# Monitoring Animal Disease and Productivity in Samoa

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# Abstract


This thesis presents two studies that form the basis of the Samoan Ministry of Agriculture and Fisheries' (MAF) recent efforts to enhance its animal disease surveillance capacity.

The first study investigated a method of enhancing the surveillance value of veterinary case data collected by the MAF's Animal Health Service, which provides the only veterinary service for livestock in the country, through temporal analysis of cases and syndromes by species. Threshold levels generated from 3-monthly moving averages combined over 3 years of veterinary case data were used to identify unusually high numbers of cases and the cause of these unusual events were investigated. Further, the analysis of data in the system identified gaps in the coverage of the Animal Health Service which helped identify alternative methods for conducting surveillance in these areas using the Crops Division advisory officers.

The objective of the second study was to identify if the veterinary case data collected by the Animal Health Service represented pig health problems in the general population. Reproduction and mortality patterns were compared on a group of 10 holdings that were regularly attended by the veterinary staff and 13 holdings that did not utilise the Animal Health Service. The performance of these holdings, measured in liveborn piglets per sow year and pre-weaning and post-weaning mortality were compared given their status as client or non-client of the service and their exposure to various management factors like confinement, protein supplementation, frequency of feeding, management time per sow per day, the use of improved or exotic breeds, the extent of commercial activity and, in the case of piglets their season of birth (rainy or dry season). The mean number of sows per herd was 6, producing a mean litter size of 6.1 piglets with a mean interfarrowing interval of 235 days. The median pre-weaning mortality per litter was 0 and a median of 1 piglet per litter was used for productive purposes (consumed, gifted or sold) at a median age of 153 days. It was found that the greatest influence on productivity in these holdings was nutrition. Sow productivity (in terms of liveborn piglets per sow year and pre-weaning survival) was best in the non-client, free range herds that did not provide protein supplementation (but whose feeding was unrestricted due to their freedom to roam and scavenge) and worst in client and non-client herds that were confined and not given protein supplementation (due to restricted and underfeeding). The mortality of pigs post-weaning was significantly higher if they were free roaming, due to their loss to predation, theft and being hit by car. The study showed that the health status of pigs was better on holdings that did not use the Animal Health Service compared with those that did.

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CHAPTER 1

# Longitudinal Study of Smallholder Pig Systems in Samoa

## 1.1 Introduction

Pigs are an important livestock species in Samoa, with a total of 167,316 pigs owned by 77% of households (Anonymous 2000). Pigs are mainly used for home consumption - for example suckling pigs are commonly slaughtered and roasted for a special occasion - and they are also used for ceremonial gifts. Farmers also sell pigs to people for these purposes.

There are no commercial piggeries in Samoa; several restaurants and hotels have pig holdings that supply their kitchens but do not trade these pigs commercially. All other pigs are raised within smallholder systems and most are free ranging (Saville & Manueli 2002) with a small number that are permanently housed or confined to an open pen. Free roaming pigs are scavengers, their diet supplemented by once or twice-daily feeding, commonly with food scraps, coconut and other common crops (breadfruit, giant taro, cassava). Generally, confined pigs are also fed the same diet once or twice daily.

The Ministry of Agriculture's Animal Health Service provides the only veterinary service to pig holdings. The major health problems for which veterinary attention is sought are poor body condition and ill thrift due to gastrointestinal parasitism and/or inadequate nutrition, sarcoptic mange and injuries. There is no available baseline information on pig productivity (farrowing and weaning rates) and mortality in backyard pig holdings in Samoa.

The first objective of this study was to obtain baseline information on reproduction and mortality in pigs. To evaluate the quality of clinical pig health data collected by the

Animal Health Service for disease surveillance purposes, the second objective was to determine if the Animal Health Service was attending to a reasonable representation of sick pigs in the population, or if there was a large number of holdings that were not reporting sick animals at all. The data from this study can enhance animal disease surveillance in Samoa as it may facilitate the detection of emerging or introduced exotic diseases in pigs.

