, B., Steinmetz, P., World Organisation for Animal, H., 2012. Position paper: improving governance for effective veterinary services in developing countries--a priority for donor funding. Rev. Sci. Tech. 31, 647-660.

Guerrier, G., Foster, H., Metge, O., Chouvin, C., Tui, M., 2013. Cultural contexts of swine-related infections in Polynesia. Clin. Microbiol. Infect. 19, 595-599.

Gummow, B., 2010. Challenges posed by new and re-emerging infectious diseases in livestock production, wildlife and humans. Livestock Science 130 (1-3), 41-46.

Lubisi, B.A., Dwarka, R.M., Meenowa, D., Jaumally, R., 2009. An Investigation into the First Outbreak of African Swine Fever in the Republic of Mauritius. Transboundary and Emerging Diseases 56, 178-188.

Murray, N., MacDiarmid, S.C., Wooldridge, M., Gummow, B., Morley, R.S., Weber, S.E., Giovannini, A., Wilson, D., 2004. Handbook on Import Risk Analysis for Animals and Animal Products: introduction and qualitative risk analysis. OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2012. Update on highly pathogenic avian influenza in animals (Type H5 and H7), http://www.oie.int/en/animal-health-in-the-world/update-on-avian-influenza/2012/ (accessed 26/02/2013), OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2013. Disease distribution map, http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/Diseasedistributionmap (accessed 26/02/2013), OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2014a. Technical disease cards, http://www.oie.int/en/animal-health-in-the-world/technical-disease-cards/ (accessed 02/03/2016), OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2014b. World Animal Health Information Database (WAHID) Interface - Disease information - Status list. http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statuslist (accessed 14/11/2014), OIE, 12, rue de Prony, 75017 Paris, France.

OIE, 2014c. World Animal Health Information Database (WAHID) Interface - Information by Country/territory - Animal health situation. http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Animalsituation (accessed 14/03/2015), OIE, 12, rue de Prony, 75017 Paris, France.

Pavlin, B.I., Kool, J.L., Samo, M.H., Gerstel, L., 2010. A standardized process for developing a national notifiable diseases list in a pacific island setting. Asia Pac. J. Public Health 22, 279-288.

Percedo Abreu, M.I., Guitián, J., Herbert-Hackshaw, K., Pradel, J., Bournez, L., Petit-Sinturel, M., Delgado, A., Sanford, B., Trotman, M., Lazarus, C., López, J.F., Gómez, L., Frías-Lepoureau, M.T., Depaz, M., Phanord, S., Titus, S., Parris-Aaron, M., Gongora, V., Lefrançois, T., 2011. Developing a disease prevention strategy in the Caribbean: the importance of assessing animal health-related risks at regional level. Revue scientifique et technique (International Office of Epizootics) 30, 725.

Secretariat of the Pacific Community, 2009a. Livestock in the Pacific, Policy Brief. Secretariat of the Pacific Community, BP DS, 98848 Noumea Cedex, New Caledonia.

Secretariat of the Pacific Community, 2009b. Report of the first FAO/OIE subregional meeting of GF-TADs for the Pacific Community region in collaboration with SPC, 25-26 June 2009, Nadi, Fiji, Secretariat of the Pacific Community, Suva Regional Office, Private Mail Bag, Suva, Fiji Islands.

Secretariat of the Pacific Community, 2011. PHAMA project target market access and high-value primary commodities, Land Ressources News. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji, p. 1.

Valarcher, J.F., Leforban, Y., Rweyemamu, M., Roeder, P.L., Gerbier, G., Mackay, D.K.J., Sumption, K.J., Paton, D.J., Knowles, N.J., 2008. Incursions of Foot-and-Mouth Disease Virus into Europe between 1985 and 2006. Transbound. Emerg. Dis. 55, 14-34.

Valenciano, M., 2001. Definition des priorites dans le domaine des zoonoses non alimentaires, Institut de Veille Sanitaire, 12, rue du Val d'Osne, 94415 Saint-Maurice cedex, France, p. 40.

Vallis, R., 2014. ERADICATE pays off in PNG. Aust. Vet. J. 92, N16.

Yarrow, R., 2008. Increasing veterinary capacity in the Pacific, Third regional meeting of Heads of Agriculture and Forestry Services (HOAFS), 3-5 September 2008, Apia, Samoa. Secretariat of the Pacific Community, Suva, Fiji, p. 4.

CHAPTER 6

GENERAL DISCUSSION

The purpose of this chapter is to summarize the key findings and conclusions of the research conducted under this study and to discuss these research outputs in the Pacific Islands context.

Three approaches were applied to focus animal health surveillance in the PICTs, and this chapter demonstrates how these approaches relate to each other and how they can be applied. In particular a framework to integrate these approaches is provided.

RECAPITULATION OF RESEARCH AIM AND OBJECTIVES

This study set out to examine ways by which animal disease surveillance in the Pacific Islands region could be better targeted to enable more efficient use of scarce resources in the PICTs.

The study had three specific objectives:

1. Produce an enhanced understanding of the current disease status in the Pacific Islands region;
2. Ascertain which of the diseases were of greatest importance within the Pacific Islands region;
3. Describe how these diseases could spread through livestock movements, and identify the key trade hubs where diseases may be disseminated within the PICTs.

PRACTICAL FRAMEWORK APPLIED UNDER THIS STUDY

The research firstly sought to gain a better understanding of the current disease status in the Pacific Islands region (Chapter 2). Then ascertained which of these diseases were of greatest importance within the region, at both the regional and national levels (Chapter 3). This would enable better disease focused surveillance and rationalisation of resources against these diseases. The next step was to describe how these diseases could spread through livestock movement and to identify the key trade hubs where diseases may be disseminated within the PICTs (Chapter 4), thus providing a framework for targeted surveillance. The product of this work therefore led to a more focused surveillance system that has the potential to optimise available resources. And finally, we aimed to use pig and poultry market chains in combination with risk pathways as a tool for identifying the highest risk areas (risk hotspots) and the practices and behaviors of market chain stakeholders (risk factors) with regards to animal disease introduction and/or spread to enable more targeted use of scarce manpower and intervention strategies for specific high risk segments of the market chain (Chapter 5).

A diagrammatic representation of the research process and related outputs is presented in Figure 6-1.

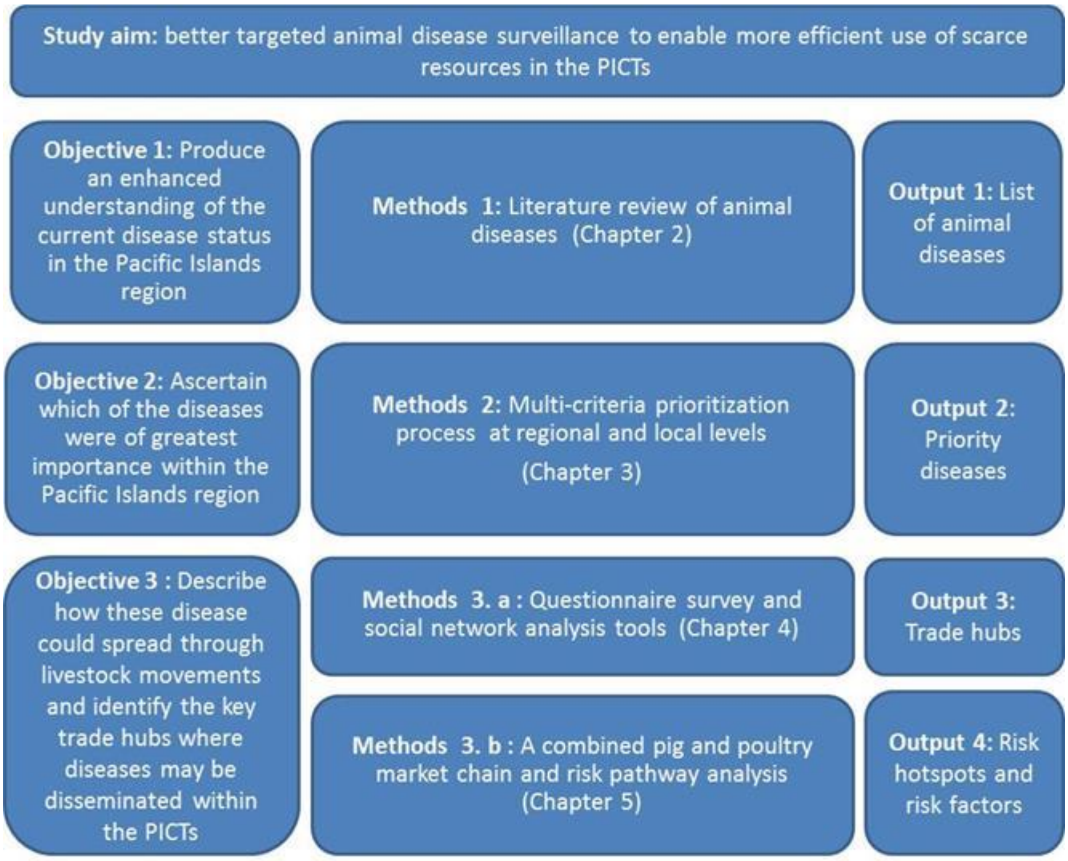


Figure 6-1: Diagrammatic representation of the research process and related outputs.

SUMMARY OF STUDY KEY FINDINGS AND CONCLUSIONS

Key findings and conclusions from the literature review presented in Chapter 2:

The literature review led to the retrieval of 158 eligible references of which only half were published since 1992 (see Chapter 2). The number of references published annually was very irregular, with peaks in publications observed in 2004 and 2011. Among the 22 PICTs included in the eligibility criteria for the literature review, half of the references provided data for PNG and New Caledonia only. A total of one hundred and one diseases and pathogens were reported for bee, bird, carabao, cat, cattle, crocodile, deer, dog, donkey, goat, horse, pig, pigeon, poultry and sheep in the Pacific Islands region, and were from 17 PICTs (77%) in particular. The study found that zoonotic diseases such as leptospirosis, scabies, bovine tuberculosis and brucellosis are endemic in many of the PICTs, but these island countries tend to be free of the most contagious livestock diseases such as HPAI, FMD, classical swine fever and rabies. This review of the current knowledge on domestic animal diseases in 22 PICTs with an emphasis on data from 1992 to 2012 showed that very little information is available on animal diseases for this region (Conclusion No 1).

Budgetary restrictions and lack of investments in animal health studies in the region over recent years probably explain the lack of recent data. Most PICTs do not have the resources to finance such research, but with the help of external funding, the Animal Health and Production Division of SPC has the mandate and the technical capacity for conducting and coordinating such studies at the regional level. Because of this lack of recent data, it couldn't be ascertained what the current disease situation in the region was, and in particular, what the key diseases of primary importance are in the region. Therefore, the literature review itself could not be used to identify what diseases surveillance programmes should be focusing on.

Key findings and conclusions from the animal disease prioritization presented in Chapter 3:

Because no single disease of importance could be identified from the literature, a disease prioritization process was conducted to identify the animal diseases of greatest importance within the Pacific Islands region at both the regional and national levels (see Chapter 3). The scoring and ranking of animal diseases of interest for the PICTs demonstrated that Leptospirosis, HPAI and Brucellosis are currently the top three priority diseases within the Pacific Islands region (Conclusion No 2).

The list of the top twenty ranked diseases for the Pacific Islands region showed a mix of endemic zoonotic diseases (such as leptospirosis ranked first; brucellosis in third position; tuberculosis in sixth) and exotic diseases (such as Highly Pathogenic Avian Influenza ranked second, Foot and Mouth Disease in fifth position and rabies in ninth position). At the national level, results showed that there were different disease ranking lists for each of the four targeted PICTs (Conclusion No 3).

Interviews with animal health and production workers demonstrated that they were unfamiliar with most of the prioritized diseases (as, for instance, only half of them knew about Leptospirosis and only a third knew about HPAI). A majority of them acknowledged that they would not be able to recognise clinical signs if outbreaks were to occur in their area (FMD would have been recognised by only half of the interviewed AHPW). This highlighted the need for further capacity building to improve the animal disease knowledge in this region (Conclusion No 4).

Additionally, the study showed that endemic diseases (parasites, flu, coccidiosis and scabies) were identified as most important by farmers, demonstrating that farmers' perceptions varied significantly from experts' opinions (Conclusion No 5). These divergences in disease priority should be taken into account when defining and setting up a targeted animal disease surveillance programme in the PICTs.

The disease priority results provide essential information for a better rationalised surveillance system. Considering that surveillance programmes are efficiently and sustainably conducted only if the stakeholders find themselves some benefits from the implemented activities, the study also gave information needed for an optimal design of surveillance programmes within the PICTs depending on whether the surveillance programme is to be regionally, nationally or locally implemented, and whether it should involve national animal health staff, animal health and production workers, or farmers.

Key findings and conclusions from the pig and poultry trade network analysis presented in Chapter 4:

Once the diseases of importance had been identified within the PICTs, we then assessed the way in which highly contagious diseases would potentially spread across the PICTs by pig and poultry movements (see Chapter 4).

