Chapter Four:

An outbreak of Very Virulent Infectious Bursal Disease in Solomon Islands chickens, 2023

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Glossary

Batch	A group of birds on a property that are the same age, purchased at the same time for the same production purpose, and housed in the same shed
Bursa of Fabricius	Part of the immune system in chickens, where B cells mature
Cloaca	The single opening at the end of the digestive, urinary and reproductive tracts in some vertebrates including chickens
Layer	A chicken kept for egg production
Meat chicken	A chicken kept until processed for meat production, also known as a broiler
Processed	The slaughter of meat chickens for consumption
Questionnaire	A series of questions used to record data about sampled chickens and farms visited
Survey	Scheduled collection and testing of samples (specimens) from livestock for surveillance purposes, generally to understand “point in time” prevalence of target diseases.
Ward	Administrative area within a province in Solomon Islands

Prologue

Background

This chapter describes an outbreak of very virulent Infectious Bursal Disease (vvIBD) in Solomon Islands chickens. In March 2023, the Pacific Engagement Program for Animal Health (PEPAH) team received an alert of chicken mortality events at several farms in Guadalcanal. The PEPAH team sits within the Office of the Chief Veterinary Officer (OCVO) at the Department of Agriculture, Fisheries and Forestry (DAFF) and works to support the Pacific region achieve improved animal health, production, biosecurity and food security outcomes (1), including through facilitation of animal health surveillance activities in the region. In response to the alert, the PEPAH team worked with the Solomon Islands Ministry of Agriculture and Livestock (MAL) to organise collection of tissue samples from several chickens at affected farms in May 2023. These samples were sent to the Australian Centre for Disease Preparedness (ACDP) for testing and in July 2023 molecular typing identified a very virulent strain of infectious bursal disease virus (vvIBDV).

Infectious bursal disease virus (IBDV) is a highly infectious pathogen that targets the developing immune cells of chickens, causing illness or death in birds typically aged between 3-6 weeks old (2). Viruses such as IBDV present a significant threat to the poultry industry in Solomon Islands, and in July 2023 MAL made an official request for the Australian Government to assist with the investigation. Between July and August 2023, DAFF and MAL staff visited 62 farms across Guadalcanal Island, the location of the provinces Capital Territory (Honiara) and Guadalcanal Province. During these visits, blood samples and oropharyngeal and cloacal swabs were collected from layer chicken batches and meat chicken batches, and farmers were asked if mass mortality events had occurred at their farm. Unlike the tissue samples collected in May 2023, the swabs collected between July and August 2023 did not undergo molecular typing, or any additional genotype PCR testing[1]. The investigation described in this chapter is the first identification of a vvIBDV in Solomon Islands.

The nomenclature surrounding classification of IBDVs is currently undergoing changes. This chapter uses naming conventions for IBDVs commonly used prior to 2024.

My role

In May 2023 I approached Corissa Miller, the Manager of the PEPAH team, to ask if I could assist with the investigation into the mass mortality events in chickens. Corissa welcomed my involvement but noted the Solomon Islands Government would direct any work done by DAFF

[1] Additional genotype PCR testing occurred after initial testing, but results were not available at the time of writing.

for this investigation. This constrained my ability to lead the investigation, including my ability to collect key information and determine which farms were visited. I began working on this investigation in September 2023, as this was when laboratory results for the samples collected between July and August 2023 were received. My role was to analyse epidemiological and laboratory data, including spatial analysis of the locations of farms visited using QGIS. This analysis aimed to describe the outbreak and to identify what, if any, risk factors may have influenced the spread of disease in chicken farms. The work I completed was also used to inform a report authored by the PEPAH team for the Department of Foreign Affairs and Trade (DFAT), outlining the PEPAH teams' achievements in the Pacific region. I also reviewed the literature on IBDV and vvIBDV epidemiology and associated control measures. A timeline of the outbreak investigation and my role is available in Appendix 4A.

I was unable to participate in the field investigation between July and August 2023 for logistical reasons. I joined the PEPAH team on a follow-up livestock survey being conducted in Solomon Islands in June 2024. During this trip, I visited some of the farms that had experienced mortalities and/or shown evidence of exposure to IBDV. I saw first-hand how poultry farms are managed in Guadalcanal, which strengthened my understanding of the unique challenges to responding to animal diseases in Solomon Islands. I also spoke to farmers about their farming practices. This in turn allowed me to develop an understanding of potential mitigation strategies that may help to prevent the spread of vvIBDV. In addition, I assisted the PEPAH team with the data collection for the livestock survey being conducted. The questionnaire used in this survey was similar to the questionnaire used in the July and August 2023 investigation, and assisting with this enhanced my understanding of the data I was analysing and helped me to develop suggestions for how data collection could be improved. More information and reflections about this travel is available in Chapter 6 (Other experiences).

Animal health and public health impact

This outbreak investigation was in response to the first identification of vvIBDV in Solomon Islands. The investigation provided a description of some of the locations of vvIBDV in Guadalcanal and highlighted that biosecurity is important to improving chicken health and production outcomes. Globally, vvIBD is regarded as one of the most significant diseases of chickens due to the economic losses it causes through loss of flocks and decreased output from farms. The reduction of available chicken meat and eggs to sell and consume has a negative impact on food security and the health of farmers, their families and their communities. Sustainable local agriculture and livestock management for food production is essential for food security in lower-middle income countries that rely on subsistence farming, and a healthy, productive poultry industry can help to achieve this. Moreover, chicken meat and eggs are common sources of protein in Solomon Islands, and a lack of protein availability may have adverse effects on children's nutrition. Improved food security also directly aligns with Sustainable Development Goal (SDG) 2 and SDG targets 2.1, 2.2, 2.3, 2.4. These targets all promote sustainable and local agricultural production and access to nutritious food (3) and are available in Appendix 4B. In addition, income loss from loss of flocks and reduced output from farms can also have negative impacts on mental health as people are unable to afford routine living costs. The economic effects of vvIBDV are further explored in the discussion.

This investigation provided an opportunity for the PEPAH team to assist the MAL team to develop skills in investigating outbreaks, as well as in educating smallholder farmers on ways to reduce the risk of vvIBDV and broader biosecurity principles. Furthermore, this investigation helped to identify areas of improvement for animal disease surveillance in Solomon Islands, which may assist in future animal or emerging disease outbreaks. These areas of improvement are elaborated in the discussion.

Lessons learned and reflections

I have experience in public health outbreak investigations from previous roles, but this study was my first introduction to animal health outbreak investigations I found developing appropriate case definitions challenging due to the limited information available for the outbreak investigation and the differences in management of layer and meat chickens. This study also developed my understanding of the importance of economic losses when investigating animal diseases, and how One Health, which recognises the connections between human health, animal health and ecosystem health, can be applied to diseases in animals that do not cause direct illness in humans. I also developed skills in preparing information for the Solomon Islands government and for DFAT. Travelling to Solomon Islands was an invaluable experience and enabled me to gain a greater understanding of the challenges unique to disease investigations in low- and middle-income countries (LMICs), and that there is no "one size fits all" approach to any disease investigations. I also learned about the livestock industry in Solomon Islands, and how important it is to have a thriving, sustainable livestock industry to promote positive animal and human health outcomes. This study extensively developed my skills in using R and R studio, and the figures in this chapter are some of the first I ever produced. I also used QGIS for the first time to complete this study, and I learned about shapefiles, coordinate layers and spatial epidemiology to produce the maps included in this chapter.

Acknowledgements

This study could not have been completed without the assistance and guidance from the following:

- The PEPAH team within OCVO, especially Dan Edson, Corissa Miller, Yushara Wijerathna and Peter Thornber, who coordinated the outbreak investigation, welcomed my working with their team for this project, answered my many questions, and facilitated my trip to Honiara in June 2024.
- Nigel Gillan, who worked as an in-country vet as part of the Australian Volunteers for International Development program run by DFAT and was the first to be alerted to the chicken mortality events.
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- Farmers throughout Guadalcanal who consented to samples and information being collected from their chickens for this investigation.
- ACDP, especially Sandra Sapats and Jianning Wang, who tested all samples collected for the survey from July-August 2023 and subsequent surveys, and also provided information on testing protocols.
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- DFAT, who provided financial support for DAFF, MAL and SPC to investigate the chicken mortality events
- Poultry experts in Australia who provided advice on testing prior to diagnosis of vvIBDV, and mitigation strategies once vvIBDV was confirmed.

Abstract

Background: In July 2023, very virulent infectious bursal disease virus (vvIBDV) was identified in chicken flocks in Solomon Islands for the first time. Viruses such as vvIBDV present a significant threat to the poultry industry in Solomon Islands due to the high mortality and prolonged immunosuppression the virus can cause, leading to significant production and economic losses. In response to the detection of vvIBDV at farms in Guadalcanal, an investigation into the spread of the disease commenced in July 2023.