## 1.2 Materials and Methods

### 1.2.1 Study Design

A longitudinal study was carried out on smallholder pig farms on Upolu Island, Samoa starting in 2005. A total of 28 pig farms was enrolled in the study from March 2005 to June 2006. Of these, one group of 13 farms was randomly selected from the list of pig-owning clients in the veterinary case database of the Animal Health Service. The second group of 15 farms, which were not clients of the veterinary service, was randomly selected from a list of plantation owners who were clients of the Crops Division of the Ministry of Agriculture. Three farms were dropped from the study due to lack of interest of the owners. Two more farms were excluded because they could only be followed for 6 months, leaving 23 farms in the study (see Figure 1.1 for geographic distribution of farms). The study was limited to pig holdings on Upolu because the logistics of visiting holdings on Savaii were too difficult given the time available.

All farms were visited to collect pig production and mortality data every 4 to 12 weeks, for 12 to 18 months. Pigs were classified into the following 3 groups:

1. Adults (females that were pregnant or had farrowed at least once plus females and males that were assessed to be of reproductive age based on farmer information)
2. Growers (weaned pigs that were not yet adults)
3. Unweaned (piglets still suckling the sow; piglets weaned themselves except on 2 farms where litters were removed from the mother into a separate pen)

Adult pigs were each assigned a unique identification number and were identified by their physical appearance (colour and markings) and by ear notches made by their owners. Unweaned and weaner pigs were identified by their litter and dam. The following data were recorded during each visit:

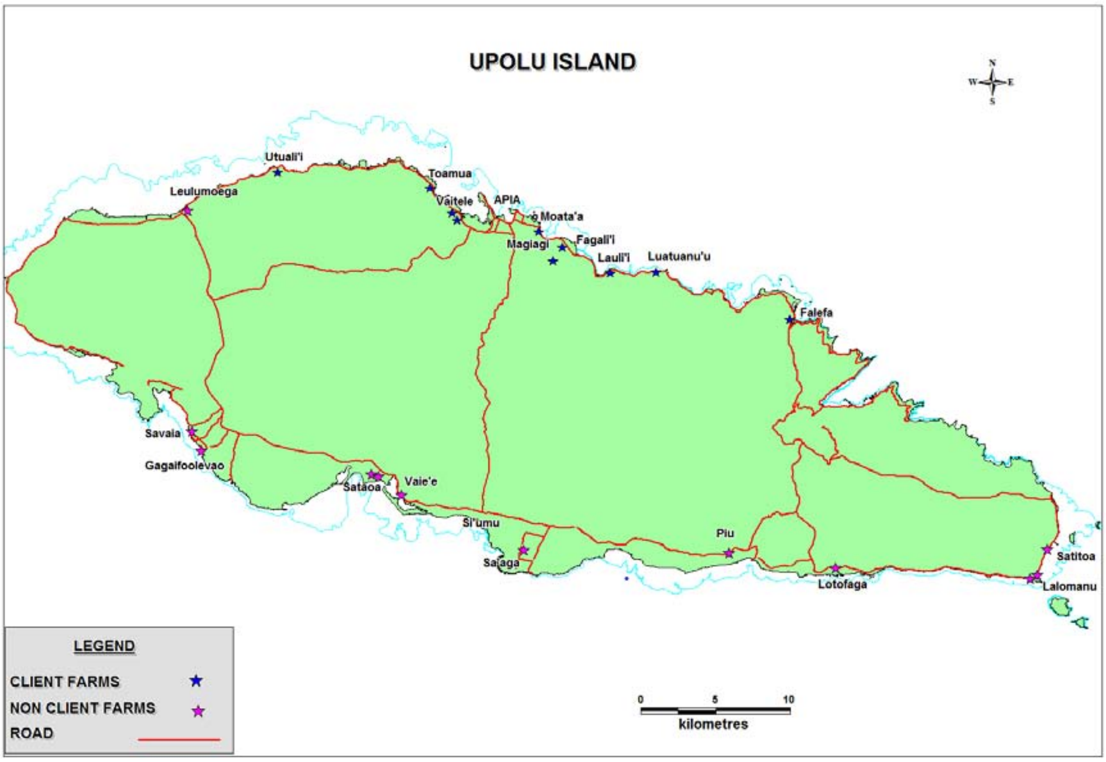


**Figure 1.1:** Map of Upolu Island showing the distribution of smallholder farms included in the longitudinal study of pig production and mortality in Samoa. Farms are divided into clients of the government's Animal Health Service and non-clients