A survey was conducted in the four targeted PICTs, with a total of 491 poultry farmers from 196 villages and 310 pig farmers from 171 villages interviewed. Regarding disease reporting and management, our results indicate that more than 80% of farmers did not experience any animal diseases over the past twelve months. A large proportion of farmers (61.3%) do not implement any preventive or control measures. Most farmers never ask for veterinary care, never engage in laboratory testing and do not report when their animals show clinical signs of disease (Conclusion No 6).

Relating to the pig and poultry movements, we found that many farmers trade only within their communities and sell directly to consumers, which reduces the risk of spreading disease. Results from the univariate and multivariate analyses show some relationship between farmers that report having had disease on their farm in the past twelve months and movements of animals on and off of their farms (Conclusion No 7).

The analysis of the poultry networks indicated that in PNG, the network is highly connected, with a giant component of more than 90% of the total number of nodes comprising this network. The capital of Morobe province, Lae, and the capital of Jiwaka province, Banz, were the nodes with the highest out-degree values of this network, which is to be attributed to the presence in these localities of the biggest day-old chick suppliers in PNG (Conclusion No 8.1). In the Solomon Islands, the poultry network is also highly connected, with a main component which includes 65% of nodes and with the capital Honaira identified as a central node (Conclusion No 8.2). In Vanuatu, the poultry network appeared less connected, with several small components, and Luganville, the largest city of Santo Island, was identified as the node with the highest degree values (Conclusion No 8.3). Like in Vanuatu, the poultry network in Fiji appeared less connected, with several small components, and Labasa and Vunivau settlements being identified as the locations with the highest degree values (Conclusion No 8.4).

The analysis of the pig networks showed that in PNG this network is less connected than the poultry network, with 10 different components. Lae lies in a central position with the highest in-degree and out-degree values of the network, and Goroka has the highest in-degree value, which is linked to the presence of important livestock markets and slaughterhouses (Conclusion No 8.5). The pig trade network of Solomon Islands showed a great connectivity, with 70% of the nodes within the main component, and the capital Honiara is the location with the highest degree of trade (Conclusion No 8.6). In Vanuatu, the pig networks show a great connectivity with about half of the nodes within the main component, and Port Vila and Luganville are the locations with the highest degree of trade (Conclusion No 8.7). The pig network in Fiji is comprised of 10 different components with a limited number of connections, except for the Northern division Nacaracara and Togalevu Estate, which are the two nodes with the highest in-degree values (Conclusion No 8.8).

Regarding the seasonality of trade, the majority of poultry and pig farmers observed an increase in sales over certain periods of the year. The highest increase in trade reported by pig and poultry farmers of the four FABN countries is associated with Christmas and New Year celebrations in December and January. Poultry farmers in PNG also see an increase in trade from April/May to October/November, related to the Coffee season, which is associated with festivities involving increased poultry consumption (Conclusion No 9).

Key findings and conclusions from the combined pig and poultry market chain and risk pathway analysis presented in Chapter 5:

Based on the prioritization of livestock diseases, HPAI and FMD were ranked at the regional level as the top priority exotic poultry and pig diseases. The PICTs are currently free of these two transboundary diseases, but most countries in the neighbouring East and South-East Asia regions reported HPAI and FMD events in the recent past. So, within this context, in the last chapter we conducted a pig and poultry market chain analysis combined with risk pathways. This was done with the aim of identifying the highest risk area (risk hotspots) of the market chains and the risky practices and behaviours of market chain stakeholders (risk factors) for animal disease introduction and/or spread. By using HPAI and FMD as model diseases because of their importance within the Pacific Islands region, determining the highest risk areas in the market chain will enable the PICTs to better target their resources at specific segments of the market chains (Chapter 5).

One key finding of this study is that legal trade pathways rely essentially on preventive measures put in place in the exporting countries while only limited control measures are undertaken by the importing countries. Control officers frequently have an agriculture background and thus have only limited diagnostic skills. Poultry imports are done by the main commercial farms which play a key role in the industry in the country by supplying most of the local poultry smallholders.

Regarding the illegal introduction pathway, results show that for the four PICTs studied, the major risk pathway identified is the introduction of undeclared goods hidden within a legal trade activity, such as in logging boats landing directly without going through an official port of entry, or undeclared goods hidden between other commodities within a container. Swill feeding, which is a very common practice in the Pacific Islands, was also identified as a significant risk factor for dissemination of pathogens to susceptible species.

With this study, we confirmed that a combined market chain and risk pathway analysis provides a practical framework for communicating risk to animal health officials and improving biosecurity (Conclusion No 10). It provides a participatory approach that helps officials to better understand the trading regulations already in place in their country and to better evaluate their role as part of the control system. Common risk patterns were found to play a role in all four PICTs. Legal trade of animals and animal products appear to rely essentially on preventive measures put in place in the exporting countries, while only limited control measures, if any, are undertaken in-country (Conclusion No 11). Illegal introduction of hidden goods within a legal trade was unanimously perceived as the highest risk for the PICTs (Conclusion No 12). Commercial farms were found to be supplying the majority of the local poultry smallholders and to play a key role in the legal importations of animal and animal products (Conclusion No 13). Swill feeding was identified as a significant risk factor for dissemination of pathogens to susceptible species (Conclusion No 14)

Table 6-1 presents the compiled list of conclusions drawn from the different approaches applied under this research study:

Table 6-1: Summary of the conclusions of the research

METHODS	CONCLUSIONS
Chapter 2 Literature review	**Conclusion No 1:** Very little information is available on animal diseases for this region
Chapter 3 Animal Disease Prioritization	**Conclusion No 2 :** Leptospirosis, HPAI and Brucellosis are currently the top three priority diseases within the Pacific Islands region
	Conclusion No 3: Different disease ranking lists were obtained at the regional level and for each of the four targeted PICTs
	Conclusion No 4: There is a need for further capacity building to improve the animal disease knowledge in this region
	Conclusion No 5: Farmer's perception varied significantly from expert opinion regarding animal disease priority in the PICTs
Chapter 4 Trade network analysis	**Conclusion No 6:** A majority of farmers do not implement any preventive or control measures, never ask for veterinary care, never engage in laboratory testing and do not report when their animals show clinical signs
	Conclusion No 7: There are some associations between farmers that report having had disease on their farm in the past twelve-months and movements of animals on and off their farms
	Conclusion No 8.1-8.8: Nodes with the highest out-degree values within the poultry and pig networks in PNG, Solomon Islands, Vanuatu and Fiji were identified
	Conclusion No 9: The highest increase in trade reported by pig and poultry farmers of the four FABN countries is associated with Christmas and New Year celebrations in December and January. In PNG, poultry farmers also have an increase in trade from April/May to October/November, related to the Coffee season
Chapter 5 Combined market chain and risk pathway analysis	**Conclusion No 10:** A combined market chain and risk pathway analysis provides a practical framework for communicating risk to animal health officials and improving biosecurity
	Conclusion No 11: Legal trade of animals and animal products appears to rely essentially on preventive measures put in place in the exporting countries while only limited control measures, if any, are undertaken in-country
	Conclusion No 12: Illegal introduction of hidden goods within a legal trade was unanimously perceived as the highest risk for the PICTs
	Conclusion No 13: Commercial farms were found to be supplying the majority of the local poultry smallholders and to play a key role in the legal importations of animal and animal products
	Conclusion No 14: Swill feeding was identified as a significant risk factor for dissemination of pathogens to susceptible species

DISCUSSION ON THE SIGNIFICANCE OF THESE KEY FINDINGS AND CONCLUSIONS

In light of the risk factors and risk hotspots identified in this study, one could wonder why the PICTs remain apparently free of the most contagious animal diseases.

As highlighted in our literature review (see Chapter 2), the retrieved information is no longer up-to-date and some grey literature might not have been retrieved, as some PICTs may have individually conducted animal disease studies without publishing the results.

One recurrent comment heard during various expert consultations conducted throughout this study was that transboundary animal diseases may have been present but did not get the opportunity to spread to susceptible species. Also, study participants felt that their remoteness, and the fact that most PICTs are archipelagos composed of multiple islands separated by sea borders, may limit the risk of spread of any contagious animal virus inadvertently introduced into the country. However, this situation is changing with more trade and movements taking place between these islands that could result in disease spread. Therefore, animal health authorities need to be prepared and develop their disease outbreak response strategy despite the lack of disease presence.

We also found that a large proportion of pig (46.7%) and poultry (79.6%) farmers never ask for assistance when diseases occur on their farm and do not report diseases. The use of laboratory testing for confirming the presence of animal diseases in pig and poultry is also poor, and the availability and maintenance of laboratory diagnostic capacities are known to be a challenge in the region.

As highlighted in Chapter 4, a non-negligible proportion of farmers (28.1% of pig farmers and 17% of poultry farmers) declared a total absence of pig or poultry movement over the past 12 months. A third of pig farmers (31.8%) also trade within their communities only, and about a quarter of pig and poultry farmers sell directly to consumers, at the farm gate or within their neighbouring community, which further reduces the risk of diseases spreading.

It therefore seems that the cultural practice of trading internally plays an important role in curtailing the spread of diseases in the PICTs. However, as these practices are eroded, the probability of disease spread increases, making targeted surveillance increasingly important.

CHAPTER 7

RECOMMENDATIONS

Results from this study can be used to formulate recommendations for better targeted animal disease surveillance in the Pacific Islands region to enable more efficient use of scarce resources in the PICTs.

PRACTICAL FRAMEWORK TO INTEGRATE THE APPROACHES APPLIED UNDER THIS STUDY

A novel aspect of the work conducted under this study is that the framework used for our research was implemented at the regional level, thus illuminating the bigger picture. The logical process developed under this study provides a practical framework that local authorities from the PICTs can follow in the future for a more integrated and better harmonized animal disease risk management.

Conduct regular animal health studies within the PICTs

Our results demonstrated that very little information is available about the current status of animal health and that the retrieved literature is no longer up-to-date. There is a need for more investment in animal disease status information in the Pacific Islands region, particularly given the tropical environment and ideal conditions for disease emergence. Ideally, further animal health studies should be launched in each of the 22 SPC member countries in order to have an accurate snapshot of the current situation within the entire region (Recommendation A). However, given economic limitations, the SPC, with the support of some funding agencies, will probably need to define where to set up these studies within the region.

Reiterate the animal disease prioritization process

The disease prioritization process implemented under this study captured the animal disease perception based on community and expert opinion. This perception is not fixed and will undoubtedly shift at a more or less progressive stage among the concerned stakeholders based on the evolving status of animal health. Therefore, such animal disease prioritization would have to be repeated and adapted whenever the animal health status within the PICTs changes significantly to adjust the focus of surveillance (Recommendation B).

Results showed that there were different disease ranking lists between the regional level and each of the four targeted PICTs indicating that a regional approach should take into account country specific needs (Recommendation C).

Considering the discrepancy observed between results at the regional and national levels, there would also be some benefit in replicating this approach to the other PICTs in order to have a more harmoniious and better integrated surveillance at the regional level (Recommendation D).

Extend the livestock movement network analysis

Due to budget and time constraints, the pig and poultry movement network survey was conducted in a limited number of provinces in each of the selected PICTs. Extending the survey to other areas would help give a more complete and accurate description and understanding of the networks in place in these countries (Recommendation E). This is particularly true in Fiji, where the lower degree of connectivity observed in our study suggested a lower risk of pig and poultry disease dissemination, but the entire pig and poultry networks were not captured, possibly along with some other central nodes that may exist. Replicating this study to other species that were not covered would also be of benefit in assessing more precisely the ways in which a disease with various potential hosts would spread within the PICTs (Recommendation F).

Conduct regular combined market chain and disease risk pathway analysis

The results of the combined market chain and risk pathway analysis reflect the risk hotspots and risk factors with regards to the introduction of HPAI and FMD at the time of the study implementation only. These risks are by their essence evolving and should be reassessed as often as animal health status is changing and the structure of the market chain is being modified (Recommendation G).

HPAI and FMD were chosen as model diseases because of their top rank in the disease prioritization at the regional level, but this approach should be reiterated for other animal diseases of priority, taking into account the specificity of each PICT and applying it to other livestock sectors of particular importance (such as the cattle industry in Vanuatu for instance) (Recommendation H).

Continuously communicate about the risks with key stakeholders

We put forward the logical framework applied in this study as a practical way of communicating risk to key stakeholders throughout the whole process of the animal disease risk analysis (Fig. 6-1), following the OIE framework (Murray et al., 2004), with:

- hazard identification through animal disease prioritization;
- disease risk assessment through the trade movement analysis and the combined market chain and risk pathways analysis;
- disease risk management through the identification and the implementation of risk mitigation measures, based on the trade hubs, risk hotspots and risk factors identified.