Methods: Between July and August 2023, cloacal and oropharyngeal swabs and whole blood samples were collected from a sample of birds at selected farms. Swabs were pooled in groups of 3 and tested for infectious bursal disease virus (IBDV), Newcastle disease virus (NDV), and avian influenza virus (AIV) using Polymerase Chain Reaction (PCR). Serum was tested for IBDV using a competitive Enzyme-Linked Immunosorbent Assay (ELISA). A questionnaire asking about flock and/or batch size and history of mortality events was also completed at each farm. Descriptive analysis and logistic regression of the data was conducted using Microsoft Excel and R Studio.

Results: Of the 62 farms visited, 30 (48%) reported recent unexpected deaths in batches of chickens. Of these 31 farms, 24 (77%) showed evidence of infection with IBDV through serology and/or PCR. Layer farms had a higher odds of infection with vvIBDV compared to meat chicken farms (Odds Ratio ─ OR 7.9; 95% CI 1.88 – 32.9). Twelve farms (19%) had 'insufficient information' to determine whether they met the outbreak case definition.

Conclusion: This investigation demonstrated that vvIBDV is present in several areas in Guadalcanal, in both layers and meat chickens. Improving biosecurity on farms through farmer education, frequent cleaning of footwear, and keeping sheds empty for several weeks between batches may reduce the spread of vvIBDV. Although vaccination of flocks against IBDV could be considered, this is known to have limited effectiveness against very virulent strains. Reducing the risk of vvIBDV in Solomon Islands will help to build a sustainable poultry industry, improving economic gains for farmers and overall food security and nutrition for communities.

Introduction

Infectious bursal disease (IBD), also known as Gumboro disease, is a disease of poultry that can cause significant economic losses for the poultry industry and impacts food security globally (2, 4-7). The disease is present around the world and is caused by the infectious bursal disease virus (IBDV) which targets developing immune cells in the bursa of Fabricius in poultry (2, 5, 8). Infection can cause depression, watery diarrhoea, ruffled feathers and death (6, 9, 10). Chickens that survive the acute illness may experience prolonged immunosuppression, reduced growth and production, and increase susceptibility to other avian diseases (7) and to diseases with zoonotic potential, such as campylobacteriosis and associated increased shedding of *Campylobacter* spp.(11).

Infectious bursal disease virus has two subtypes (subtype 1 and subtype 2), but illness in poultry is only caused by subtype 1 (2, 4, 6, 7, 9). Within subtype 1 there are 3 forms of the virus: classical IBDV, variant IBDV, and very virulent IBDV (vvIBDV) (2, 4, 6, 7, 9). These classifications are determined by specific mutations in the genome identifiable through molecular typing or PCRs that target these regions of the genome (Appendix 4C) (2, 5, 7). The most severe form of the virus is vvIBDV, which is associated with mutations in the hypervariable region of the VP2 gene (2, 5, 7). These strains are also characterised by significant flock mortalities of between 50% and 100% (6, 9, 10), though there is some evidence of mortality levels of less than 25% in meat chicken flocks (12, 13) and less than 40% in layer flocks (13). Infected chickens may also show other signs of acute infection and experience prolonged immunosuppression (6, 9, 10).

Infectious bursal disease virus spreads in chickens via the faecal-oral route, and the virus can survive in the environment for long periods of time (6, 8, 10). Vaccination of commercial poultry flocks against IBDV is one of the best measures to reduce poultry losses, however outbreaks of vvIBD have occurred in some vaccinated flocks (14-17). Additionally, there are risks associated with the use of live vaccines, including the potential for the vaccine to revert to a pathogenic form of the virus (2, 7). While IBDV poses no direct threat to human health, given the effect of this disease on food security and livelihoods and its survivability in the environment, IBD is a disease of significance to One Health (7).

Solomon Islands is a network of 992 islands in the Pacific Ocean (18) and Australia is the country's largest development partner (19). In LMICs such as Solomon Islands (20) the uptake of commercial poultry farming can result in a reliable source of income and promote food security (21). The presence of diseases such as vvIBD can therefore result in significant economic losses (21). Once vvIBDV is established, these strains tend to become the most dominant in affected countries (10, 22). It is also difficult to prevent further incursions at farms with a history of infection (12) which can further exacerbate economic losses (23).

This chapter describes an outbreak of vvIBDV in layer and meat chicken farms in Guadalcanal, the country's largest island and location of the capital Honiara. While there is evidence to suggest IBDV has been present in Solomon Islands at least as early as 2016 (24), this outbreak is the first to confirm vvIBDV in Solomon Islands.

Methods

Outbreak identification

In March 2023, the Australian volunteer vet in Solomon Islands was alerted to a mortality event in a chicken flock in Guadalcanal (18, 19). In addition to mortalities, chickens showed signs of weakness, lethargy, and mild, pale diarrhoea (25), leading the vet to make a presumptive diagnosis of inclusion body hepatitis (IBH) (25). In April 2023, a second farm reported a similar event, and the same preliminary diagnosis was made. Following this, the Pacific Engagement Program for Animal Health (PEPAH) team within the Department of Agriculture, Fisheries and Forestry (DAFF) organised the collection of tissue samples from birds at these farms. After consultation with poultry experts, these samples were tested for IBDV and IBH by PCR at the Australian Centre for Disease Preparedness (ACDP). In July 2023, ACDP advised that of the 31 samples submitted for testing, 29 (94%) had tested positive to IBDV. Three positive samples were sequenced and identified as a vvIBDV strain. No samples were positive for IBH.

Epidemiological and laboratory investigation

Study design

This investigation was a retrospective observational study of chicken farms in Guadalcanal. Outbreak farms were those that met the case definition for “confirmed infected premises” and “probable infected premises”. Objectives of the investigation were:

1. To describe the distribution of vvIBDV in Guadalcanal
2. To identify risk factors for vvIBDV at chicken farms
3. To improve understanding of the epidemiology of vvIBDV in Guadalcanal
4. To equip MAL livestock officers with skills to investigate outbreaks, and to build operational capacity of MAL staff in disease prevention, preparedness and response.’

The hypotheses of the study were:

1. vvIBDV is present in additional farms in Guadalcanal that did not report illness or mortalities to MAL
2. Farms with histories of mortality events will show evidence of infection with IBDV.

Case definitions

Case definitions for this investigation were based on laboratory results and reports of signs consistent with vvIBDV observed on farms (i.e high mortality rates observed in flocks). At the time of farm visits in July – August 2023, farmers reported that they first observed large numbers of unexpected deaths in flocks on their farms between June 2022 and August 2023. The PCR assay used in this investigation does not differentiate between very virulent, variant, or classical forms of IBDV and further typing was not performed, therefore both clinical signs and laboratory results were used to classify farms as confirmed infected premises, probable infected premises, non-outbreak premises, and non-outbreak premises – past flock suspected. In addition, a category of 'insufficient information' was created for farms where there was not enough information to determine whether the farm met the outbreak case definition (Table 4.1).

Confirmed infected premises and probable infected premises met the outbreak farm case definition. Confirmed and probable infected premises are reported separately throughout this chapter to highlight the challenges with diagnosing vvIBDV in the absence of molecular or genotype testing. Similarly, non-outbreak premises and non-outbreak premises–past flock suspected are considered non-outbreak farms and are reported separately to highlight the importance of clinical signs in the diagnosis of vvIBDV in Solomon Islands.

Table 4.1. Farm case definitions and criteria for farms visited between July-August 2023 as part of very virulent infectious bursal disease virus field investigations, Guadalcanal, Solomon Islands

Farm outbreak status	**Farm case definition**	**Mass mortality (between June 2022 and August 2023)**	**Laboratory results**
Outbreak farms	Confirmed infected premises	N/A	Molecular typing positive for vvIBDV
		≥50% of layer chicken batch ≥25% of meat chicken batch	Positive IBDV PCR result in at least 1x chicken or rooster in a batch of chickens
	Probable infected premises	≥50% of layer chicken batch ≥25% of meat chicken batch	Positive IBDV serology result in at least 1x chicken or rooster in a batch of chickens
Non-outbreak farms	Non-outbreak premises	<50% of layer chicken batch <25% of meat chicken batch	Positive <u>or</u> Negative laboratory results in a batch of chickens
	Non-outbreak premises – past flock suspected	≥50% of layer chicken batch ≥25% of meat chicken batch	No results positive for IBDV but timing of sample collection does not align with timing of clinical signs of disease
Insufficient information	Insufficient Information	Unknown	Positive IBDV PCR <u>or</u> positive IBDV serology in at least 1x chicken or rooster in a batch of chickens *<u>or</u>* Results inconclusive in at least one bird in a batch of chickens and no positive results recorded for any other chickens in the same batch

Sampling

Between July and August 2023, members of the PEPAH team travelled to Solomon Islands to investigate the outbreak and collect further samples. The selection of farms was through a combination of convenience and snowball sampling across several administrative boundaries (wards) in the northern region of Guadalcanal Island. Teams collected farm-level data and bird-level data using two questionnaires prepared in ArcGIS which were exported into an Excel spreadsheet. Concurrently, teams collected whole blood and oropharyngeal and cloacal swabs from a selection of birds at each farm they visited. Collections included both swabs and blood samples from most birds. In some cases, only swabs were collected for younger, smaller birds. A tissue sample was collected from a recently deceased bird at one farm. Sampled birds were caught individually by team members.