1. Adult pigs

    - Adults present in the herd and the condition score of each
    - Adults no longer in the herd since the last visit, and the cause of their loss
    - Farrowings since the last visit

2. Litters and grower pigs

    - Litter birthdate (for newly enrolled litters)
    - Number born alive (for newly enrolled litters)
    - Number born dead (for newly enrolled litters)
    - Number of losses from litters and grower group and the date and cause of each, if known
    - Weaning date

It was rare to find all animals in a herd present at any one visit; in these cases the owner was asked to provide information on animals that were not present during a visit. Herds were classified as “free-range” either if the pigs were allowed to roam freely all the time or roamed freely during the day and were locked in a fenced area at night. “Confined” herds spent all their time in either a fenced enclosure on dirt or in housing on cement. Under free range systems, some sows seclude themselves just prior to farrowing and according to their owners do not come home with their litters for up to 3 weeks. For these sows, their litters’ birthdates were recorded as the day the sow left the herd for farrowing. Number born alive was the number of piglets at first sighting of the litter. Number born dead could not be recorded for these litters.

Owners were encouraged to contact the Animal Health Service in the event of an illness or death in the herd so that the cause could be investigated. They were also asked to note ill animals since the last visit - these were described as those pigs that were inappetent, lethargic, and generally unthrifty compared to the other animals in the herd or compared to the individual’s normal state. Other common signs of illness that farmers were asked to look out for were diarrhoea, weight loss, paralysis or paresis and injuries.

A questionnaire was also given to farmers at the start of the study. The questionnaire included information on farm management such as:

- Frequency of feeding
- Feedstuffs commonly used
- Whether improved-breed animals were bought for the breeding herd
- Daily number of hours that owners spent working on their pig farms
- Whether the owners sold pigs for profit
- Whether pigs were reared on their owner’s land

Owners were given the option of completing the questionnaire themselves, or answering the questions in an interview during the first visit.

All data were recorded in Microsoft Access (2003) from which they were subsequently extracted for manipulation and analysis in Microsoft Excel (2003) and R (Version 2.3.1).

### 1.2.2 Exposure Variables

Table 1.1 shows the farm, litter and animal level variables used in all analyses. Some variables were combined into one if they were highly correlated. For example, protein supplementation was only provided by some client farmers with confined herds. It was not provided to free range herds, whether owned by clients or non-clients. Because there was a high correlation between being a client, having a confined system and providing protein supplement, and there was only a small number of farms in some categories, these three variables were combined to form one composite explanatory variable, referred to as the composite 'Client status/management' variable, categorised as follows:

- Non-client with a free range system with no supplementation (12 farms)
- Non-client with a confined system with no supplementation (1 farm) was combined with Client with a confined system with no supplementation (4 farms)
- Client with a free range system with no supplementation (2 farms)
- Client with a confined system with supplementation (4 farms)

### 1.2.3 Descriptive Analyses

The reproductive performance of sows was described by the average number of piglets born live per litter per sow, the number of piglets born per sow per year, and (using data from the 59 sows that farrowed more than once during the study) the interfarrowing interval. Pre-weaning losses were divided into productive and non-productive losses. Productive losses or offtake were defined as piglets that were consumed, gifted or sold, while non-productive losses were piglets that died or were permanently lost from the study and hadn't been consumed, gifted or sold. Productive offtake was also presented for piglets that were consumed, gifted or sold at any age (pre- and post-weaning). Median time from birth to productive offtake and from birth to non-productive offtake was calculated for pigs taken off at all ages (including pre- and post-weaning). Median time from enrolment to death or loss was calculated for female pigs enrolled in the study as adults. Descriptive statistics were calculated for the total group of study farms and separately for the client and non-client groups.