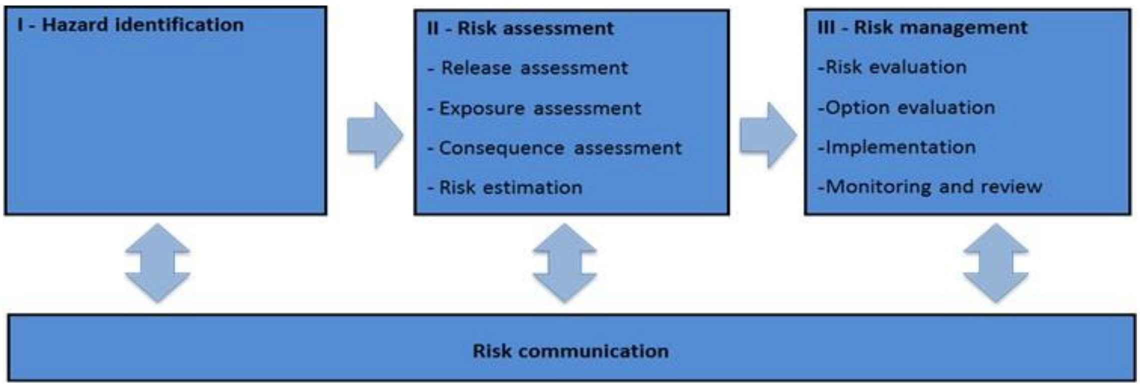


Figure 7-1: OIE risk analysis framework

Continuous communication about the risks should be carried out with key stakeholders (Recommendation I). Being that different stakeholders may have different perceptions of a particular risk and different opinions on the risk reduction strategy to adopt, a consultative approach involving the value chain stakeholders, along with the animal health and livestock production authorities, is essential to maintain continuous risk communication throughout the different steps of the risk management process. It ensures a more transparent decision-making approach on animal disease risk management and increases the chance of reaching an agreement on the contribution of different stakeholders to the adopted risk mitigation measures.

IDENTIFIED LIMITATIONS AND GAPS IN THE PICTS' ANIMAL HEALTH SYSTEMS

The analysis of our results led to the identification of some limitations and gaps among the PICTs animal health systems and livestock sector that would need to be addressed for an optimal implementation of surveillance programmes.

Build capacity for improved animal health knowledge

Our study highlighted farmers' limited perceptions of disease risks and thus there is a need for further training of farmers on animal diseases and on the risks relating to animal diseases, and for awareness campaigns on minimum biosecurity requirements (Recommendation J).

Another critical limitation identified in our study is that most field animal health and production workers are unfamiliar with the top-priority diseases and a majority would not recognise their clinical signs if they were to occur in the PICTs, highlighting again the need for further training of animal health workers in animal diseases (Recommendation K).

The PICTs local animal health authorities, with the support of regional and international agencies, will have to address these gaps for optimal and sustainable surveillance programmes in the region. The region has received some external aid for paravet training being conducted in some PICTs (Secretariat of the Pacific Community, 2012), which should partly address this need. Our study results confirm the need for extending and expanding this kind of training for AHPW and for raising awareness among farmers in the region.

Improve biosecurity at the farm level

Any interventions relating to the prevention and the control of animal diseases are to be considered as a global effort to limit the impact of such diseases among the livestock production systems and potentially among the human population.

Several practices that potentially increase the risk of disease introduction and/or dissemination have been identified through our study (see Chapters 4 and 5). Our results confirmed that the traditional Pacific Islanders husbandry practices and the limited level of biosecurity provide favourable conditions for the potential introduction and spreading of animal diseases. A large proportion of pig and poultry farmers (61.3% and 44.6% respectively) do not implement any preventive or control measures to avoid or limit the impact of animal diseases. Almost half of the farmers also raised other animals apart from pigs or poultry. Our study showed that about a quarter of pig farmers and 12% of poultry farmers mix their animals with the animals of other farmers within their villages, which increases the risk of disease dissemination between villages as well (see Chapter 4).

This is consistent with farmers of the Pacific Island region who tend to have small-scale subsistence-based farms with limited numbers of animals but a diversified number of species (FAO, 1998; Guerrier, Foster, Metge, Chouvin, & Tui, 2013; Secretariat of the Pacific Community, 2009). This local context produces potentially favourable conditions for the introduction and dissemination of diseases across species within a farm, such as leptospirosis, which is endemic in the region (see Chapter 2), or foot-and-mouth disease, if they were to be introduced (Swallow, 2012). These results confirm the need to implement adequate biosecurity measures within pig and poultry farms to prevent animal diseases from being introduced onto their farms. Awareness should thus be raised amongst farmers about risky husbandry practices and about disease prevention to avoid the distribution of pathogens when they trade animals (Recommendations L). As the international scientific and technical organisation in charge of supporting the development in the region, SPC has the mandate and capacity for conducting and coordinating such awareness campaigns that could be implemented and expanded through the training of trainers (ToT) to reach the maximum number of farmers in the PICTs.

It is to be highlighted though that some of these husbandry practices are part of the cultural heritage of the Pacific Islanders, and our results are not aiming to stop these practices, but rather to adapt them so they can be more biosecure. The use of swill in particular is a common practice and banning it would be impractical and would represent a real waste for the local communities. Instead, advocating for a proper treatment of the swill (sufficiently cooked) amongst the pig farmers or limiting the use of introduced swill and foodstuff from vessels is rather the way forward (Recommendation M).

Among the farmers who reported implementing biosecurity measures, 15.8% of pig farmers and 8.1% of poultry farmers reported using natural medicines (such as traditional herbs, coconut milk/cream, lemon juice, salt water to prevent and/or control animal diseases like flu, skin diseases, worms or to clean wounds). Because it falls beyond the scope of our research, this finding was not investigated any further, but additional research is required to confirm the actual effectiveness of such natural medicines. Based on the results, adequate message campaigns should then inform communities of the effectiveness of these local practices and whether their animals are protected or not. There is also the potential risk in accepting traditional treatments that the reporting of disease outbreaks will be delayed or remain unreported while the treatment is being administered.

Improvement in the livestock production husbandry will limit the risk of occurrence of animal diseases and is expected to be of benefit to the farmers in terms of livestock productivity, and ultimately will help to protect the public health.

Build laboratory capacity (Recommendation N)

In addition to efficient human resources at the field level, surveillance systems require adequate laboratory diagnostic capacity. As indicated in Chapter 5, the use of laboratory testing for confirming the presence of animal diseases in pig and poultry industries is poor in the surveyed countries. The availability and the maintenance of laboratory diagnostic capacities are known to be a challenge in the Pacific as it is in many developing countries (Bhatia & Narain, 2010; Jeggo, 2000). Currently, only two of the FABN countries (i.e. Fiji and PNG) have adequate laboratory facilities for a basic animal disease diagnostic capacity. The cost-benefit of a laboratory confirmation may not be perceived as positive by farmers and the shortage of animal health staff makes the collecting of samples a challenge, especially in remote areas.

This study was conducted as part of a Food Animal Biosecurity Network (FABN) project that aimed at "delivering enhanced animal health field and laboratory capability to the Pacific Islands, particularly in the area of animal disease surveillance, to allow assessment under OIE guidelines for trade in animals and animal products" (Gummow, 2014). Our work on disease prioritization at the regional and national levels helped identify high priority diseases and is thus expected to assist in better addressing the disease diagnostic needs within the region and in the four targeted PICTs. The results of our work, which were based on a rational and transparent disease prioritization process, may help attract external funding support for improving the current equipment and facilities and in enhancing the staff laboratory testing skills in the regional laboratories.

RECOMMENDATIONS FOR FUTURE TARGETED SURVEILANCE PROGRAMMES IN THE PICTS

Considering the scarce financial and manpower resources available within most of the PICTs, choices have to be made as to where disease prevention and control measures should target. The results of this study provide some insights for setting up more cost effective and efficient targeted surveillance programmes.

Animal diseases to be targeted by surveillance programmes

The results of our study (Chapter 3) show a mix of exotic and endemic animal diseases among the top-twenty priority diseases listed within the PICTs, which demonstrates the complexity of discriminating between diseases. Our approach established a field application which used a rational and transparent approach to assist decision-makers in identifying the animal diseases of priority for surveillance within the PICTs.

The cut-off for the number of diseases to be included in a surveillance programme is generally determined by budget constraints; more diseases surveyed allows for a more accurate snapshot of the disease status in the region. Depending on funding opportunities, future surveillance programmes within the Pacific Islands region should investigate the current status of one or more identified priority diseases (Recommendation O).

At the time of implementation of the study (2012-2013), Leptospirosis, HPAI and Brucellosis were identified as the top three priority diseases at the regional level. At the national level, it was FMD, Brucellosis and Tuberculosis in Fiji, Salmonellosis, Avian infectious laryngotracheitis, HPAI and Porcine reproductive respiratory syndrome in PNG, swine erysipelas, bovine venereal campylobacteriosis, leptospirosis and infectious bronchitis in Solomon Islands, and Newcastle disease, HPAI and anthrax in Vanuatu.

These results indicate that a regional approach for surveillance programmes within the Pacific Islands should also take into account the priority diseases identified at the national level when being implemented in the selected PICTs (Recommendation P).

Risk hotspots and trading hubs to be targeted by surveillance programmes

Results from the pig and poultry movement network analysis (Chapter 4) and from the combined pig and poultry market chain and risk pathway analysis (Chapter 5) provide some insights on where to assign priority for the limited resources for animal disease surveillance.

The commercial pig and poultry farms localised in the capital cities of the studied provinces were identified as trade hubs where diseases are the most likely to spread from (Chapter 4 and Chapter 5). Surveillance programmes should therefore target these farms as a priority to increase the chances of detection of a contagious disease, should one be introduced and spread within the PICTs (Recommendation Q). While it appears unrealistic to set up a syndromic surveillance system across all the PICTs, these commercial farms and to a broader extent any pig and poultry farms localised in the provincial capital cities could be targeted first for enrolment. This would require an adequate training of the selected farmers on what to report and an importance placed upon early reporting of animal disease for rapid intervention measures. To ensure a full involvement of farmers, such a syndromic surveillance system should also take into account the need to report on not only diseases of priority identified at the regional and national level, but also diseases identified as priorities for the farmers themselves so that the surveillance system implemented becomes a win-win approach.

Official ports of entry for live animals and animal products were also identified as risk hotspots where infectious pathogens are the most likely to be introduced through the entrance of undeclared goods hidden within legal trade activity. Preliminary steps of targeted surveillance systems to identified risk factors should include training of national staff involved in import control on animal diseases, and their potential impact if they were to be introduced (Recommendation R). This would assist them in better understanding the trading regulations in place in their country and in better evaluating the role of his/her duties as part of the control system.

While systematic examination of every passenger, container, car and boat landing on the PICTs is unrealistic, increased random checks of imported commodities should also be set up at these ports of entry together with random visual checks of live animals (Recommendation S). Sentinel flocks and herds in close proximity to ports could also be considered as a useful early detection mechanism, as is currently done in Australia for bee diseases, screw-worm fly and japanese encephalitis (Cookson, 2009; NSW government, 2010; Plant

Health Australia, 2016). This would potentially limit the risk of introduction of contagious animal diseases within the PICTs.

Periods to be targeted by surveillance programmes

While animal diseases can potentially emerge and spread year round, periods with higher volume of trade represent high risk periods and should therefore be targeted when active surveillance can't be implemented continuously due to limited human and financial resources.

Christmas and New Year celebrations in the four studied PICTs and the Coffee season in PNG were identified as periods of the year with increased pig and poultry trade and are therefore of potentially higher risk for disease spread (Chapter 4). Scarce resources allocated to the surveillance of pig and poultry diseases in the PICTs should thus be used in priority over December and January, and additionally from April/May to October/November, for poultry disease surveillance in PNG (Recommendation T).

In concrete terms, this could be materialised in an increased frequency of random checks at the official ports of entry, an increased frequency of symptom reporting by commercial farms involved in syndromic surveillance, and potentially some active surveillance with sample collection for laboratory testing in targeted farms (commercial farms and farms located within capital cities) during these highest risk periods in the four studied PICTs.

Such targeted surveillance activities conducted during these risk periods would allow for a prioritization of the limited economic and human resources and are expected to increase the chances of detection of any contagious disease if it was to occur in the PICTs.

A diagrammatic representation of the research process with related outputs and expected outcomes based on recommendations formulated here is presented in Figure 7-2.

Table 7-1 synthesizes the recommendations formulated under this study with cross-refernced conclusions drawn from the different approaches applied under this research study and the targets for implementation.