Blood samples were collected from the brachial wing vein of each chicken into yellow-top glass vascular blood tubes using a 25-gauge needle for adult birds and stored on ice. Needles and blood tubes were changed between each bird. Samples were allowed to clot for 2-6 hours then centrifuged at 3,500RPM for 15 minutes before the serum was decanted into microtubes and refrigerated. Flocked swabs were used to swab both the oral cavity and cloaca of the same bird, and entire ends of the swabs were placed in viral transport media and refrigerated. The refrigerated serum and swab samples were couriered by air to ACDP. Serum was tested for the presence of antibodies to IBDV, Newcastle disease virus (NDV), and avian influenza virus (AIV) using a competitive ELISA, and swabs were pooled in groups of 2 or 3 and tested for IBDV, NDV and AIV by a TaqMan Assay PCR. For IBDV testing, an IBDV-all assay PCR that does not differentiate between IBDV subtypes was used. A diagnostic algorithm for IBDV testing and a protocol for IBDV PCR testing is provided in Appendix 4D.

Farm outbreak status was determined for each premises based on whether the case definition was met. Using Excel, laboratory results from ACDP were manually merged with bird-level data. Data was analysed using Microsoft® Excel® for Microsoft 365 MSO (Version 2403 Build 16.0.17425.20236) 64-bitand RStudio 2023.06.1-524 (26). Maps were created using QGIS 3.22.10 (27), with shapefiles sourced from the Pacific Data Hub (28).

Logistic regression was performed to determine if there was an association between infection with vvIBDV and farm type, farms having multiple age classes or farms having a location in Capital Territory. All farms with 'Insufficient Information' were excluded from the regression model.

Ethics

This investigation received an ethics waiver from the ANU Human Research Ethics Council as per protocol 2017/909, "Request for waiver of consent for use of data in research for Master's in Applied Epidemiology students for 'Outbreak Investigation' and 'Surveillance in Public Health' projects".

Results

Farm types

A total of 62 farms were visited between July and August 2023. Of the 62 farms visited, 32 (52%) were meat chicken farms, 23 (37%) were layer farms, four (6%) farmed both layers and meat chickens, and three (5%) were local breed farms. Across the 62 farms, a total of 694 birds were sampled, of which 346 birds (50%) showed evidence of infection with IBDV (Table 4.2). Of all farms visited, 30 (48%) reported recent unexpected deaths in batches of chickens (Appendix 4E).

Table 4.2. Overview of sampling and testing of chickens after initial report of mortalities and during outbreak investigation

Date of collection	Number of farms visited	Number of birds sampled	Tissue samples collected	Tissue samples positive for IBDV	Swab samples collected	Swab samples positive for IBDV	Blood samples collected	Blood samples positive for IBDV	Number of samples typed
April-May 2023 (initial reports)	2	31	31	29	0	0	0	0	3
July-August 2023 (outbreak investigation)	62	694	1	1	691	39	637	323	0

Farm case definition

Of the 62 farms visited, 3 (5%) were classified as 'confirmed infected premises', 14 (23%) were classified as 'probable infected premises', 27 (44%) were classified as 'non-outbreak premises', 6 (10%) were classified as 'non-outbreak premises–past flock suspected', and 12 (19%) were classified as 'insufficient information' (Figure 4.1). These 'insufficient information' farms showed laboratory evidence of IBDV infection but had an unknown history of mortality events, or the proportion of deaths in a batch of chickens was unknown (n = 10). One of the 12 'insufficient information' farms only reported inconclusive or negative results, and one farm only reported positive results in a sample that was pooled with another farm. Seventeen (27%) farms met the outbreak case definition. Of these 17 farms, 11 (65%) were layer farms.

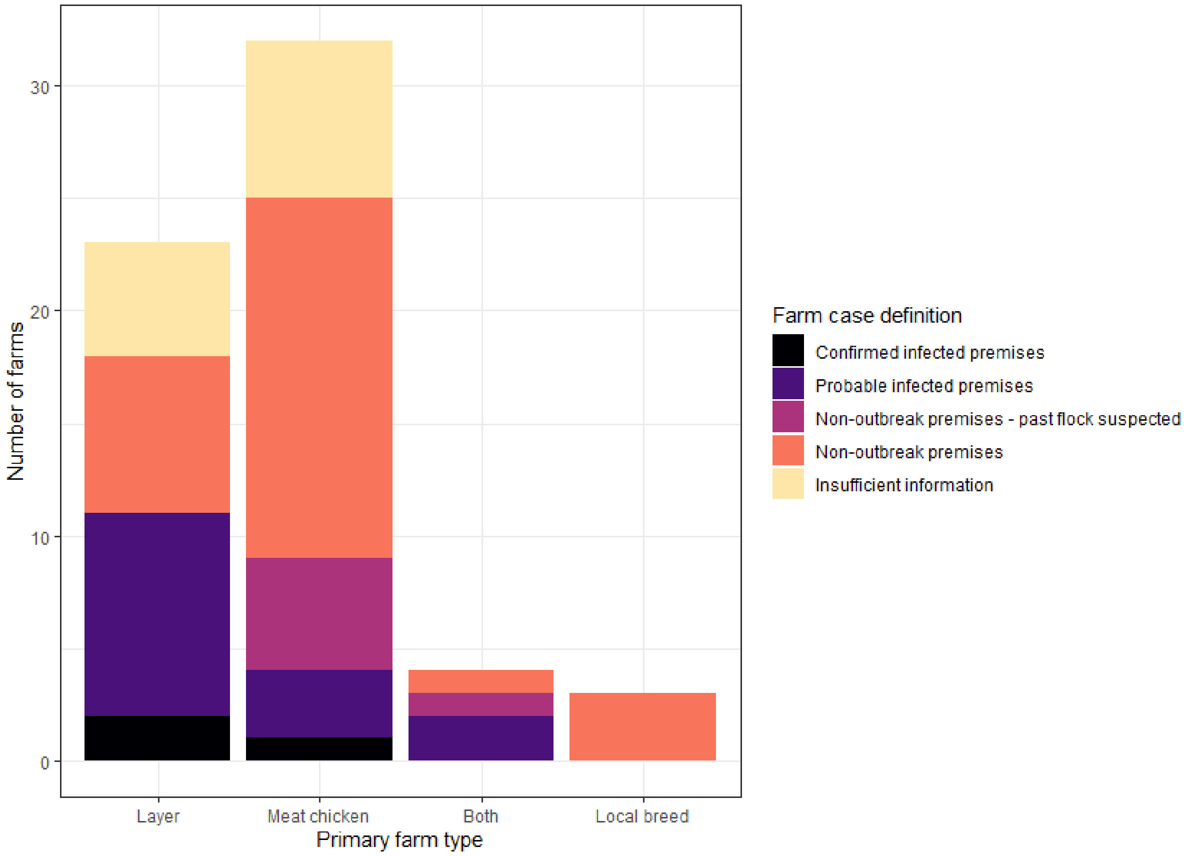

Figure 4.1. Very virulent infectious bursal disease virus farm case definition by farm type, Guadalcanal, July-August 2023

Of the 32 meat chicken farms visited, five (16%) were classified as 'non-outbreak premises - past flock suspected'. One farm with both layers and meat chickens was also given this classification. This farm reported mortalities in meat chickens but only layers showed evidence of infection with IBDV. Two farms with both layers and meat chickens were classified as 'probable infected premises' and one was classified as a non-outbreak premises.

All local breed farms that were visited were classified as 'non-outbreak premises'.

Farm locations

Farms were located across northern parts of Guadalcanal Island, and outbreak classifications of all farms varied across all wards (Figure 4.2, Appendix 4F).