**Table 1.1:** Exposure variables used in the analyses of factors affecting reproduction and mortality of pigs raised by smallholder farmers in Samoa

| Variable | Description | Analysis in which used |
|---|---|---|
| **Farm-level variables** | | |
| Client status / management | 0: Non-client of Animal Health Service, Free range system, Diet rarely or never supplemented with extra protein sources | All analyses |
| | 1: Client and Non-client, Confined system, Diet rarely or never supplemented with extra protein sources | |
| | 2: Client, Free range system, Diet rarely or never supplemented with extra protein sources | |
| | 3: Client, Confined system, Diet always supplemented with extra protein sources | |
| Own land | 0: Pigs run on land belonging to farmer | All analyses |
| | 1: Pigs run on land not belonging to farmer | |
| Frequency of feeding | 0: Fed once a day or less | All analyses |
| | 1: Fed twice a day or more | |
| Improved breeds (Pure- or cross-breed Duroc and Landrace) | 0: Farmers rarely or never buy in improved breeds for their breeding herd | All analyses |
| | 1: Farmers regularly buy in improved breeds for their breeding herd | |
| Commercial activity | 0: Farms are non-commercial; do not sell pigs for profit | All analyses |
| | 1: Farms regularly sell some pigs for cash | |
| Disease | 0: Less than 2 reported cases of illness during the study | All analyses |
| | 1: 2 or more reported cases of illness during the study | |
| Management time per sow | Total daily minutes spent working with pig herd divided by the average number of sows in the farm during the study period | All analyses |
| **Litter-level variables** | | |
| Weaning age | Unit: Days. The last day when piglets in a litter were seen to be suckling their mother or, in the case of 2 farms, the day when the litter was removed from its mother into a separate grower pen. | Cox proportional hazards regression |
| Season a litter was born | 0: Dry season (June - November). 1: Rainy season (December - May) | Logistic regression, Cox proportional hazards regression |
| **Animal-level variables** | | |
| Time at risk (TAR) | Total TAR for adults was the time from enrolment to death, slaughter, trade, loss or the end of the study. Total TAR for piglets was the time from birth to death, slaughter, trade, loss or the end of the study. | Poisson regression, Cox proportional hazards regression |

### 1.2.4 Modeling Risk Factors Associated with Reproduction

The association between farm management factors and the number of liveborn piglets per sow per year was assessed using Poisson regression analysis. The model was fitted in R using the glmmML package for generalised linear mixed models with a random intercept. The analysis only included those female pigs that were enrolled as adults at the first visit to each farm ($n = 123$), excluding those that entered the herd or came of reproductive age later in the study. Sows' total time at risk in the study was taken from date of enrolment until death or loss, productive offtake or the end of the study period. The log of the time at risk was used as an offset in the model. Intracluster correlation was calculated for farm and sow to determine the need for model adjustment for clustering (see Table1.5). The data were deemed to be markedly clustered if the intracluster correlation coefficient (ICC), $\rho$ was greater than 0.10. In addition to this, significance of overdispersion of the data was assessed using Bohning's test statistic (using EpiR package, built for R version 2.6.2).

The association between each exposure variable described in Table 1.1 and the outcome variable, piglets per sow year was screened by univariate poisson regression analysis. Exposure variables associated with the outcome at a significance level of $p \leq 0.2$ were used to build the preliminary multivariate poisson model in a forward stepwise fashion, starting with the most significant variable. A manual backward stepwise procedure was then used to eliminate 1 non-significant variable at a time and retaining only those variables that significantly improved model fit at a p-value of $\leq 0.05$ using the likelihood ratio test and Akaike's Information Criteria (AIC).

Two-way interactions were modeled to determine the presence of any significant ($p < 0.05$) meaningful or biologically plausible interaction terms. Confounding was assessed by monitoring the changes in regression coefficients when a variable was added or removed from the model.

Residual plots in the final model were examined for unusual patterns and the presence of outliers - in the presence of the latter, the data relevant to that outlier were assessed for error and effect on the model fit. Model fit was also assessed by testing the association between predicted and observed values, using $R^2$, the Pearson correlation coefficient.

### 1.2.5 Modeling Risk Factors Associated with Pre-weaning Mortality

The association between farm management factors, season of birth and pre-weaning mortality in piglets was explored using logistic regression. The analysis included all piglets born alive in all 159 litters that were born during the study period as well as all piglets born alive in 30 litters that were born before - but unweaned at - the start of the study. Mortality was defined as piglets that were found dead or which were permanently lost from the study and which had not been consumed, gifted or sold.