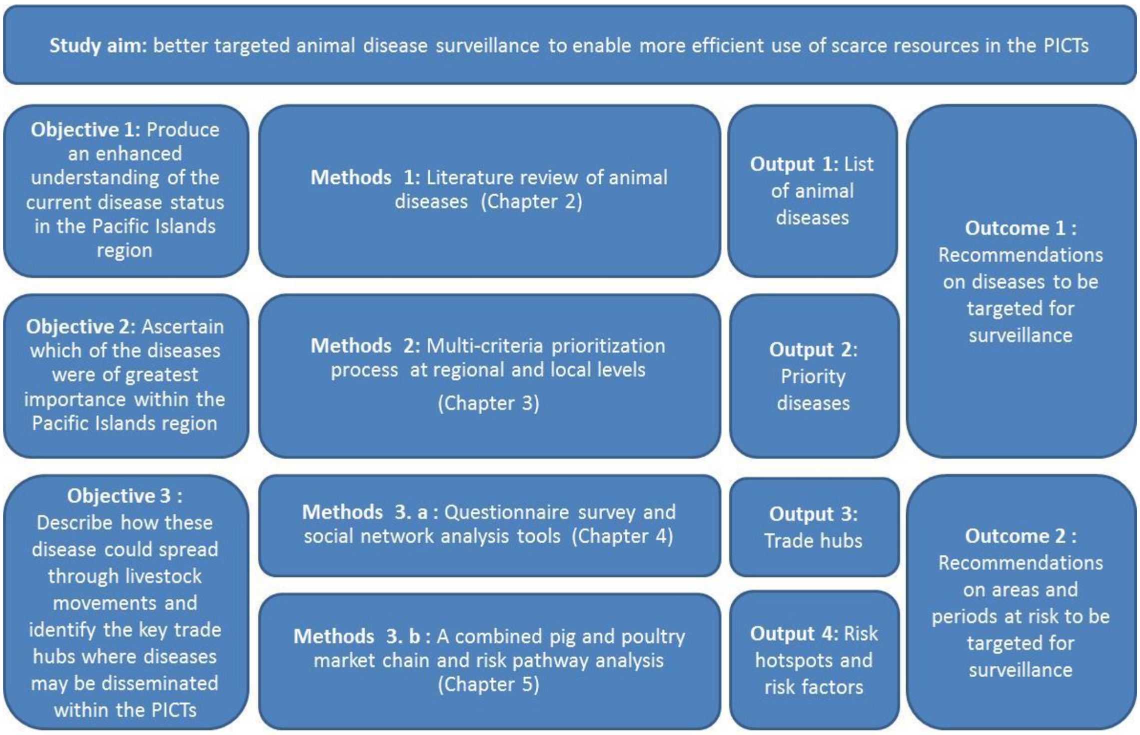


Figure 7-2: Diagrammatic representation of the research process with related outputs and expected outcomes based on research recommendations.

Table 7-1: Recommendations cross-referenced to the conclusions of the research and targets for implementation

METHODS	CONCLUSIONS	RECOMMENDATIONS	TARGETS
Chapter 2 Literature review	**Conclusion No 1:** Very little information is available on animal diseases for this region	**Recommendation A:** Further animal health studies should be launched in each of the 22 SPC member countries in order to have an accurate snapshot of the current situation within the entire region	PICTs animal health authorities, with eventually the support from regional organisations
Chapter 3 Animal disease prioritization	**Conclusion No 2 :** Leptospirosis, HPAI and Brucellosis are currently the top three priority diseases within the Pacific Islands region	**Recommendation B:** The animal disease prioritization should be repeated and adapted whenever the animal health status within the PICTs changes significantly to capture shift in disease priorities among the concerned stakeholders based on the evolving status of animal health in order to adjust the surveillance focus **Recommendation O:** Future surveillance programmes within the Pacific Islands region should investigate the current status for one or more identified priority diseases	PICTs animal health authorities, with eventually the support from regional organisations
	Conclusion No 3: Different disease ranking lists were obtained at the regional level and for each of the four targeted PICTs	**Recommendation C:** regional approach should take into account country specific needs **Recommendation D:** This approach should be applied to the other PICTs in order to have a better harmonised and integrated surveillance at the regional level **Recommendation P:** A regional approach for surveillance programmes within the Pacific Islands should also take into account the priority diseases identified at the national level when being implemented in the selected PICTs	PICTs animal health authorities, with eventually the support from regional organisations
	Conclusion No 4: There is a need for further capacity building to improve the animal disease knowledge in this region	**Recommendation K:** Further training of animal health workers in animal diseases should be conducted	Animal health workers
	Conclusion No 5: Farmers' perceptions varied significantly from expert opinions regarding animal disease priority in the PICTs	**Recommendation J:** Further training of farmers on animal diseases and awareness campaigns on minimum biosecurity requirements and on the risks relating to animal diseases should be conducted	Farmers

Table 7-1 (cont'): Recommendations cross-referenced to the conclusions of the research and targets for implementation

METHODS	CONCLUSIONS	RECOMMENDATIONS	TARGETS
Chapter 4 Trade network analysis	**Conclusion No 6:** A majority of farmers do not implement any preventive or control measures, never ask for veterinary care, never engage in laboratory testing and do not report when their animals show clinical signs	**Recommendation N**: Build laboratory capacity **Recommendation J:** There is a need for further training of farmers on animal diseases and awareness campaigns on minimum biosecurity requirements and on the risks relating to animal diseases	Laboratory staff Farmers
	Conclusion No 7: There are some associations between farmers that report having had disease on their farm in the past twelve-months and movements of animals on and off their farms	**Recommendation J:** There is a need for further training of farmers on animal diseases and awareness campaigns on minimum biosecurity requirements and on the risks relating to animal diseases **Recommendation L:** Awareness should be raised among farmers about husbandry practices at risk and about disease prevention to avoid the distribution of pathogens when they trade animals	Farmers Farmers
	Conclusion No 8.1-8.8: Nodes with the highest out-degree values within the poultry and pig networks in PNG, Solomon Islands, Vanuatu and Fiji were identified	**Recommendation E:** Extending the survey to other areas would help to give a more complete and accurate description and understanding of the networks in place in these countries **Recommendation F:** This study should be replicated to other species for assessing more precisely the way a disease with various potential hosts would potentially spread within the PICTs	PICTs animal health authorities (at national and local levels) PICTs animal health authorities (at national and local levels)
	Conclusion No 9: The highest increase in trade reported by pig and poultry farmers of the four FABN countries is associated with Christmas and New Year celebrations in December and January. In PNG, poultry farmers also have an increase in trade from April/May to October/November, related to the Coffee season	**Recommedation T:** Scarce resources allocated to the surveillance of pig and poultry diseases in the PICTs should be used in priority over December-January and additionally from April/May to October November for poultry disease surveillance in PNG	PICTs animal health authorities (at national and local levels)

Table 7-1 (cont'): Recommendations cross-referenced to the conclusions of the research and targets for implementation

METHODS	CONCLUSIONS	RECOMMENDATIONS	TARGETS
Chapter 5 Combined market chain and risk pathway analysis	**Conclusion No 10:** A combined market chain and risk pathway analysis provides a practical framework for communicating risk to animal health officials and improving biosecurity	**Recommendation I:** Continuous communication about the risks should be carried out with key stakeholders	Key stakeholders (from both public and private sectors, at regional, national and local levels)
	Conclusion No 11: Legal trade of animals and animal products appear to rely essentially on preventive measures put in place in the exporting countries while no or only limited control measures are undertaken in-country	**Recommendation R:** National staff involved in import control on animal diseases and their potential impact if they were to be introduced should be further trained to assist them in better understanding the trading regulations in place in their country and better evaluating the role of his/her duties as part of the control system.	Quarantine / Biosecurity officers
	Conclusion No 12: Illegal introduction of hidden goods within a legal trade was unanimously perceived as the highest risk for the PICTs	**Recommendation S:** Random checks of imported commodities should be set up at the ports of entry together with random visual checks of live animals	Quarantine / Biosecurity officers
	Conclusion No 13: Commercial farms were found to be supplying the majority of the local poultry smallholders and to play a key role in the legal importations of animal and animal products	**Recommendation Q:** Surveillance programmes should target commercial farms as a priority to increase the chances of detection of a contagious disease, should one be introduced and spread within the PICTs	Animal health authorities (at national and local levels)
	Conclusion No 14: Swill feeding was identified as a significant risk factor for dissemination of pathogens to susceptible species	**Recommendation M:** Proper treatment of the swill (sufficiently cooked) or limiting use of introduced swill from vessels and introduced foodstuff should be advocated among the pig farmers	Farmers

CONCLUSION

The results of our research led to a better understanding of the significance and spread of livestock diseases within the Pacific Islands region. Along with the risk factors and risk hotspots identified in the study, this information provides some insights for better targeted livestock disease surveillance and biosecurity priorities within the Pacific Island countries and territories.

The work conducted in this study provides a practical framework for PICTs to use and replicate in the future for a more rational and transparent allocation of scarce resources towards animal disease prevention and control. Limitations and gaps identified through our research work should however be addressed first.

With increasing globalization across the world, local, regional and international movements of people, animals and goods represent increased risks of spread of pathogens. Hopefully the Pacific Islands region will continue benefiting from its current animal disease free status. The results presented here in this thesis will assist PICTs be better prepared should a major infectious animal disease outbreak occur in the region in the future.

REFERENCES

Bhatia, R., Narain, J.P., 2010. Review paper: the challenge of emerging zoonoses in Asia pacific. Asia-Pac. J. Public Health 22, 388-394.

Cookson, B., 2009. AQIS surveillance for exotic animal pests and diseases in coastal northern Australia. Australian Veterinary Association.

FAO, 1998. Grazing Livestock in the Southwest Pacific., in: FAO (Ed.), FAO Sub-Regional Office for the Pacific, Apia. Samoa.

Guerrier, G., Foster, H., Metge, O., Chouvin, C., Tui, M., 2013. Cultural contexts of swine-related infections in Polynesia. Clin. Microbiol. Infect. 19, 595-599.

Gummow, B., 2014. Establishing a Food Animal Biosecurity Network, Australian Government - AusAID, Public sector linkages program - Activity completion report. James Cook University, Townsville, 4811, QLD, Australia.

Jeggo, M.H., 2000. An International Approach to Laboratory Diagnosis of Animal Diseases. Ann. N. Y. Acad. Sci. 916, 213-221.Murray, N., MacDiarmid, S.C., Wooldridge, M., Gummow, B., Morley, R.S., Weber, S.E., Giovannini, A., Wilson, D., 2004. Handbook on Import Risk Analysis for Animals and Animal Products: introduction and qualitative risk analysis. OIE, 12, rue de Prony, 75017 Paris, France.

NSW government, 2010. Surveillance at ports to keep bee pests out. http://www.dpi.nsw.gov.au/content/archive/agriculture-today-stories/ag-today-archives/september-2010/keep-bee-pests-out (accessed 06 May 2016).

Plant Health Australia, 2016. National Bee Pest Surveillance Program. http://www.planthealthaustralia.com.au/national-programs/national-bee-pest-surveillance-program/ (accessed 09 May 2016).

Secretariat of the Pacific Community, 2009. Livestock in the Pacific, Policy Brief. Secretariat of the Pacific Community, BP DS, 98848 Noumea Cedex, New Caledonia.

Swallow, R., 2012. Risk of Foot-and-Mouth Disease for the Pacific NorthWest Economic Region. Transbound. Emerg. Dis. 59, 344-352.

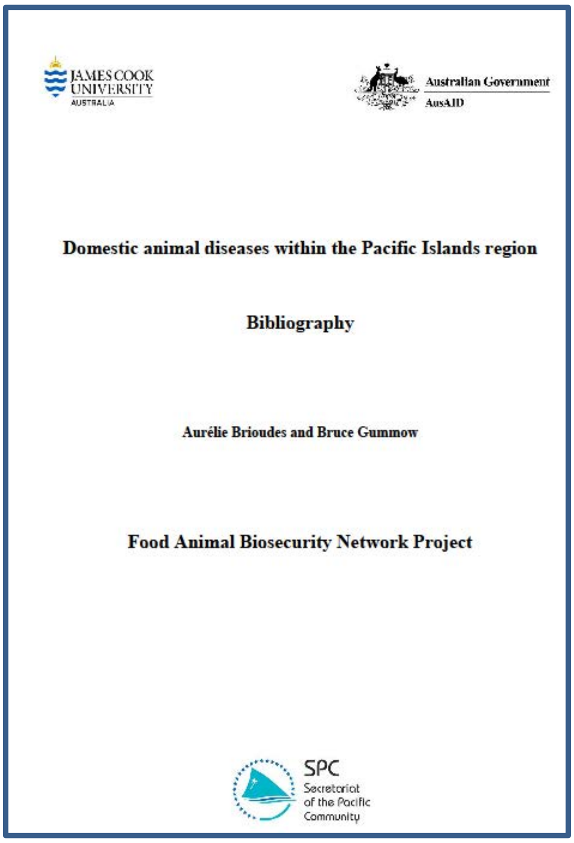
APPENDICES

APPENDIX 1

BIBLIOGRAPHY ON DOMESTIC ANIMAL DISEASES WITHIN THE PACIFIC ISLANDS REGION

REFERENCE:

Brioudes, A., Gummow, B., 2013. Domestic animal diseases within the Pacific Islands region. Bibliography. Secretariat of the Pacific Community, Suva Regional Office, Suva, Fiji.