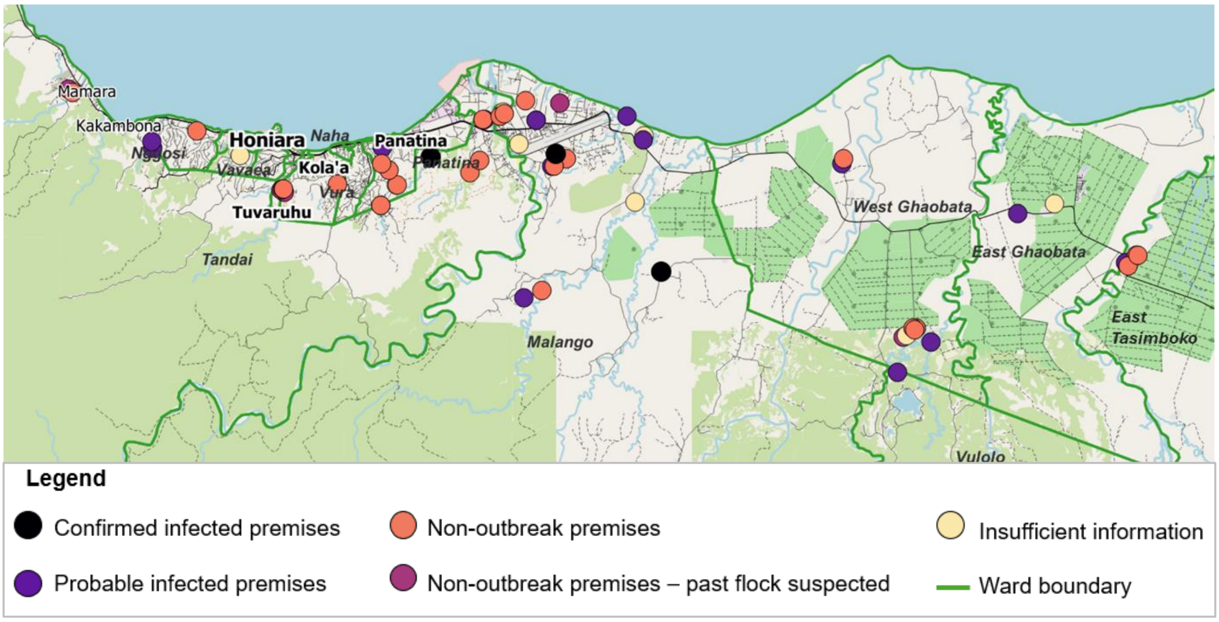

Figure 4.2. Spatial distribution of farms[2] investigated for very virulent infectious bursal disease virus by farm case definition, Capital Territory and surrounds, July-August 2023

Fifty (81%) farms visited were located outside of Capital Territory in Guadalcanal province, including all 'confirmed infected premises' farms. Sampling occurred at 12 farms in Honiara (Capital Territory) across five wards, and at 50 farms in Guadalcanal Province across seven wards. Malango had the highest number of sampled farms (n = 20, 32% of all farms visited) and the highest number of outbreak farms (n = 7, 41% of outbreak farms). Excluding wards where only one farm was sampled, the highest proportion of outbreak farms occurred in East Ghaobata (n = 2, 50%) (Table 4.3).

[2] 4 farms located outside of map area. See appendix 4G for supplementary maps

Table 4.3. Distribution and farm case definition of farms investigated for very virulent infectious bursal disease virus between July-August 2023, by ward and province, Guadalcanal

Province	Ward	Count of farms by farm case definition					Total (n)
		Confirmed infected premises	Probable infected premises	Non-outbreak premises – past flock suspected	Non-outbreak premises	Insufficient information	
Capital Territory (Honiara)	Panatina	0	1	0	3	1	5
	Kola'A	0	0	1	3	0	4
	Matankio	0	0	1	0	0	1
	Mbumburu	0	0	0	0	1	1
	Nggoi	0	0	0	1	0	1
Guadalcanal Province	Malango	2	5	1	6	6	20
	Tandai	1	3	1	6	0	11
	West Ghaobata	0	2	1	4	1	8
	East Tasimboko	0	0	1	2	2	5
	East Ghaobata	0	2	0	1	1	4
	Saghalu	0	0	0	1	0	1
	Vulolo	0	1	0	0	0	1
Total		**3**	**14**	**6**	**27**	**12**	**62**

Date illness first observed

All farms were visited between July 2023 and August 2023. Date illness first observed was reported for 38 farms at the time of visit, including all 17 outbreak farms. Dates illness first observed ranged from June 2022 to August 2023. All three confirmed infected premises reported an onset of illness between March and May 2023. No farms that reported illness onset after June 2023 met the outbreak farm case definition (Figure 4.3).

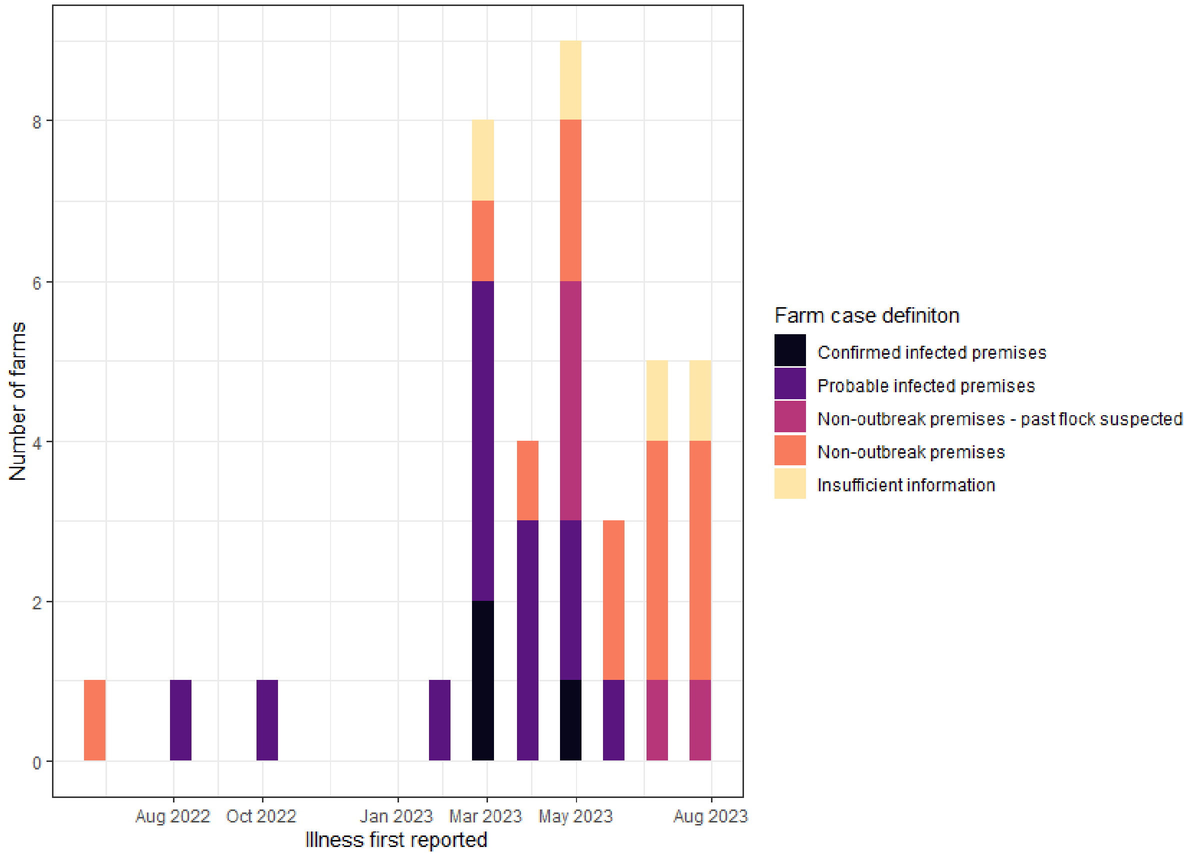

Figure 4.3. Month illness first observed for all farms visited in July-August 2023, by very virulent infectious bursal disease virus farm case definition Guadalcanal[3]

Logistic regression

Layer farms had 7.9 times higher odds of infection with vvIBDV compared to meat chicken farms[4] (OR 7.9, 95% CI 1.88 – 32.9).

Farms located in Guadalcanal province had 7.3 times higher odds of infection with vvIBDV compared to farms in Capital Territory (OR 7.3, 95% CI 0.84 – 63.34)5.

Farms with 2 age classes had 0.75 times lower odds of infection with vvIBDV compared to farms with 1 age class (OR 0.8 95% CI 0.23 – 2.49).

Farms located within 200 meters from a river, creek or the coast had 1.5 times odds of infection with vvIBDV compared to farms not located near a river or the coast (OR 1.5, 95% CI 0.42 – 5.32).

[3] At the time of visit in July-August 2023, farmers reported observing earliest clinical signs (mass mortalities) at their farm from June 2022 – August 2023
[4] Excludes farms with local breeds or with both layers and meat chickens
[5] Excludes farms with more than 2 age classes

Discussion

This investigation demonstrated the presence of vvIBDV in several farms across Guadalcanal. Outbreak farms in this investigation experienced significant flock losses due to mortalities, causing substantial economic losses for farmers. In Solomon Islands, a day-old meat chicken chick typically costs approximately $4-5 Australian dollars (AUD), and adult meat chickens sell for approximately $20-30 AUD depending on weight. Factoring in the cost of chicken feed (approximately $32 AUD for 20kg, or $8-11 AUD per meat chicken in its lifetime[6]), if a meat chicken is processed at 6-8 weeks old as intended the farmer will make a profit. Similarly, a day-old layer chick costs around $9-10 AUD, and a carton of 10 eggs sells for approximately $7 AUD. A layer chicken begins laying at approximately 20 weeks of age, and by this time each chicken will have cost approximately $25 AUD to feed[7]. If a bird dies before it can be processed for meat or before it begins to lay the farmer will incur the cost of the day-old chick and the feed up until the bird's death but not recover any of these costs through sale for processing or sale of eggs. These losses can be significant when a large proportion of the flock is affected.