Intracluster correlation was calculated for farm, sow and litter to determine the need for model adjustment for clustering (see Table1.7). The data were deemed to be markedly clustered if the Intracluster correlation coefficient (ICC), $\rho$ was greater than 0.10.

The model was assembled by the same process described above for the Poisson regression analysis, including litter as a cluster term. The model was fitted in R again using the glmmML package for generalised linear mixed models with a random intercept. With the elimination of each non-significant variable, the significance of the difference in deviance between the reduced and previous model was assessed using the log-likelihood ratio test. Related to this was the comparison of the AIC (Akaike's Information Criteria) of the reduced and full model.

The relationship of the continuous variable, 'Time per sow' and the outcome variable was assessed by categorising 'Time per sow' by its quartiles, and plotting these against the regression coefficients of the univariate model of 'Time per sow'. A straight line plot would indicate linearity in the variable's log odds and thus a linear relationship with the outcome, thus complying with model assumptions. Non-linearity was accounted for by keeping 'Time per sow' as a 4-level categorical variable.

Two-way interactions and confounding were explored as before with the Poisson regression analysis.

Model fit was assessed as with the Poisson regression analysis, using residuals and Pearson's product moment correlation test.

### 1.2.6 Modeling Risk Factors Associated with Post-weaning Mortality

There were 479 pigs that survived to weaning during the study. For these, Cox proportional hazards (Cox-PH) analysis was used to determine the association between farm management factors, season of birth, weaning age and the post-weaning survival time (up to 200 days after weaning).

The analysis was carried out using the survival package in R (Version 2.3.1). Each variable was initially screened for a significant effect on post-weaning time to death by Kaplan-Meier analysis. Kaplan-Meier curves were plotted to visually assess differences in survival amongst different levels or groupings of a variable. The continuous variables ’Wean age’ and ’Time per sow’ thus were categorised into their quartiles to enable Kaplan-Meier analysis. Log rank tests were used to assess significance of differences across the levels of each variable.

Variables were further screened by univariate Cox-PH analysis. As with the Poisson and logistic analyses, all variables that were significant in the univariate analyses at $p \leq 0.02$ were used to build the preliminary Cox-PH model, which was then reduced by backward stepwise elimination starting with the least significant variable. The relationships of the continuous variables, ’Time per sow’ and ’Wean age’ with the outcome were assessed by categorising each variable by its quartiles, and plotting these against the regression coefficients from its univariate Cox-PH model. Non-linearity was accounted for by keeping these variables as 4-level categorical variables. ’Wean age’, however was further reduced to a 2-level variable after an assessment of its Kaplan-Meier curves showed little difference between the 4 levels. Likelihood ratio statistics and AIC values were used to compare the difference between a reduced model and the full model. Confounding and 2-way interactions were assessed in the same way as in the previous analyses. Because all weaners in the study farms were raised together in one cohort, ICC was assessed at farm level only and clustering accounted for by adding a farm random effect to the Cox-PH model.

After backward stepwise elimination, the model was tested to ensure that it met the assumption of proportional hazards. This was done by examining plots of the scaled Schoenfeld residuals over time for each variable in the model to ensure that the residuals were randomly scattered around 0 (i.e. had a slope of 0). The significance of the Pearson product-moment correlation between the scaled Schoenfeld residuals and time was assessed by Chi-squared test statistic. If the slope of a variable’s residuals was not 0 and the Chi-squared test was significant ($p < 0.05$), the variable was transformed into a time-dependent covariate.Time-dependent covariates were interaction terms between each of 3 intervals of the post-weaning period (created by classing the post-weaning period into 0 - 50 days, 51 - 100 days, 101 - 200 days) and the variable in question. The model with the time-dependent covariates was again assessed for further reduction. The final model was arrived at by removing non-significant variables and retaining any confounding variables.

The presence of outliers was determined by visualisation of boxplots of the deviance residuals for each of the variables. Influential statistics were visualised in the form of dfbeta residual plots, showing the changes in each regression coefficient upon the removal of each of the observations. Outliers were assessed further by visualising boxplots of days lived postweaning, stratified by the levels of the variable in question. Overall goodness of fit of the model was assessed using the Schemper and Stare $R^2$, measuring correlation between observed and predicted values in the model.