JAMES COOK UNIVERSITY AUSTRALIA

Australian Government AusAID

Domestic animal diseases within the Pacific Islands region

Bibliography

Aurélie Brioudes and Bruce Gummow

Food Animal Biosecurity Network Project

SPC Secretariat of the Pacific Community

APPENDIX 2

TEMPLATE FOR THE PRIORITIZATION OF ANIMAL DISEASES IN THE PACIFIC ISLANDS AT THE REGIONAL LEVEL

No	Animal diseases in Pacific Island region	Affected Species	Criteria 1: Occurrence in live animals in the Pacific Islands region (MEDIAN)	Criteria 2: Potential severity of the disease for animals (MEDIAN)	Criteria 3: Occurrence in humans in the Pacific Islands region (MEDIAN)	Criteria 4: Potential severity of the disease for humans (MEDIAN)	Criteria 5: Epidemic potential (threat of spread) among animals in the Pacific Islands region (MEDIAN)	Criteria 6: Effectiveness of animal surveillance system in the Pacific Islands region (MEDIAN)	Criteria 7: Potential economic impact of the disease on the local / national trade in the Pacific Islands region (MEDIAN)	Criteria 8: Potential economic impact of the disease on the regional/international trade in the Pacific Islands region (MEDIAN)	Criteria 9: Potential impact of the disease on the farmers' livelihood in the Pacific Islands region (MEDIAN)	Criteria 10: Potential impact of the disease on the food supply in the Pacific Islands region (impact on consumers/community) (MEDIAN)	Total scoring	Ranking
1	Actinomycosis	Animals												
2	Akabane virus	Cattle												
3	American foulbrood	Bees												
4	Amoeba disease (Malpighamoeba)	Bees												
5	Anaplasmosis	Cattle, Buffalos												
6	Anthrax	Animals,HUMAN												
7	Aujeszky's disease	Pigs, Dogs												
8	Avian chlamydiosis	Poultry, Pigeons												
9	Avian encephalomyelitis	Poultry												
10	Avian infectious bronchitis	Poultry												
11	Avian infectious laryngotracheitis	Poultry												
12	Avian leukosis	Poultry												
13	Avian malaria	Poultry												
14	Avian mycoplasmosis (M. Synoviae)	Poultry												
15	Avian spirochaetosis	Poultry												
16	Babesiosis	Cattle												
17	Balantidium	Pigs												
18	Bartonellae	Cats, Cattle,												
19	Black queen cell virus	Bees												
20	Blackleg	Animals												
21	Bluetongue	Ruminants												
22	Botulism	Animals												
23	Bov. genital campylobacteriosis	Cattle												
24	Bovine ephemeral fever	Cattle												
25	Bovine leukosis	Cattle												
26	Bovine virus diarrhea (BVD)	Cattle												
27	Brucellosis	Animals,												

No	Animal diseases in Pacific Island region	Affected Species	Criteria 1: Occurrence in live animals in the Pacific Islands region (MEDIAN)	Criteria 2: Potential severity of the disease for animals (MEDIAN)	Criteria 3: Occurrence in humans in the Pacific Islands region (MEDIAN)	Criteria 4: Potential severity of the disease for humans (MEDIAN)	Criteria 5: Epidemic potential (threat of spread) among animals in the Pacific Islands region (MEDIAN)	Criteria 6: Effectiveness of animal surveillance system in the Pacific Islands region (MEDIAN)	Criteria 7: Potential economic impact of the disease on the local / national trade in the Pacific Islands region (MEDIAN)	Criteria 8: Potential economic impact of the disease on the regional/international trade in the Pacific Islands region (MEDIAN)	Criteria 9: Potential impact of the disease on the farmers' livelihood in the Pacific Islands region (MEDIAN)	Criteria 10: Potential impact of the disease on the food supply in the Pacific Islands region (impact on consumers/community) (MEDIAN)	Total scoring	Ranking
28	Canine distemper virus	Dogs												
29	Caprine arthritis/encephalitis	Goats												
30	Caseous lymphadenitis	Small ruminants												
31	Chalkbrood (fungus)	Bees												
32	Chlamydiosis	Crocodiles,												
33	Chronic paralysis virus	Bees												
34	Classical swine fever	Pigs												
35	Clostridial infections	Goats												
36	Coccidiosis	Animals												
37	Commensal and opportunistic bacteria, including Salmonella spp.	Birds												
38	Contagious ophthalmia	Small ruminants												
39	Contagious pustular dermatitis	Small ruminants												
40	Crocodylocapillaria longiovata	Crocodiles												
41	Cysticercosis	Dogs, Pigs,												
42	Dermatophilosis	Cattle, Goats												
43	Dirofilariasis	Cats, Dogs												
44	Echinococcosis/hydatidosis	Dogs, Sheep,												
45	Ectoparasites	Animals												
46	Ehrlichia canis	Dogs												
47	Endoparasites	Animals ??												
48	Entamoeba polecki	Pigs												
49	Enterotoxaemia	Animals												
50	Enterovirus encephalomyelitis	Pigs												
51	Enzootic bovine leukosis	Cattle												
52	Enzootic pneumonia	Pigs												
53	Epizootic haemorrhagic disease	Deers												
54	Equine coital exanthema	Horses												
55	Equine Herpes virus	Horses												
56	Equine infectious anaemia	Horses												

No	Animal diseases in Pacific Island region	Affected Species	Criteria 1: Occurrence in live animals in the Pacific Islands region (MEDIAN)	Criteria 2: Potential severity of the disease for animals (MEDIAN)	Criteria 3: Occurrence in humans in the Pacific Islands region (MEDIAN)	Criteria 4: Potential severity of the disease for humans (MEDIAN)	Criteria 5: Epidemic potential (threat of spread) among animals in the Pacific Islands region (MEDIAN)	Criteria 6: Effectiveness of animal surveillance system in the Pacific Islands region (MEDIAN)	Criteria 7: Potential economic impact of the disease on the local / national trade in the Pacific Islands region (MEDIAN)	Criteria 8: Potential economic impact of the disease on the regional/international trade in the Pacific Islands region (MEDIAN)	Criteria 9: Potential impact of the disease on the farmers' livelihood in the Pacific Islands region (MEDIAN)	Criteria 10: Potential impact of the disease on the food supply in the Pacific Islands region (impact on consumers/community) (MEDIAN)	Total scoring
57	Equine Influenza A	Horses											
58	Equine leucoencephalomalacia	Horses											
59	Equine rhinopneumonitis	Horses											
60	Equine viral arteritis	Horses											
61	European foulbrood	Bees											
62	Fasciolosis	Ruminants											
63	Filariosis	Animals											
64	Foot and Mouth disease	Pigs, Cattle,											
65	Foot-rot	Ruminants											
66	Fowl cholera	Poultry											
67	Fowl pox	Poultry											
68	Getah virus	Horses											
69	Halfmoon disorder (nutritional /genetic?)disorder)	Bees											
70	Heat-stable enterotoxin II-producing enterotoxigenic E. coli	Pigs											
71	Hendra virus[Henipavirus)	Bats, (Horses)											
72	Henipavirus[Hendra and Nipah)	Bats, (Pigs)											
73	Hepatitis E virus	Pigs											
74	Highly Path. Avian influenza (HPAI)	Poultry, HUMANS											
75	Inf. Bov. Rhinotracheit. (IBR/IPV)	Cattle											
76	Infec. bursal disease (Gumboro)	Poultry											
77	Infectious bovine rhinotracheitis (IBR)	Cattle											
78	Infectious coryza	Poultry											
79	Japanese encephalitis virus	Horses (											
80	Johne's disease	Cattle, Goats											
81	Kashmir bee virus	Bees											
82	Leishmaniosis	Dogs											
83	Leptospirosis	Animals,											
84	Listeriosis	Animals											
85	Low pathogenic avian influenza	Poultry											

No	Animal diseases in Pacific Island region	Affected Species	Criteria 1: Occurrence in live animals in the Pacific Islands region (MEDIAN)	Criteria 2: Potential severity of the disease for animals (MEDIAN)	Criteria 3: Occurrence in humans in the Pacific Islands region (MEDIAN)	Criteria 4: Potential severity of the disease for humans (MEDIAN)	Criteria 5: Epidemic potential (threat of spread) among animals in the Pacific Islands region (MEDIAN)	Criteria 6: Effectiveness of animal surveillance system in the Pacific Islands region (MEDIAN)	Criteria 7: Potential economic impact of the disease on the local / national trade in the Pacific Islands region (MEDIAN)	Criteria 8: Potential economic impact of the disease on the regional/international trade in the Pacific Islands region (MEDIAN)	Criteria 9: Potential impact of the disease on the farmers' livelihood in the Pacific Islands region (MEDIAN)	Criteria 10: Potential impact of the disease on the food supply in the Pacific Islands region (impact on consumers/community) (MEDIAN)	Total scoring	Ranking
86	Marek's disease	Poultry												
87	Melioidosis	Animals												
88	Murray Valley encephalitis virus	Poultry												
89	Mycoplasma spp.	Goats, Poultry												
90	Mycoplasmosis (M. Gallisepticum)	Poultry												
91	Myxomatosis	Rabbits												
92	Newcastle disease	Poultry												
93	Nosemosis	Bees												
94	Other avian salmonellosis	Poultry												
95	Other pasteurelloses	Poultry												
96	Ovine epididymitis (B.ovis)	Sheep												
97	Parvovirus	Dogs, Pigs												
98	Pasteurella spp.	Goats												
99	Plasmodium	Birds												
100	Porcine reproductive respiratory syndrome (PRRS)	Pigs												
101	Porcine rotavirus	Pigs												
102	Psittacosis	Poultry												
103	Q fever	Cattle, Sheep,												
104	Rabbit haemorrhagic disease	Rabbits												
105	Rabies	Animals,												
106	Ross River virus	Animals												
107	Rubulavirus	Bats												
108	Sacbrood virus	Bees												
109	Salmonellosis	Poultry, Sheep												
110	Serpulina pilosicoli	Dogs, Pigs,												
111	Sheep mange	Sheep												
112	Shiga-like toxin I-producing E. Col	Cattle												
113	Simbu serogroup	Cattle												
114	Small hive beetle infestation	Bees												

No	Animal diseases in Pacific Island region	Affected Species	Criteria 1: Occurrence in live animals in the Pacific Islands region (MEDIAN)	Criteria 2: Potential severity of the disease for animals (MEDIAN)	Criteria 3: Occurrence in humans in the Pacific Islands region (MEDIAN)	Criteria 4: Potential severity of the disease for humans (MEDIAN)	Criteria 5: Epidemic potential (threat of spread) among animals in the Pacific Islands region (MEDIAN)	Criteria 6: Effectiveness of animal surveillance system in the Pacific Islands region (MEDIAN)	Criteria 7: Potential economic impact of the disease on the local / national trade in the Pacific Islands region (MEDIAN)	Criteria 8: Potential economic impact of the disease on the regional/international trade in the Pacific Islands region (MEDIAN)	Criteria 9: Potential impact of the disease on the farmers' livelihood in the Pacific Islands region (MEDIAN)	Criteria 10: Potential impact of the disease on the food supply in the Pacific Islands region (impact on consumers/community) (MEDIAN)	Total scoring	Ranking
115	Strangles	Horses												
116	Streptococcus suis type 1	Pigs												
117	Subcutaneous filarial worm	Pigeons												
118	Surra/Trypanosomosis	Animals												
119	Swine erysipelas	Pigs												
120	Swine influenza	Pigs												
121	Tetanus	Goats, Pigs												
122	Theileriosis	Cattle												
123	Toxoplasmosis	Animals,												
124	Transmissible gastroenteritis (TGE)	Pigs												
125	Trichinellosis	Crocodiles, Pigs												
126	Trichomonosis	Animals												
127	Tropilaelaps infestation	Bees												
128	Tuberculosis	Cattle, HUMANS												
129	Varroosis	Bees												
130	Vesicular stomatitis	Cattle, Goats,												
131	Vibrionic dysentery	Pigs												
132	Wax moth	Bees												

APPENDIX 3

QUESTIONNAIRE FOR THE PRIORITIZATION OF ANIMAL DISEASES IN THE PACIFIC ISLANDS AT THE COUNTRY LEVEL

Food Animal Biosecurity Network Project

Survey on animal diseases in the Pacific Island region

The aim of this study is to identify and rank animal diseases of importance for each pilot islands of the FABN project.

The main point of this survey is to **collect information from animal health experts and staff from the region** who have an experience and some practical knowledge about the animal health field situation that might not be captured into the published literature or now be out of date. Therefore, you are invited to complete the attached **questionnaire based on <u>your knowledge and experience</u> of livestock diseases <u>in your country</u>.**

In the following survey, you will be asked to answer a series of questions for 20 animal diseases pre-selected based on the results of a similar survey which has recently been conducted at the regional level with the participation of Animal Health experts from SPC.

Should you not have enough experience and/or knowledge about one of these diseases, answer "no" to the question about your "confidence" for answering questions about this disease. **However, the more diseases you can provide information on in this survey, the better.**

If you think that one or several other important disease(s) in your country should be included in this questionnaire, please detail which disease(s) and answer the series of questions at the end of this survey (See the end of the section "ANIMAL DISEASES").

Notes on completing this survey form using Microsoft Word ver 97-2003 or later.

- Your answers can be entered in the highlighted area. This area will expand to fit your answer. When highlighted, any text in the box will be deleted as you type or you can click in the answer area to edit an earlier response.
- Use the TAB (Shift+TAB to go backwards) or mouse to move between questions. Use the mouse to select options in checkboxes or drop down lists.
- You can save and change / edit your responses to the survey as required.

PERSONAL INFORMATION:

Name:	
Gender:	☐ Female ☐ Male
Job Title / Position:	
Organization:	
Address:	City/Town: Province: Country:
Contact details:	Email address: Phone number:

EDUCATION AND PROFESSIONAL BACKGROUND:

What is your highest education qualification?	☐ Primary school ☐ High school ☐ Tertiary ☐ Bachelor ☐ Master ☐ PhD ☐ Other:
In what field did you study?	☐ Veterinary sciences ☐ Animal health ☐ Animal production ☐ Agriculture ☐ Other:
How many years of working experience do you have so far on this field?	