The majority of farms classified as outbreak farms were layer farms which is consistent with the epidemiology of the disease in other parts of the world (2). However, illness consistent with vvIBD was reported in 14 meat chicken farms. While only seven of these meat chicken farms showed evidence of infection with IBDV, this investigation demonstrated that meat chicken flocks, as well as layer flocks, can experience severe mortality from infection with IBDVs. As IBDVs are known to be extremely resilient in the environment (10), it is likely infected farms will continue to experience recurrent outbreaks of vvIBD without preventative measures in place, as an enclosure may contain viable virus for several weeks or months after removal of chickens (10). In this investigation, five meat chicken farms and one farm with both meat chickens and layer chickens reported deaths in previous flocks but showed no laboratory evidence of IBDV in current flocks. It is possible that the chickens sampled at these farms evaded infection with IBDV despite its survivability in the environment, though this requires further investigation. It may also be that these farms experienced disease caused by another pathogen.

Complete histories were not available for farms classified as 'insufficient information'. As genotyping was only performed on samples collected from farms in May 2023, laboratory confirmatory evidence of infection with vvIBDV was not available for the majority of farms visited between July and August 2023. The IBDV-all assay PCR alone is not sufficient to

[6] 20 cents per day per meat chicken
[7] 18 cents per day per layer chicken

identify vvIBDV as the assay does not target the hypervariable VP2 region where the mutations associated with vvIBDV are located. In the absence of genotyping, clinical evidence is required to classify farm outbreak status, and collecting this information should be prioritised for future surveys. Collecting this information and collecting it at more regular intervals would also help to assist in the understanding of the epidemiology of vvIBD in Solomon Islands. If feasible, molecular typing should be performed on all positive PCR samples to confirm vvIBDV. There are plans to undertake molecular typing of the PCR positive samples from this investigation, but this is not an option for serum samples and so accurate collection of farm histories remains essential.

During surveys conducted by the PEPAH team, it is common practice for the same individuals who collect samples to also record data. This can result in errors as sampling is often prioritised over data collection. Delegating one or two people, including a MAL livestock officer, to focus only on data collection at the time of sample collection may assist with data completeness and analysis. For example, both the farm level and bird level questionnaires had several fields that were not filled out at every farm, particularly the three fields relating to farm location and fields relating to numbers of birds. Combining the two questionnaires and having the farm-level questions regarding illness or deaths in chickens, the number of deaths observed, and size of the flock as compulsory fields at the beginning of the questionnaire may help to ensure history is recorded at the time of sampling. In addition, farm coordinates are automatically collected at the time of sample collection, thus the number of location fields could be reduced to farm names and local area names, allowing other variables to be prioritised for collection. Pooling samples across different farms should also be avoided to reduce confusion in interpreting whether farms showed evidence of infection with IBDV, and subsequent surveys have tried to mitigate this by sampling cohorts in multiples of three.

In addition to information regarding farm history, the questionnaire could also be improved by including information about risk factors for infection with vvIBDV. Information regarding sources of chickens and food or on-farm biosecurity practices was minimal and not standardised in this investigation, so these factors could not be examined. Additional variables such as source of day-old chicks and how long poultry farmers have kept poultry for could be included as pre-defined drop-down items in the questionnaire. Selecting an option from these drop-down could be made compulsory for completion of the questionnaire, helping to ensure this field is completed. This information would improve understanding of vvIBD in Solomon Islands and should be included in future surveys. Collecting this information in a designated field rather than an open text “notes” field would also streamline analysis.

The farms included in this investigation were limited to northern regions of Guadalcanal, in part due to the logistics of travel in Solomon Islands. The PEPAH team and MAL have commenced visits to other provinces within Solomon Islands for routine livestock surveys, but travel is still limited within provinces due to logistical challenges. However, information collected through routine surveys in these additional areas could help to assist with understanding the prevalence of vvIBDV in Solomon Islands. Knowledge of numbers and distribution of chicken farms across Solomon Islands would also improve understanding of the outbreak.

Another limitation of the study was that visits to the farms included in the investigation occurred several months after mortalities were first reported. As discussed earlier, some meat chicken flocks sampled in this investigation were purchased after batches with clinical signs of vvIBDV had been processed or died, therefore the cause of this earlier illness cannot be confirmed. In addition, the time between when illness was observed and farms were investigated increases the potential for recall bias, which could result in misclassifications of farm outbreak status. Improved reporting by farmers and improved visibility of MAL and livestock officers could support prompt response to disease events in the future. Surveillance activities could also be improved through further upskilling of MAL staff in undertaking outbreak investigations. Free epidemiology training modules are available online (29, 30), and Australia and Solomon Islands' other development partners could also assist with sustainable capacity building within MAL to improve early detection and response to future IBD and other animal disease events. Moreover, surveillance could be improved by routine use of applications such as Epicollect (31), a free online collection tool that would enable real-time, digital records to be made when illness in flocks is reported to MAL staff.

Preventing the spread of vvIBDV is paramount to reducing production and economic losses in Guadalcanal and throughout Solomon Islands. Where possible, farms should ensure equipment is not shared with other farms (12), and that all waste is removed from farms and safely disposed of if large numbers of deaths are observed within batches of chickens. Keeping sheds empty, ideally for several months between batches should be promoted amongst farmers, and may mean encouraging farmers to build more than one shed on their property, though many farms already do this. Batches of chickens could also be separated by fitting existing sheds with dividers to keep areas separate. Each area would require its own access point to prevent movement of material between the flocks. Promoting the use of local materials should be encouraged to reduce costs associated with shed construction. Another transmission risk for vvIBDV is through movement of people on farms. While farmers may only work at one farm, transmission within the farm is possible if there are multiple sheds at a property. Placing slip-on footwear outside each shed to wear when tending to each individual chicken shed or area could assist with reducing risk of spread within a property. The effectiveness of this strategy would need to be further explored and complemented with appropriate veterinary health education, as many farmers choose to work barefoot. In addition, the virus could be spread by other individuals who come onto the property, including children and individuals purchasing eggs or chickens directly from the farm.

Another consideration that could assist in the prevention of vvIBDV is vaccination. Globally, vaccination is used to control IBD, but these programs are complex with several types of vaccinations available and appropriate implementation would require further research (2, 10, 32-34). Furthermore, effective vaccination programs require significant resources, and historically IBDV vaccinations are known to have limited efficacy in preventing infection with very virulent strains of IBDV (2, 14-17, 35, 36). However, if implemented correctly vaccinations may reduce the magnitude of mortalities in batches of chickens among farms infected with vvIBDV, in addition to reducing viral shedding. Decisions regarding vaccination would need further investigation and input from Solomon Islands Government.

Conclusion

This investigation demonstrated that vvIBDV is present in several areas in Guadalcanal, in both layers and meat chickens. Some farms with histories of mortalities showed no evidence of infection with IBDV, and some farms with evidence of IBDV reported no mass mortality events or history was unavailable. The source of vvIBDV in Solomon Islands could not be determined. Infected farms are likely to have recurrent infections if preventative measures are not implemented. Additional information on where day old chicks are sourced from, where chicken feed is sourced from and what vaccinations or medications are given to birds would be useful to further understand the epidemiology of vvIBD in Solomon Islands. Improvements to the surveillance of animal diseases in Solomon Islands including upskilling MAL staff could assist with identifying the risk pathways if future outbreaks were to occur. While vaccination programs for IBD have been implemented globally, these should be considered in conjunction with biosecurity practices to reduce the spread of IBD in Solomon Islands. Reducing the risk of vvIBDV in Solomon Islands will help to build sustainable agricultural systems and support economic development and food and nutrition security for communities.

References

1. Pacific Engagement Program for Animal Health. Pacific Engagement Program for Animal Health Strategic Plan [Unpublished]. 2024.