LIVESTOCK SECTOR:

According to your experience and knowledge, what are the most important livestock productions in your country?

(Cross ☐ where appropriate in the table below)

Livestock productions	1st most important	2nd most important	3rd most important	4th most important	5th most important
Bees	☐	☐	☐	☐	☐
Cats	☐	☐	☐	☐	☐
Cattle (beef)	☐	☐	☐	☐	☐
Cattle (dairy	☐	☐	☐	☐	☐
Crocodiles	☐	☐	☐	☐	☐
Deers	☐	☐	☐	☐	☐
Dogs	☐	☐	☐	☐	☐
Goats	☐	☐	☐	☐	☐
Horses	☐	☐	☐	☐	☐
Pigs	☐	☐	☐	☐	☐
Pigeons	☐	☐	☐	☐	☐
Poultry	☐	☐	☐	☐	☐
Sheep	☐	☐	☐	☐	☐

Comment (optional):

LIVESTOCK DISEASES:

According to your experience and knowledge, what are the most important livestock diseases for your country (being livestock diseases present in your country OR diseases that could potentially be introduced in your country):

Most important disease 1:

Most important disease 2:

Most important disease 3:

Most important disease 4:

Most important disease 5:

ANIMAL DISEASES:

The same series of 10 questions are to be completed below for the 20 pre-selected diseases. At the end of this section, you can suggest other diseases that you consider as important and that should be included in this survey. In that case, please complete the same series of 10 questions. A comment section is created for each disease to give you the opportunity to provide more details or any clarification you would like to add. Please be aware that a disease might not be present in your country (i.e Occurrence is Nil) but has the potential to create an economical or social impact if it was to be introduced in your country.

DISEASE 1: Anthrax

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 2: Avian infectious laryngotracheitis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 3: Brucellosis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

<u>DISEASE 4:</u> Classical swine fever

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

<u>Comment:</u>

<u>DISEASE 5:</u> Ectoparasites (External parasites)

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

<u>Comment:</u>

DISEASE 6: Endoparasites (Internal parasites)

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

<u>DISEASE 7:</u> Foot-and-mouth disease

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

<u>Comment:</u>

DISEASE 8: Fowl pox

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 9: Highly pathogenic avian influenza (HPAI)

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 10: Infectious bursal disease (Gumboro)

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 11: Infectious coryza

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

<u>DISEASE 12:</u> Leptospirosis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community)**?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

<u>Comment:</u>

<u>DISEASE 13:</u> Marek's disease

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

<u>Comment:</u>

DISEASE 14 : Newcastle disease

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 15: Porcine reproductive respiratory syndrome (PRRS)

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 16 : Rabies

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 17 : Salmonellosis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 18 : Tuberculosis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 19 : Varrosis

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community)**?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

DISEASE 20 : Vibrionic dysentery

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

Please complete the table below for the livestock diseases you identified as the most important in your country in Page 3 of this questionnaire (only if the diseases you identified are not part of the previous list of 20 diseases from page 4 to 23).

YOUR PRIORITY DISEASE: ………………

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

Please complete the table below for the livestock diseases you identified as the most important in your country in Page 3 of this questionnaire (only if the diseases you identified are not part of the previous list of 20 diseases from page 4 to 23).

YOUR PRIORITY DISEASE: ……………….

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

Please complete the table below for the livestock diseases you identified as the most important in your country in Page 3 of this questionnaire (only if the diseases you identified are not part of the previous list of 20 diseases from page 4 to 23).

YOUR PRIORITY DISEASE: ....

Do you feel you confident enough for answering questions about this disease in your country?

☐ No: Go to the next disease section;

☐ Yes: Please answer the questions below

1/ What is the **occurrence** of this disease in live **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
2/ What is or what would be the **severity** of the disease for **animals** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
3/ What is the **occurrence** of this disease in **humans** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
4/ What is or what would be the **severity** of this disease for **humans** in your country?	☐ Nil ☐ Weak ☐ Moderate ☐ Severe ☐ No opinion
5/ What is the **epidemic potential (threat of spread**) of this disease among **animals** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
6/ What is the **effectiveness of animal surveillance system** for this disease in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
7/ What is the potential **economic impact** of this disease on **the local / national trade** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
8/ What is the potential **economic impact** of the disease on the **regional / international** trade in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
9/ What is the potential **impact of the disease on the farmers' livelihood** in your country?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion
10/ What is the potential **impact of the disease on the food supply** in your country **(impact on consumers/community**)?	☐ Nil ☐ Low ☐ Moderate ☐ High ☐ No opinion

Comment:

APPENDIX 4

TEMPLATE FOR THE PRIORITIZATION OF ANIMAL DISEASES IN THE PACIFIC ISLANDS BY PARAVETS

Paravet questionnaire on livestock diseases

PERSONAL INFORMATION:

Name:	
Gender:	☐ Female ☐ Male
Job Title / Position:	
Organization:	
Address:	City/Town: Province: Country:
Contact details:	Email address: Phone number:

EDUCATION AND PROFESSIONAL BACKGROUND:

What is your highest education qualification?	☐ Primary school ☐ High school ☐ Tertiary ☐ Bachelor ☐ Master ☐ PhD ☐ Other:
In what field did you study?	☐ Veterinary sciences ☐ Animal health ☐ Animal production ☐ Agriculture ☐ Other:
How many years of working experience do you have so far on this field?	

Q1- In your point of view, what are the most important diseases threatening the livestock in your area? *It can be diseases present in your area or disease absent of your area.. If you don't know the name of the disease, write down the signs of diseases observed on animals.*

-

-

-

Q2 - Based on your knowledge and experience, what diseases have been occurring on livestock in your area in the previous 12 months? *If you don't know the disease name, write down the signs observed.*

-

-

-

Q3 – Among the list of diseases in the table below please indicate the diseases your already heard about (Cross ☒ where appropriate)

- ☐ Anthrax
- ☐ Avian infectious laryngotracheitis
- ☐ Brucellosis
- ☐ Classical swine fever
- ☐ Ectoparasites
- ☐ Endoparasites
- ☐ Foot and Mouth disease
- ☐ Fowl pox
- ☐ Highly Pathogenic Avian influenza (HPAI)
- ☐ Infec. bursal disease (Gumboro)
- ☐ Infectious coryza
- ☐ Leptospirosis
- ☐ Marek's disease
- ☐ Newcastle disease
- ☐ Porcine reproductive respiratory syndrome (PRRS)
- ☐ Rabies
- ☐ Salmonellosis
- ☐ Tuberculosis
- ☐ Varroosis
- ☐ Vibrionic dysentery

Q4 – Among the list of diseases in the table below please the diseases you think you would be able to recognise the disease signs on animals if they were to happen in your area (Cross ☒ where appropriate)

- ☐ Anthrax
- ☐ Avian infectious laryngotracheitis
- ☐ Brucellosis
- ☐ Classical swine fever
- ☐ Ectoparasites
- ☐ Endoparasites
- ☐ Foot and Mouth disease
- ☐ Fowl pox
- ☐ Highly Pathogenic Avian influenza (HPAI)
- ☐ Infec. bursal disease (Gumboro)
- ☐ Infectious coryza
- ☐ Leptospirosis
- ☐ Marek's disease
- ☐ Newcastle disease
- ☐ Porcine reproductive respiratory syndrome (PRRS)
- ☐ Rabies
- ☐ Salmonellosis
- ☐ Tuberculosis
- ☐ Varroosis
- ☐ Vibrionic dysentery

APPENDIX 5

DOCUMENT DISTRIBUTED TO WORKSHOP PARTICPANTS FOR THE DISEASE RISK ASSESSMENT

Import risk analysis for animal and animal products

Objective:

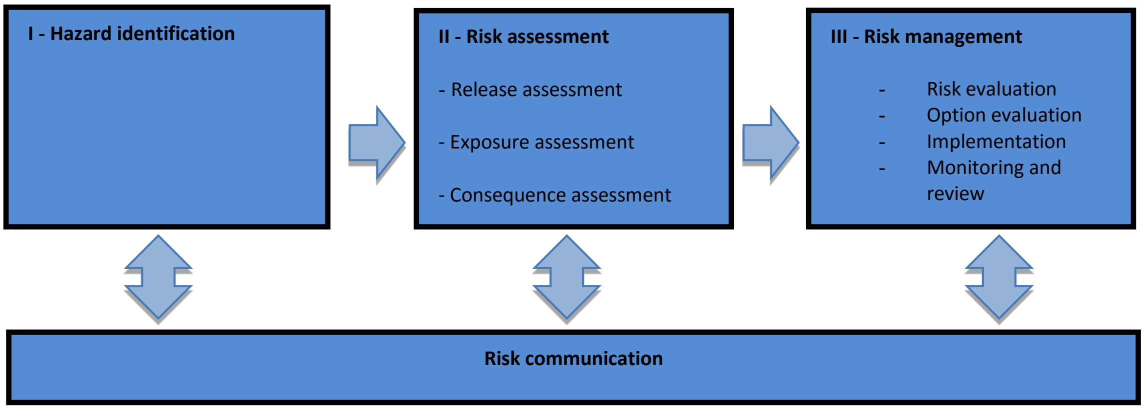
- To identify and describe the different risk pathways pig/poultry diseases might be introduced in The PICTs.
- To assess the likelihood of introduction of Pig/Poultry diseases and its likely consequences as a result of legal or illegal importation of live pigs or pig products.

Possible routes by which pig/poultry diseases may enter in the PICTs:

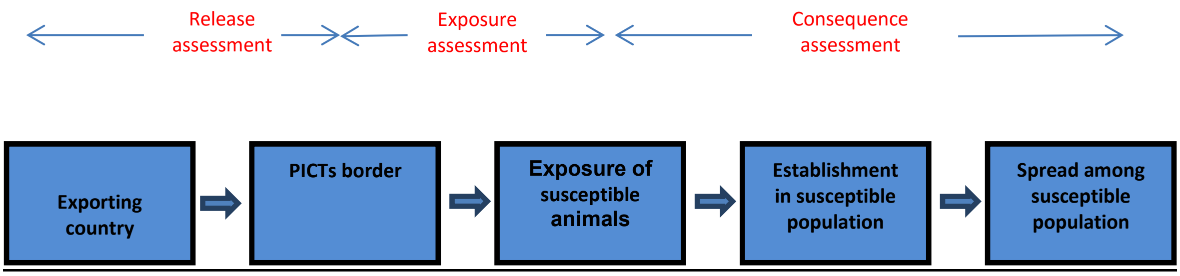
- Infected live pig/poultry (legal and illegal trade)
- Infected pig/poultry products (legal and illegal trade)
- Infected wild pig/bird
- Virus-contaminated vehicles / Fomites
- Airborne transmission (when relevant, FMD for example)

Overall risk assessment:

OIE risk analysis framework for import of animals and animal products:



Components of a risk assessment:



Risk Assessment:

- **Risk of release:** Estimation of overall probability along the risk pathways to trace the method by which a pathogen reaches a production site;
- **Risk of exposure:** Estimation of the degree of exposure based on relevant factors:
    - *Biological factors:* Susceptibility of animals likely to be exposed, means of transmission, infectivity, virulence and stability of potential hazards, route of infection, outcome of infection;
    - *Country factors:* Presence of potential intermediate hosts or vectors, animal and human demographics, farming and husbandry practices, customs and cultural practices, geographical and environmental characteristics;
    - *Commodity factors: Volume of commodity flow, number of times the risk pathway is active,* intended use of imported animal, waste disposal practices, quantity of commodity to be imported.
- **Consequences:** Estimation of the potential impact of the disease introduction based on:
    - Direct consequences: outcome of the infection in domestic and wild animals
        - The potential for amplification of infection (size of any resulting outbreak);
        - The potential for spatial spreading (spread to new geographic areas);
        - The potential for spread across species (spread to other species or to human);
        - The potential for humanitarian losses (loss of livelihoods, loss of human lives).
    - Economic losses (as a result of the outbreak itself and of the control and eradication costs, surveillance costs, potential trade losses (embargoes, sanctions and lost market opportunities);
    - Environmental impacts (amenity values, social, cultural and aesthetic conditions)

Risk estimation: integrating the results of the release assessment, exposure assessment and consequence assessment to produce overall measures of risks associated with the hazards identified.

Risk estimation = [(Risk of release X Risk of exposure) X Consequences]

Table 1: Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition
High	The event would be very likely to occur
Moderate	The event would occur with an even probability
Low	The event would be unlikely to occur
Negligible	The event would almost certainly not occur

Table 2: Combination of risks

	Negligible	**Low**	**Moderate**	**High**
Negligible	Negligible	Negligible	Low	Moderate
Low	Negligible	Low	Moderate	Moderate
Moderate	Low	Moderate	Moderate	High
High	Moderate	Moderate	High	High

Pathogen pathways and *Release scenario diagrams*

LEGAL TRADE

Selection of the exporting country

↓ **R1:** Infection exists at source of live pigs/pig product

Selection of live pigs/pig products

↓ **R2:** Pig/pig products selected for shipment are infected

Export procedures in the exporting country

↓ **R3:** Infected pigs/pig products are not detected by health inspection in the exporting country

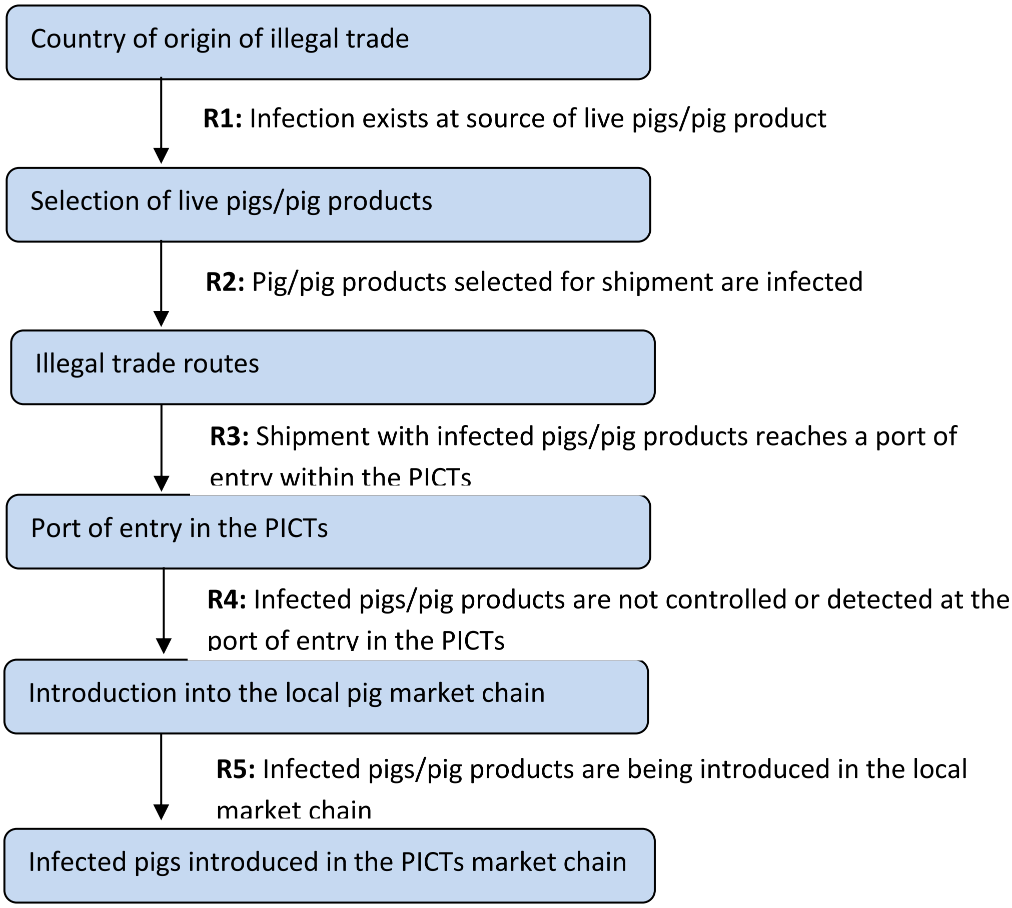
Import procedures in the PICT

↓ **R4:** Infected pigs/pig products are not detected at the control post in the PICTs

Infected pigs introduced in the PICTs market chain

Release assessment = R1 x R2 x R3 x R4

ILLEGAL TRADE



Release assessment = R1 x R2 x R3 x R4 X R5

APPENDIX 6

HIGHLY PATHOGENIC AVIAN INFLUENZA RISK ASSESSMENT TEMPLATE

Qualitative risk analysis framework for introduction of HPAI in the Pacific Island Countries and Territories

Outbreak scenarios:

1. **Legal importation of live poultry**
2. **Illegal introduction of live poultry**
3. **Legal importation of poultry product**
4. **Illegal introduction of poultry product**
5. **Introduction of infected wild poultry**
6. **Introduction of virus-contaminated vehicles / fomite**

1. Legal importation of live poultry

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of live poultry	Depends on the location of the source		
R2. Poultry selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Infected poultry are not detected by health inspection in the exporting country	Depends on application of regulations by veterinary authorities and on ease of detection		
R4. Infected poultry are not detected at the control post in the PICTs **Risk of release**	Depends on operation and facilities at border and on route taken		

Risk assessment steps	**Risk factors**	**Relevant information from the PICTs**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors:* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

2. Illegal introduction of live poultry

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of live poultry	Depends on the location of the source		
R2. Poultry selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Shipment with Infected poultry reaches a port of entry within the PICTs	Depends on distances with the source and means of transport used		
R4. Infected poultry are not controlled or detected at the port of entry in the PICTs	Depends on the access to uncontrolled port of entry		
R5. Infected poultry are being introduced in the local market chain **Risk of release**	Depends on prices and local demand for live poultry/poultry products		

Risk assessment steps	**Risk factors**	**Relevant information from PICT**	**Risk estimation**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors:* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

3. Legal importation of poultry products (meat, whole carcasses, eggs, hatching eggs)

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of poultry products	Depends on the location of the source		
R2. Poultry products selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Infected poultry products are not detected by health inspection in the exporting country	Depends on application of regulations by veterinary authorities and on ease of detection		
R4. Infected poultry products are not detected at the control post in the PICTs **Risk of release**	Depends on operation and facilities at border and on route taken		

Risk assessment steps	**Risk factors**	**Relevant information from PICT**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

4. Illegal introducion of poultry products (meat, whole carcasses, eggs, hatching eggs)

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of poultry products	Depends on the location of the source		
R2. Poultry products selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Shipment with Infected poultry products reach a port of entry within the PICTs	Depends on distances with the source and means of transport used		
R4. Infected poultry products are not controlled at the port of entry in the PICTs	Depends on the access to uncontrolled port of entry		
R5. Infected poultry are being introduced in the local market chain **Risk of release**	Depends on prices and local demand for live poultry/poultry products		

Risk assessment steps	**Risk factors**	**Relevant information from PICT**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

5. Introduction of infected wild birds

Thanks to their geographic isolation (islands surrounded by the Pacific Ocean), natural introduction of wild poultry in the PICTs is most unlikely to happen.

Risk assessment steps	**Risk factors**	**Relevant information from PICT**	**Risk estimations**
Risk of release	Cf risk pathway analysis		
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

6. Introduction of virus-contaminated vehicles / fomite

Risk assessment steps	**Risk factors**	**Relevant information from PICT**	**Risk estimations**
Risk of release	Cf risk pathway analysis		
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

APPENDIX 7

FOOT-AND-MOUTH DISEASE RISK ASSESSMENT TEMPLATE

Qualitative risk analysis framework for introduction of FMD in the Pacific Island Countries and Territories

<u>Outbreak scenarios:</u>

1. **Legal importation of live pigs**
2. **Illegal introduction of live pigs**
3. **Legal importation of pig meat**
4. **Illegal importation of pig meat**
5. **Introduction of infected wild pigs**
6. **Introduction of virus-contaminated vehicles / fomite**
7. **Air borne transmission of FMD**

7. Legal importation of live pigs

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of live pigs	Depends on the location of the source		
R2. Pig selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Infected pigs are not detected by health inspection in the exporting country	Depends on application of regulations by veterinary authorities and on ease of detection		
R4. Infected pigs are not detected at the control post in the PICTs **Risk of release**	Depends on operation and facilities at border and on route taken		

Risk assessment steps	**Risk factors**	**Relevant information from the PICTs**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors:* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

8. Illegal importation of live pigs

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of live pigs	Depends on the location of the source		
R2. Pig selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Shipment with Infected pigs reaches a port of entry within the PICTs	Depends on distances with the source and means of transport used		
R4. Infected pigs are not controlled or detected at the port of entry in the PICTs	Depends on the access to uncontrolled port of entry		
R5. Infected pigs are being introduced in the local market chain **Risk of release**	Depends on prices and local demand for live pigs/pig products		

Risk assessment steps	Risk factors	Relevant information from SI	Risk estimation
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors:* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

9. Legal importation of pig meat

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of pig products	Depends on the location of the source		
R2. Pig products selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Infected pig products are not detected by health inspection in the exporting country	Depends on application of regulations by veterinary authorities and on ease of detection		
R4. Infected pig products are not detected at the control post in the PICTs **Risk of release**	Depends on operation and facilities at border and on route taken		

Risk assessment steps	**Risk factors**	**Relevant information from SI**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

10. Illegal importation of pig meat

Risk pathway step	Factors influencing the probability (Risk factors)	Relevant information from the PICTs	Probability level
R1. Infection exists at source of pig products	Depends on the location of the source		
R2. Pig products selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection		
R3. Shipment with Infected pig products reach a port of entry within the PICTs	Depends on distances with the source and means of transport used		
R4. Infected pig products are not controlled at the port of entry in the PICTs	Depends on the access to uncontrolled port of entry		
R5. Infected pigs are being introduced in the local market chain **Risk of release**	Depends on prices and local demand for live pigs/pig products		

Risk assessment steps	**Risk factors**	**Relevant information from SI**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

11. Introduction of infected wild pigs

Thanks to their geographic isolation (islands surrounded by the Pacific Ocean), natural introduction of wild pig in the PICTs is most unlikely to happen.

Risk assessment steps	**Risk factors**	**Relevant information from SI**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

12. Introduction of virus-contaminated vehicles / fomite

Risk assessment steps	**Risk factors**	**Relevant information from SI**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

13. Air borne transmission of FMD

Risk assessment steps	**Risk factors**	**Relevant information from SI**	**Risk estimations**
Risk of release	Cf risk pathway analysis	Table above	
Risk of exposure	• *Biological factors* • *Country factors* • *Commodity factors*		
Consequences	• Direct consequences • Economic losses • Environmental impacts		
Overall risk assessment			

General comment:

APPENDIX 8

INFORMATION SHEET ABOUT THE FARMER SURVEY

SPC Secretariat of the Pacific Community

JAMES COOK UNIVERSITY AUSTRALIA

INFORMATION SHEET

Survey on livestock movements and trading practices within the Pacific Island region

The Secretariat of the Pacific Community in association with **James Cook University** and **in-country animal health departments** are currently carrying out a project called the "Food Animal Biosecurity Network" (FABN) in 4 pilot countries of the Pacific Island region: Fiji, PNG, Vanuatu and the Solomon Islands.

The main objective of this project is to enhance field animal disease surveillance capacities and one of the project activities consists in a **survey of the livestock (pig and poultry) movements and trading practices within the Pacific Island region**. The objective of this survey is to understand how these activities influence the potential spread of pig and poultry diseases within the Pacific Island countries and territories (PICTs).

This survey is conducted through **questionnaire-based interviews** at different levels: farms, abattoirs and markets, in the 4 pilot PICTs.

As a **pig/poultry farmer** or **pig/poultry product seller** or **pig/poultry middleman**, you are being invited to participate in this survey. This survey should take about 30 minutes of your time. The interview is to be conducted immediately, here or at the closest venue of your choice.

Taking part in **this survey is voluntary** and you are free to decline to answer the any particular question you do not wish to answer without explanation or prejudice.

Your responses and contact details will be strictly confidential. The data from the study will be used in research publications and reports to the Secretariat for the Pacific Community (SPC), James Cook University (JCU) and the Australian Agency for International Development (AusAID). You will not be identified in any way in these publications.

This survey might not benefit you directly but the information learned in **this study should improve the prevention and control of animal diseases in your country.**

If you have any question about this study, feel free to contact Dr Aurelie Brioudes at the Secretariat for the Pacific Community in Suva, FIJI by email: or telephone:

Thank you in advance.

Best regards,

Aurelie Brioudes

APPENDIX 9

FARMER SURVEY QUESTIONNAIRE

FARMER SURVEY

INFORMED CONSENT FORM

This administrative form has been removed

Survey on livestock movements and trading practices within the Pacific Island region

Date of the survey:	
Location	☐ **Fiji** ☐ **PNG** ☐ **Solomon Islands** ☐ **Vanuatu**
Interviewer's name : *(Capital letter)*	
Contact details:	**Telephone:** **Email:**

The survey questionnaire below is divided into 4 parts:

(A) Personal information,
(B) Farm structure,
(C) Trading practices,
(D) Livestock diseases.

A. Personal information

Questions
Q1- Name of the farmer? *(Capital letter)*
Q2- Gender of farmer? ☐ Male ☐ Female
Q3 - Telephone contact of the farmer?
Q4- Locality of the farm? *(Capital letter)* Province: District/Ward: Village:
Q5 – Only if possible, please record the GPS coordinates of the farm:
Q6 - Please detail the residential address of the farmer if it is different from the farm locality: Province: District/Ward: Village:
Q7 - For how many years has the interviewee been a farmer?