2. Dey S, Pathak DC, Ramamurthy N, Maity HK, Chellappa MM. Infectious bursal disease virus in chickens: prevalence, impact, and management strategies. Vet Med (Auckl) [Internet]. 2019; 10:85-97. Available from: https://www.ncbi.nlm.nih.gov/pubmed/31497527. DOI: 10.2147/VMRR.S185159

3. The United Nations. Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture [Internet]. New York (USA): UN; 2024 [cited Jul 2024]. Available from: https://www.un.org/sustainabledevelopment/hunger/

4. Ngo CP, Nguyen KP, Tran DTA, Van TM, Le TQ, Tran BN. Epidemiological and molecular characteristics of Infectious bursal disease virus naturally infected in the broiler flocks in the Mekong Delta of Vietnam during 2015 and 2018. Veterinary Integrative Sciences [Internet]. 2024; 22(2):251-63 DOI: 10.12982/VIS.2024.019

5. Legnardi M, Poletto F, Alam S, Cherfane A, Le-Tallec B, Franzo G, et al. Molecular epidemiology of infectious bursal disease virus in the Near East and Persian Gulf regions. Avian Pathol [Internet]. 2024; 53(1):56-67. Available from: https://www.ncbi.nlm.nih.gov/pubmed/37823857. DOI: 10.1080/03079457.2023.2270531

6. Orakpoghenor O, Oladele SB, Abdu PA. Infectious bursal disease: Transmission, pathogenesis, pathology and control - an overview. World's Poultry Science Journal [Internet]. 2020; 76(2):292-303. DOI: 10.1080/00439339.2020.1716652

7. Nwagbo I, Milani A, Salviato A, Zamperin G, Sulaiman L, Maurice N, et al. Genomic analysis of infectious bursal disease virus in Nigeria: Identification of unique mutations of yet unknown biological functions in both segments A and B. Vaccines (Basel) [Internet]. 2023; 11(4):867. Available from: https://www.ncbi.nlm.nih.gov/pubmed/37112779. DOI: 10.3390/vaccines11040867

8. Mili SA, Islam MS, Al Momen Sabuj A, Haque ZF, Pondit A, Hossain MG, et al. A cross-sectional seroepidemiological study on infectious bursal disease in backyard chickens in the Mymensingh District of Bangladesh. Vet Med Int [Internet]. 2022; 20(2022): 9076755. Available from: https://www.ncbi.nlm.nih.gov/pubmed/36106173. DOI: 10.1155/2022/9076755

9. Hishamund P, Emikpe BO, Shyakaa A. Seroprevalence and associated factors of infectious bursal disease (IBD) in indigenous chicken in eastern province in Rwanda. J

Immunoassay Immunochem [Internet]. 2023; 44(3):296-308. Available from: https://www.ncbi.nlm.nih.gov/pubmed/36659816. DOI: 10.1080/15321819.2023.2167521

10. Eterradossi N, Saif YM, Diseases of Poultry: Infectious Bursal Disease, DE Swayne, Editor. 2013, John Wiley & Sons, Inc. p. 27.

11. Subler KA, Mickael CS, Jackwood DJ. Infectious bursal disease virus-induced immunosuppression exacerbates Campylobacter jejuni colonization and shedding in chickens. Avian Dis [Internet]. 2006; 50(2):179-84. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16863064. DOI: 10.1637/7434-090705R.1

12. Pitesky M, Cataline K, Crossley B, Poulos M, Ramos G, Willoughby D, et al. Historical, spatial, temporal, and time-space epidemiology of very virulent infectious bursal disease in California: a retrospective study 2008-2011. Avian Dis [Internet]. 2013; 57(1):76-82. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23678733. DOI: 10.1637/10302-071112-Reg.1

13. Animal Health Australia. Response strategy: Infectious bursal disease (hypervirulent form) (version 5.0). Australian Veterinary Emergency Plan (AUSVETPLAN), edition 5. Canberra (AU): Animal Health Australia; 2021

14. Omer MG, Khalafalla AI. Epidemiology and laboratory diagnosis of very virulent infectious bursal disease virus in vaccinated chickens in Khartoum, Sudan. Open Vet J [Internet]. 2022; 12(1):33-43. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35342736. DOI: 10.5455/OVJ.2022.v12.i1.5

15. Samy A, Courtillon C, Briand FX, Khalifa M, Selim A, Arafa AES, et al. Continuous circulation of an antigenically modified very virulent infectious bursal disease virus for fifteen years in Egypt. Infect Genet Evol [Internet]. 2020; 78 (2020):104099. Available from: https://www.ncbi.nlm.nih.gov/pubmed/31676447. DOI: 10.1016/j.meegid.2019.104099

16. Drissi Touzani C, Fellahi S, Gaboun F, Fassi Fihri O, Baschieri S, Mentag R, et al. Molecular characterization and phylogenetic analysis of very virulent infectious bursal disease virus circulating in Morocco during 2016-2017. Arch Virol [Internet]. 2019; 164(2):381-90. Available from: https://www.ncbi.nlm.nih.gov/pubmed/30367293. DOI: 10.1007/s00705-018-4076-3

17. Vera F, Craig MI, Olivera V, Rojas F, Konig G, Pereda A, et al. Molecular characterization of infectious bursal disease virus (IBDV) isolated in Argentina indicates a regional lineage. Arch Virol [Internet]. 2015; 160(8):1909-21. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26026955. DOI: 10.1007/s00705-015-2449-4

18. The United Nations. Country Facts: The Permanent Mission of Solomon Islands to the United Nations [Internet]. [place unknown], UN; [cited 14 Dec 2023]; Available from: https://www.un.int/solomonislands/solomonislands/country-facts.

19. The Departmenrt of Foreign Affairs and Trade. Solomon Islands country brief [Internet]. Canberra (AU): 2023; [cited 14 Dec 2023]; Available from: https://www.dfat.gov.au/geo/solomon-islands/solomon-islands-country-brief.

20. The World Bank. World Bank Country and Lending Groups [Internet]. Washington DC (USA): The World Bank; 2024 [cited 9 Apr 2024]. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

21. Mubamba C, Ramsay G, Abolnik C, Dautu G, Gummow B. Is syndromic data from rural poultry farmers a viable poultry disease reporting tool and means of identifying likely farmer responses to poultry disease incursion?. Prev Vet Med [Internet]. 2018; 153:84-93. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29653740. DOI: 10.1016/j.prevetmed.2018.03.002

22. Mwenda R, Changula K, Hang'ombe BM, Chidumayo N, Mangani AS, Kaira T, et al. Characterization of field infectious bursal disease viruses in Zambia: evidence of co-circulation of multiple genotypes with predominance of very virulent strains. Avian Pathol [Internet]. 2018; 47(3):300-13. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29517272. DOI: 10.1080/03079457.2018.1449941

23. Musa IW; Sai'du L; Abalaka ES. Economic impact of recurrent outbreaks of gumboro disease in a commercial poultry farm in kano, Nigeria. Asian Journal of Poultry Science [Internet]. 2012; 6(4):152-9. DOI: 10.3923/ajpsaj.2012.152.159

24. Perrone ST. National Priority Animal Disease List for Solomon Islands SIBDP Phase III. [Unpublished]. 2022.

25. Gillan N. Disease Investigation Report. Livestock Solomon Islands Ministry of Agriculture. [Unpublished] 2023.

26. R Core team. R: A Language and Environment for Statistical Computing [Internet]. Vienna (Austria): R Foundation for Statistical Computing; 2023 [cited 24 Oct 2024]. Available from: https://www.R-project.org.

27. QGIS.org. QGIS Geographic Information System. [place unknown]. QGIS Association; 2024. [cited 24 Oct 2024]. Available from http://www.qgis.org

28. Rua LDL. 2009_Solomon_Islands_PHC_Admin_Boundaries. Pacific Data Hub: 2020.

29. Field Epidemiology in Action. eLearning [Internet]. Wallsend (AU): FEiA; 2024 [cited 21 May 2024]. Available from: https://www.fieldepiinaction.com/elearning.

30. Asia Pacific Consortium of Veterinary Epidemiology (APCOVE). APCOVE eLearning modules and case studies [Internet]. Camden (AU): APCOVE; 2023 [cited 10 Jul 2024]; Available from: https://www.apcove.com.au/resources/english/#modules.

31. Centre for Genomic Pathogen Surveillance. Epicollect5 [v5.1.52] [Internet]. Oxfordshire (UK): Centre for Genomic Pathogen Surveillance; 2024. [cited 30 May 2024]. Available from: https://five.epicollect.net/.

32. Mekuriaw A, Bitew M, Gelaye E, Mamo B, Ayelet G. Infectious bursal disease: outbreak investigation, molecular characterization, and vaccine immunogenicity trial in Ethiopia. Trop Anim Health Prod [Internet]. 2017; 49(6):1295-302. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28620682. DOI: 10.1007/s11250-017-1328-2

33. Jenberie S, Lynch SE, Kebede F, Christley RM, Gelaye E, Negussie H, et al. Genetic characterisation of infectious bursal disease virus isolates in Ethiopia. Acta Trop [Internet]. 2014; 130(100):39-43. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24145155. DOI: 10.1016/j.actatropica.2013.09.025

34. Adamu J, Owoade AA, Abdu PA, Kazeem HM, Fatihu MY. Characterization of field and vaccine infectious bursal disease viruses from Nigeria revealing possible virulence and regional markers in the VP2 minor hydrophilic peaks. Avian Pathol [Internet]. 2013; 42(5):420-33. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23919308. DOI: 10.1080/03079457.2013.822055

35. Pikula A, Lisowska A, Jasik A, Smietanka K. Identification and assessment of virulence of a natural reassortant of infectious bursal disease virus. Vet Res [Internet]. 2018; 49(1):89. Available from: https://www.ncbi.nlm.nih.gov/pubmed/30208951. DOI: 10.1186/s13567-018-0586-y

36. Wang W, He X, Zhang Y, Qiao Y, Shi J, Chen R, et al. Analysis of the global origin, evolution and transmission dynamics of the emerging novel variant IBDV (A2dB1b): The accumulation of critical aa-residue mutations and commercial trade contributes to the emergence and transmission of novel variants. Transbound Emerg Dis [Internet]. 2022 Sep; 69(5):e2832-e51. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35717667. DOI: 10.1111/tbed.14634

Appendix 4A: Timeline of very virulent infectious disease virus outbreak identification and response, and my role

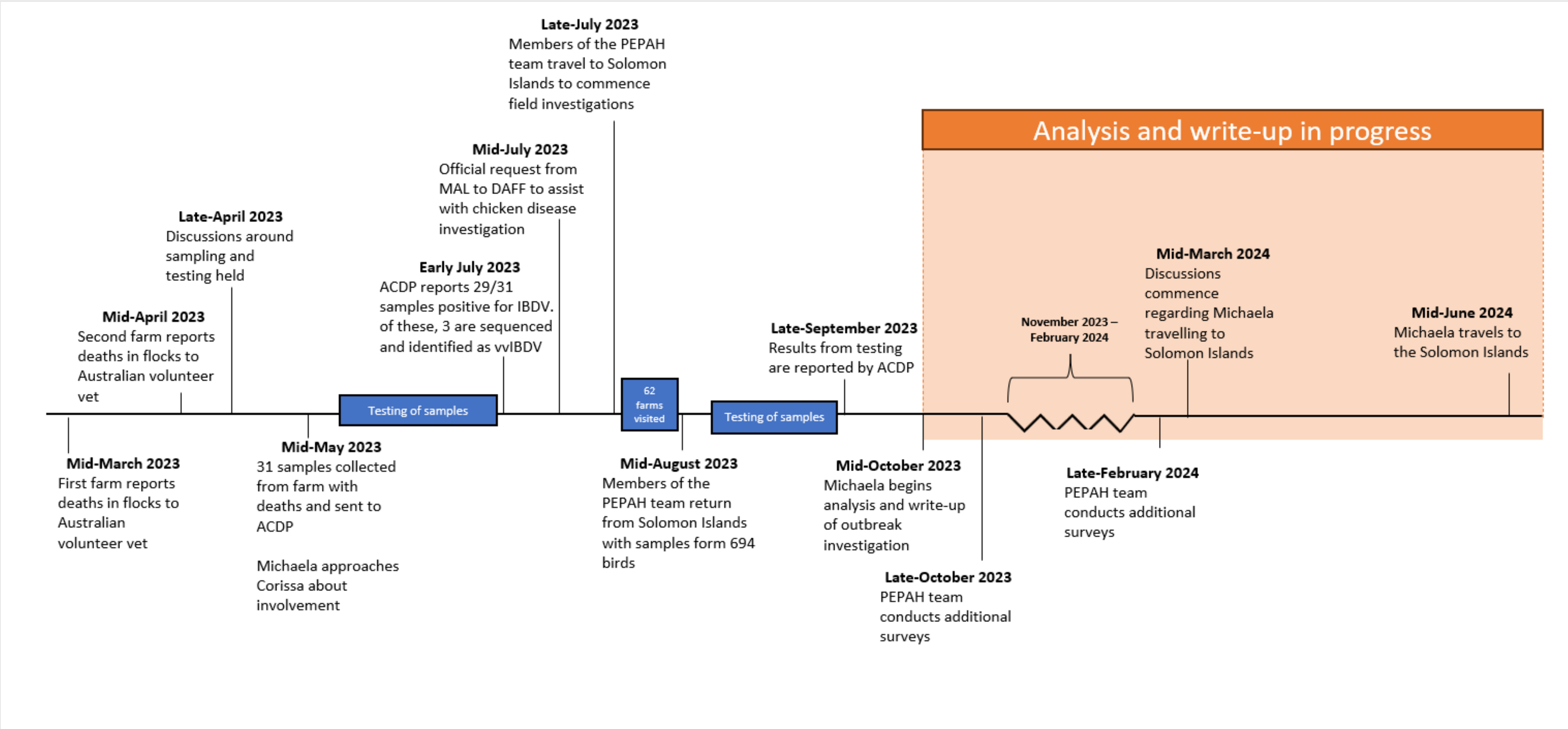

Figure 4A.1. Timeline of significant events in very virulent infectious disease virus outbreak investigation and my involvement, 2023 – 2024.

Appendix 4B: Sustainable Development Goal 2 – End hunger, achieve food security and improved nutrition and promote sustainable agriculture (3)

Goal 2 overview

Goal 2 is about creating a world free of hunger by 2030.The global issue of hunger and food insecurity has shown an alarming increase since 2015, a trend exacerbated by a combination of factors including the coronavirus disease of 2019 pandemic, conflict, climate change, and deepening inequalities.

Goal 2 Targets 2.1, 2.2, 2.3 and 2.4

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

Appendix 4C: Molecular typing of the hypervariable region of the VP2 gene of Infectious bursal disease virus

[redacted]

Classical IBDV

Very virulent IBDV

Variant IBDV

- vvIBDV characterised by amino acid substitutions circled in red
- Variant IBDV characterised by amino acid substitutions in black boxes

Figure 4C.1. Hypervariable region of the infectious bursal disease virus VP2 gene including regions significant to differentiating forms of infectious bursal disease virus, provided to the Solomon Islands Ministry of Agriculture and Livestock by the Australian Centre for Disease Preparedness

Appendix 4D: Infectious bursal disease virus testing

Diagnostic Algorithm

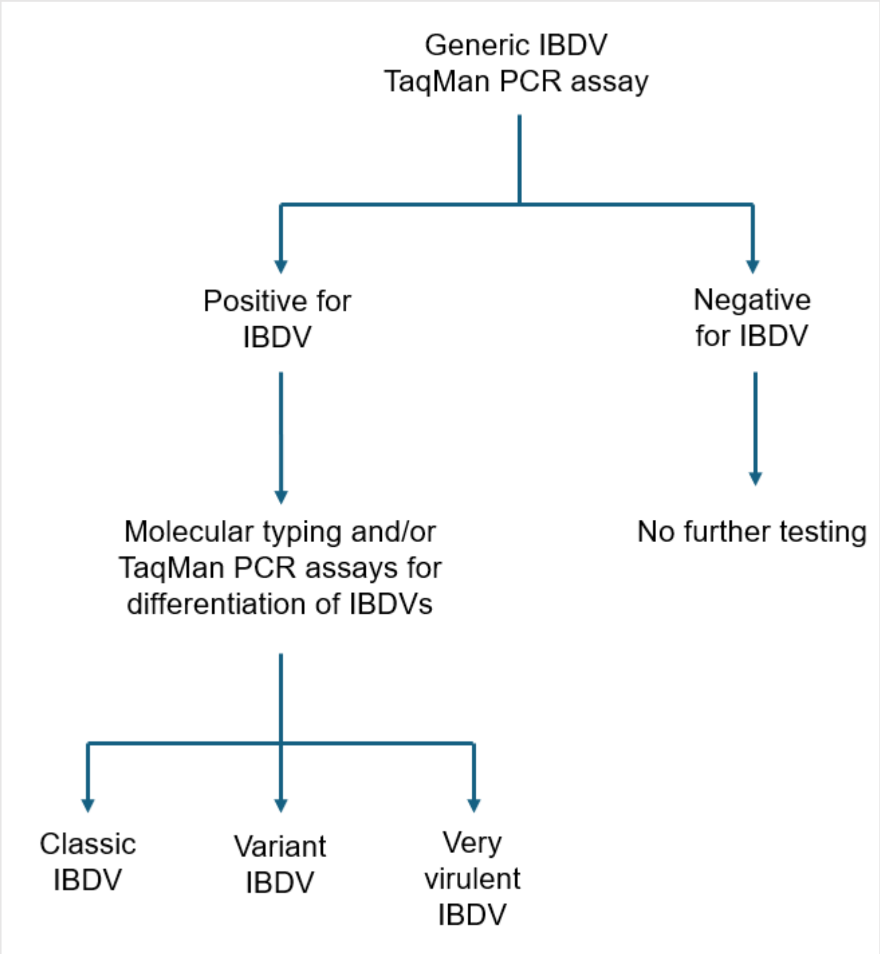

Figure 4D.1. Basis overview of diagnostic algorithm for generic and differential testing of infectious bursal disease virus

Infectious bursal disease virus Real-Time TaqMan PCR Assay

Inhouse protocol prepared by Jianning Wang, ACDP

15 µl of ribonucleic acid (RNA) samples and positive controls must be heat-denatured at 98°C for 5 min, then quickly chilled on ice for 2 min before adding into a total quality management mastermix plate. Samples are cycled at:

1X 45°C 10 min, 95°C 10 min

45X 95°C 15 sec, 60°C 45 sec

PCR primer targets vary for generic detection of IBDV and for detection of vvIBDV.