B. Farm Structure

Questions (Please fill in or cross ☒ where appropriate)
Q8 - What type of animals do you keep? ☐ **Poultry** , go to question Q9 ☐ Pigs, go to question Q14 **(if the farmer keeps both, complete 2 different questionnaires: one questionnaire for pigs and another one for poultry)**
POULTRY
Q9 - What is the total number of poultry kept in the farm? Please detail for each species: ☐ Chicken: ☐ Ducks: ☐ Pigeons: ☐ Other (Please detail):
Q10 - Please indicate the breed of poultry kept in the farm : ☐ Native Pacific poultry breed (Please detail): ☐ Imported breed (Please detail): ☐ Mixed breed (Please detail): ☐ Other breed (Please detail):
Q11 - Please indicate which categories of poultry are kept in the farm? ☐ **Breeder** (Poultry reared for reproducing), please detail number: ☐**Broiler** (Poultry reared for meat), please detail number: ☐ **Layer** (Poultry reared for eggs), please detail number: ☐ **Other** (Please detail):
Q12 - Please indicate the farm raising system? ☐ Free range poultry farming (with poultry allowed to wander around the village) ☐ Traditional /Semi-intensive poultry farming (with poultry kept in fields or in a small poultry-house) ☐ Large scale / Intensive poultry farming (with poultry kept in confined spaces) ☐ Other (Please detail):
Q13 - Do you mix your flock with animals from other farm(s)? (any animals, not only poultry) ☐ No, go to question Q19 ☐ Yes, please detail the **location** (Province, District/Ward and Village) of other farm(s):

PIGS
Q14 - What is the total number of pigs kept in the farm?
Q15 - Please indicate the breed of pigs kept in the farm: ☐ Native Pacific pig breed (Please detail): ☐ Imported breed (Please detail): ☐ Mixed breed (Please detail): ☐ Other breed (Please detail):
Q16 - Please indicate the categories of pig production kept in your farm? ☐ Breeding, please detail number: ☐ Fattening, please detail number: ☐ Other (Please detail):
Q17 - Please indicate the farm raising system? ☐ Free range pig farming (with pigs allowed to wander around the village) ☐ Traditional / semi/intensive pig farming (with pigs kept in fields or in a small pig-house) ☐ Large scale / intensive pig farming (with pigs kept in a pig-shed / larger pig-house) ☐ Other (Please detail):
Q18 - Do you mix your pig herd with animals from other farm(s)? (any animals, not only pigs) ☐ No ☐ Yes, please detail the location (Province, District/Ward and Village) of the other farm(s):
OTHER SPECIES
Q19 - What are the other species kept on this farm? (Cross ☒ where appropriate) ☐ **Pigs**, please give the total number : ☐ **Poultry**, please give the total number: ☐ **Cattle**, please give the total number: ☐ **Goats**, please give the total number: ☐ **Sheep**, please give the total number: ☐ **Horses**, please give the total number: ☐ **Rabbits**, please give the total number: ☐ **Dogs**, please give the total number: ☐ **Cats**, please give the total number: ☐ **Other**, please detail and give total number:

C. Trading practices

The objective of this section is to describe the type and the frequency of **live animal and animal product movements to the farm** (section "on-farm movements") **and from the farm** (section "off-farm movements").

In this section, **the term "animals" refers to pigs or poultry**, depending on whether the interviewee is raising pigs or poultry.

ON-FARM MOVEMENTS

LIVE ANIMALS

Q20 - During the previous 12 months, did you have any new live animals (pig / poultry) entering your farm?

☐ **No**, go to question Q22

☐ **Yes**, please detail in the table below for <u>each time</u> new animals were entering the herd/flock:

- **Category of animals**: ex: piglet, sow, boar / day old chick, pullets, chicken, ducks ...
- **Origin of animals**: Please detail where these live animals were coming from (Ex: Farm or market ...),
- **<u>Location:</u>** detail where these new animals were coming from (precise location with the Province, District/Ward, village /town),
- **Number of new animals**: total number of new animals entering the herd / flock,
- **Period / Frequency**: detail when or how often the new animals were entering your farm (which month of the year or frequency of live animal supply- ex: once per month or every 3 months...).

Category of animal	Origin of animals	**<u>LOCATION</u> (important field)** *(Province, District/Ward, village / town)*	Number of animals entering the flock	Period of the year or Frequency
•				
•				
•				
•				
•				
•				

<u>Additional comment (if required):</u>

Q21 - Did you use a middleman for purchasing and bringing these new animals into your farm?

☐ **No**

☐ **Yes**, please detail where this middleman is based (location: Province, District/Ward and Village):

ANIMAL PRODUCTS *(refer to material derived from the body of a live animal)*

Q22 - During the previous 12 months, did you bring any of the following animal products into your farm?

Please cross ☒ where appropriate:

- Carcass (dead poultry/pig):................................ ☐ No ☐ Yes
- Offal (organs such as liver, kidney, heart...): ... ☐ No ☐ Yes
- Swill (restaurant left over):................................ ☐ No ☐ Yes
- Waste meat from butcher /slaughterhouse: .... ☐ No ☐ Yes
- Semen for artificial insemination: .... ☐ No ☐ Yes
- Meat and bone meal:... ☐ No ☐ Yes
- Blood:........ ☐ No ☐ Yes
- Bones: .... ☐ No ☐ Yes
- Eggs:.......... ☐ No ☐ Yes
- Skin: .... ☐ No ☐ Yes
- Feathers: ..... ☐ No ☐ Yes
- **Other**, please detail:

If you crossed ☒ Yes for any of the animal products above, please detail in the table below:

- **Category of animal products**: as ticked in boxes above (Ex: carcass, eggs ...)
- **Origin**: Please detail where these animal products were coming from (Ex: Abattoir, market, farmer, hatchery...),
- **Location:** Detail the location where these animal products were coming from (with the Province, District/Ward, village /town).
- **Quantities of animal products**: Total number of animal products entering the farm (ex: 20 egg trays, 10kg of swill ...)
- **Period or Frequency**: detail when or how often these animal products were brought into your farm? (Ex: in January and July or once per semester or every 3 weeks);

Category of animal products	Origin of animal products (Abattoir, market, farmer, hatchery...)	**LOCATION (important field)** *(Province, District/Ward, village / town)*	Quantities of animal products	Period of the year or Frequency
•				
•				
•				
•				
•				
•				

Additional comment (if required):

Q23 -Did you use a middleman for purchasing and bringing these animal products into your farm?

☐ **No**

☐ **Yes**, please detail where this middleman is based? (location: Province, District/Ward and Village):

OFF-FARM MOVEMENTS

LIVE ANIMALS

Q24 - During the previous 12 months, did you sell or give any live animals from your farm?

☐ **No**, go to question Q26

☐ **Yes**, please detail in the table below for <u>each time</u> animals were sold or given:

- **Category of animals**: ex: piglet, sow, boar / day old chick, pullets, chicken, ducks...
- **Destination**: Please detail where these animals were sent to (Ex: Abattoir, slaughter house, market, farm...),
- **<u>Location:</u>** Detail the location where these animals were sent to (precise the Province, District/Ward, village /town),
- **Number of new animals**: total number of animals leaving the herd / flock,
- **Period / Frequency**: detail when or how often animals have been leaving your farm (which month of the year or frequency of live animal selling- ex: in March 2012 or once per month or every 3 months...).

Category of animals	Destination (Ex: Abattoir, market, farmer...)	**<u>LOCATION</u> (important field)** *(Province, District/Ward, village / town)*	Number of animals	Period of the year or Frequency
•				
•				
•				
•				
•				
•				

<u>Additional comment (if required):</u>

Q25 - Did you use a middleman for selling these animals from your farm?

☐ **No**

☐ **Yes**, where is this middleman based? (Please detail the location: Province, District/Ward and Village):

ANIMAL PRODUCTS

Q26 - During the previous 12 months, did you sell or give any of the following animal products from your farm?

Please cross ☒ where appropriate:

- Carcass (dead poultry/pig):.............................. ☐ No ☐ Yes
- Offal (organs such as liver, kidney, heart...): ... ☐ No ☐ Yes
- Meat: .... ☐ No ☐ Yes
- Fat: .... ☐ No ☐ Yes
- Semen for artificial insemination: .... ☐ No ☐ Yes
- Eggs: .... ☐ No ☐ Yes
- Blood:.......... ☐ No ☐ Yes
- Bones: .... ☐ No ☐ Yes
- Skin:........... ☐ No ☐ Yes
- Feathers: ...... ☐ No ☐ Yes
- Manure : ...... ☐ No ☐ Yes
- **Other**, please detail:

If you crossed ☒ Yes for any of the animal products above, please detail in the table below:

- **Category of animal products**: as ticked in boxes above (Ex: carcass, eggs ...),
- **Destination**: detail where these animal products were sent to (Ex: butcher, market, farmer, relative/friend ...),
- **Location**: detail the location where these animal products were sent to (the Province, District/Ward, village /town),
- **Quantities of animal products**: total number of animal products sent off your farm (ex: 2 carcasses, 5 kg of offal...),
- **Period of the year or Frequency**: detail when or how often these animal products were sold and sent off your farm (in March and December or once per month or every 3 months...).

Category of animal products	Destination (Ex: butcher, market, farmer...)	**LOCATION (important field)** *(Province, District/Ward, village / town)*	Quantities of animal products	Period of the year or Frequency
•				
•				
•				
•				
•				
•				

Additional comment (if required):

Q27 – Did you use a middleman for selling these animal products from your farm?

☐ **No**

☐ **Yes**, where is this middleman based? (Please detail the location: Province, District/Ward and Village):

SEASONALITY OF TRADE
Q28 – Are there periods over the year when you sell more live animal or animal products than usual? ☐ No ☐ Yes, please detail the period of the year and the associated occasion if any: (<u>Ex</u>: increased trade of pigs for the "Wedding season"; increased trade of poultry late December –early January for Christmas...)

Categories of animals or animal products (Ex: chickens, piglets, eggs...)	**Periods with increased trade** (Ex: Dec-Jan; Easter...)	**Occasion** (Ex: Christmas, Wedding...)
•		
•		
•		

D. Livestock diseases

Q29 - Based on your knowledge and experience, what are the diseases the most at risk for your herd / flock? *If the farmer doesn't know the name of the disease, write down the signs of diseases observed on animals.*

-
-
-
-
-

Q30 - What measures do you implement for preventing OR controlling diseases among your herd / flock? Please detail the nature of the measures: (in case of vaccination programme, please detail for which diseases).

-
-
-
-
-

Q31 - Did your flock/herd get any disease during the previous 12 months? *If the farmer doesn't know the name of the disease, write down the signs observed.*

☐ No

☐ Yes, please detail

- Which disease(s):
- Was the diagnostic confirmed by laboratory testing for this/these disease(s)? ☐ No ☐ Yes

Q32- Based on your knowledge and experience, what diseases have been occurring on livestock in your village or in the neighbouring villages in the previous 12 months? *If the farmer doesn't know the disease name, write down the signs observed.*

☐ No

☐ Yes, please detail:

-
-
-
-
-

Q33 - When your animals are sick or present abnormal signs, who do you contact for assistance?

☐ You never ask assistance to anyone

☐ Another experienced farmer

☐ Community /village chief

☐ Paravet, please detail his/her location (Province, District/Ward, village):

☐ Government animal health or production staff, please detail his/her location:

☐ Other (please detail):

Q34 - During the previous 12 months, did you ask for assistance from these people for health problems among your herd/flock?

☐ No

☐ Yes, please detail:

- The period when it happened (which months over the past year):
- What kind of health problem it was:

Q35 – During the previous 12 months, did you found any dead animals among your flock/herd?

☐ No

☐ Yes, please detail the approximate total number of dead animals:

Q36 – Usually, what do you do with the carcasses / dead bodies? (Cross ☒ where appropriate)

☐ Burn	☐ Burry	☐ Family consumes	☐ Dog consumes
☐ Sell	☐ Nothing	☐ Other, please detail:	

COMMENT : Please provide any additional comment or detail of relevance from the interview

APPENDIX 10

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL FOR RESEARCH OR TEACHING INVOLVING HUMAN SUBJECTS

This administrative form
has been removed

APPENDIX 11

FINAL REPORT FOR RESEARCH OR TEACHING INVOLVING HUMAN SUBJECTS

This administrative form has been removed

APPENDIX 12

STATEMENT FROM COPYRIGHT OWNERS FOR THE PUBLISHED PAPER "A REVIEW OF DOMESTIC ANIMAL DISEASES WITHIN THE PACIFIC ISLANDS REGION" (CHAPTER 2)

This administrative form
has been removed

APPENDIX 13

STATEMENT FROM COPYRIGHT OWNERS FOR THE PUBLISHED PAPER "DISEASES OF LIVESTOCK IN THE PACIFIC ISLANDS REGION: SETTING PRIORITIES FOR FOOD ANIMAL BIOSECURITY" (CHAPTER 3)

This administrative form has been removed

APPENDIX 14

STATEMENT FROM COPYRIGHT OWNERS FOR THE PUBLISHED PAPER "UNDERSTANDING PIG AND POULTRY TRADE NETWORKS AND FARMING PRACTICES WITHIN THE PACIFIC ISLANDS AS A BASIS FOR SURVEILLANCE" (CHAPTER 4)

This administrative form has been removed

APPENDIX 15

STATEMENT FROM COPYRIGHT OWNERS FOR THE PUBLISHED PAPER "FIELD APPLICATION OF A COMBINED PIG AND POULTRY MARKET CHAIN AND RISK PATHWAY ANALYSIS WITHIN THE PACIFIC ISLANDS REGION FOR TARGETED SURVEILLANCE AND BIOSECURITY" (CHAPTER 5)