Appendix 4E: Supplementary tables – evidence of infection and farm history

Table 4E.1. Evidence of infection with very virulent infectious bursal disease virus and farm history, all farms, Guadalcanal 2023

	Evidence of infection		No evidence of infection		Further investigation required		
	n	% (of all farms)	n	% (of all farms)	n	% (of all farms)	**Grand Total**
Infected premises	1	*1.6*	0	*0*	0	*0.0*	**1**
Suspect premises	23	*37.1*	7	*11.3*	0	*0.0*	**30**
No suspicion vvIBDV	6	*9.7*	9	*14.5*	0	*0.0*	**15**
Need history	9	*14.5*	6	*9.7*	1	*1.6*	**16**
Grand Total	**39**	**62.9**	**22**	**35.5**	**1**	**1.6**	**62**

Table 4E.2. Evidence of infection with very virulent infectious bursal disease virus and farm history, layer farms, Guadalcanal 2023

	Evidence of infection		No evidence of infection		Further investigation required		
	n	% (of all farms)	n	% (of all farms)	n	% (of all farms)	**Grand Total**
Infected premises	1	*4.3*	0	*0*	1	*4.3*	**2**
Suspect premises	12	*52.2*	0	*0*	0	*0*	**12**
No suspicion vvIBDV	3	*13.0*	1	*4.3*	0	*0*	**4**
Need history	4	*17.4*	1	*4.3*	0	*0*	**5**
Grand Total	**20**	***87.0***	**2**	***8.7***	**1**	***4.3***	**23**

Table 4E.3. Evidence of infection with very virulent infectious bursal disease virus and farm history, meat chicken farms, Guadalcanal 2023

	Evidence of infection		**No evidence of infection**		**Further investigation required**		
	n	% (of all farms)	n	% (of all farms)	n	% (of all farms)	**Grand Total**
Infected premises	0	*0.0*	0	*0.0*	0	0	**0**
Suspect premises	7	*21.9*	7	*21.9*	0	0	**14**
No suspicion vvIBDV	1	*3.1*	7	*21.9*	0	0	**8**
Need history	5	*15.6*	5	*15.6*	0	0	**10**
Grand Total	**13**	***40.6***	**19**	***59.4***	**0**	**0**	**32**

Appendix 4F: Supplementary maps

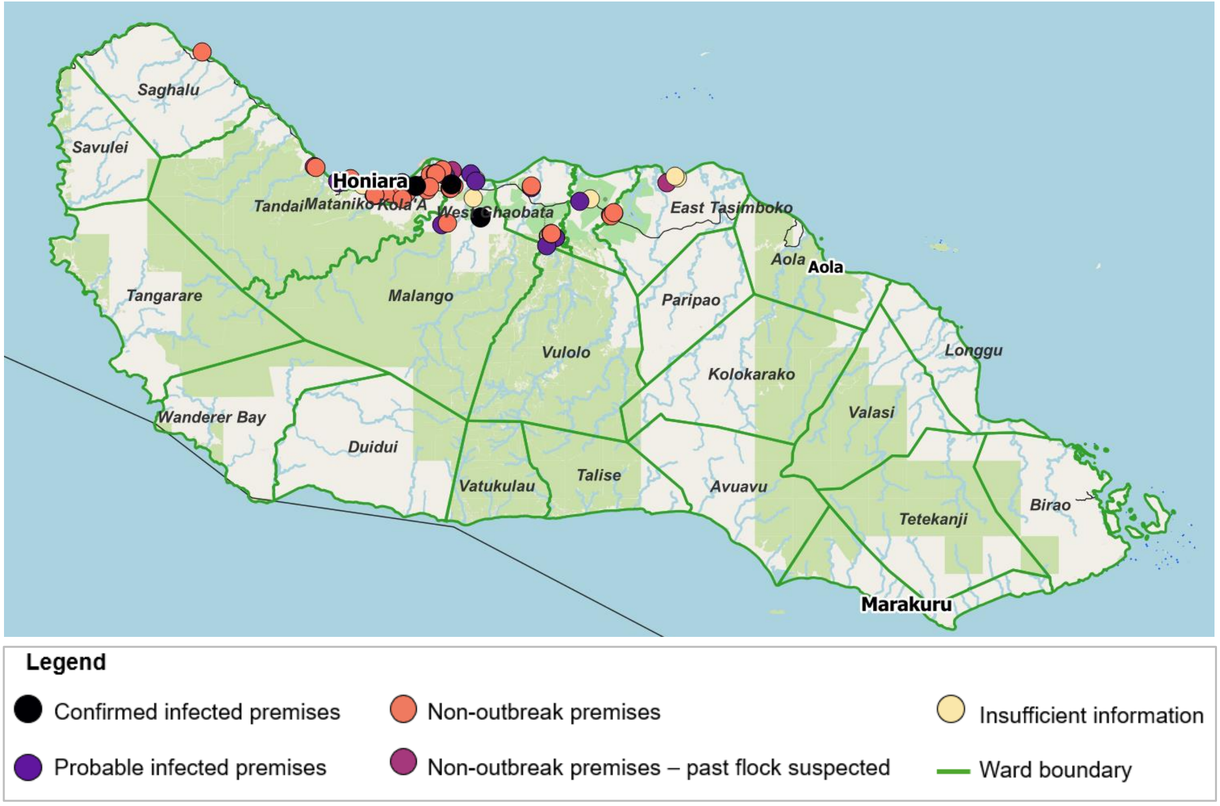

Figure 4F.1. Spatial distribution of farms investigated for with very virulent infectious bursal disease virus by farm case definition status, Guadalcanal island, July-August 2023

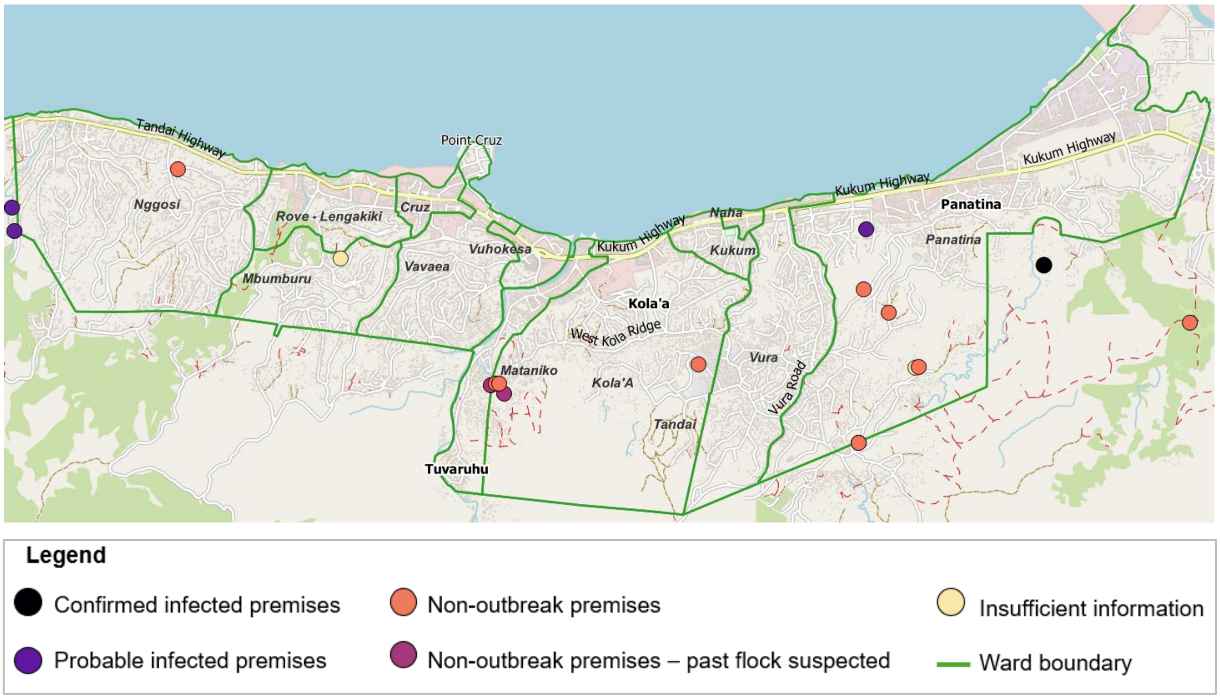

Figure 4F.2. Spatial distribution of farms investigated for very virulent infectious bursal disease virus by farm case definition, Capital Territory, Guadalcanal, July-August 2023