## 1.3 Results

The overall median time for which a farm was observed in the study was 11.1 months with a minimum of 9.8 months and a maximum of 16.7 months. There was a significant difference in the number of months for which a client farm was under observation compared with a non-client farm (Wilcoxon rank sum test = $p = 0.03$), with a median of 13.1 months for clients and 11.1 months for non-clients. The median number of visits per farm was 5, with a minimum of 4 and a maximum of 6. There was no significant difference between client and non client farms in the number of visits carried out (Wilcoxon rank sum test = $p = 0.09$). The difference in observation time between clients and non clients was controlled for in the analyses by classifying farms into the composite 'Client status/management' variable.

There were 4 farmers who preferred to fill in the farm management questionnaire in their own time. Two of these returned the completed questionnaire at the second visit; the other two towards the end of the study period. The other 19 farmers answered the questionnaire during an interview on the first visit.

On average farmers included in the study owned 6 sows, with no significant difference in the number owned by clients and non-clients ($p = 0.36$). There were 8 client farmers who owned boars, while non-client farmers relied on free-roaming boars from other herds to mate with their sows. Of the client farmers owning boars, 3 owned 2 (1 farmer had a total of 4 boars during the course of the study but only 2 boars at any one time) while the others owned only a single boar. Eight of the ten client farmers managed their pigs in a confined system, of which 2 raised their pigs in houses with concrete floors and the remaining 6 confined their pigs in a small fenced outdoors area. Only 1 of the 13 non-client farmers confined their pigs within a fenced area although the fence was not secure and the pigs escaped regularly. The remaining 12 farmers allowed their pigs to roam freely during the day, 4 of which owned the land on which their pigs roamed while the remaining pigs roamed on other peoples' land.

Almost all pig herds (21 out of 23), including confined and free range, were fed raw coconut either as the sole feed or the most common feed. Sixty percent of client farmers and 60% of non-client farmers fed their pigs raw coconut twice a day. Four farmers, all clients of the Animal Health Service regularly fed their pigs protein supplement in the form of fish waste from the fish market and meat scraps collected from restaurants. All except one farmer fed their pigs at least once a day. One client farmer did not feed his pigs daily, leaving them to scavenge out in the forest and plantations and feeding them every second or third day. Non-client farmers spent more time managing their pigs than client farmers, with a median time of 0.7 hours per adult pig per day compared with 0.4 for client farmers. Only a small number of farmers (5) sold pigs regularly, including 3 client and 2 non-client farmers. Two of the 3 client farmers that sold pigs bought improved or exotic breeds for breeding, while the 2 non-client farmers who bought improved breed pigs did not regularly sell pigs.

None of the farmers in the study kept records of their herds and all collected data relied partly on what was seen on the day of the visit but mostly on farmer recall.

Tables 1.2 and 1.3 show the descriptive statistics for all farms and for client and non client farms.

### 1.3.1 Piglets per Sow-year - Poisson Analysis

Of the total 137 sows enrolled during the study, 121 were enrolled on the first visit and 124 had litters during the study period. There were 110 sows that were parity 1 or greater at enrolment, 13 of which did not have a litter during the study period. There were 27 sows of parity 0 that were classified as being of reproductive age at the start of the study because the farmers had confirmed they had been mated or were pregnant and all

**Table 1.2:** Descriptive statistics for observation time, pig ownership, and pig production and mortality for 23 farms in a study of reproduction and mortality of pigs raised by smallholder farmers in Samoa during a follow-up period of up to 18 months.

| Variable | n | Mean (95% CI[a]) | Median[b] (IQR[c]) | Min[d] | Max[e] |
|---|---|---|---|---|---|
| Observation time per farm (months) | 23 | 12.0 (11.3, 12.7) | 11.1 (10.8, 12.9) | 9.8 | 16.7 |
| Visits per farm | 23 | 4.9 (4.6, 5.2) | 4.9 (4.5, 5.0) | 4 | 6 |
| Sows per farm | 23 | 6 (4.8, 7.2) | | 1 | 11 |
| Boars per farm | 23 | 0.6 (0.2, 1) | 0 (0, 1) | 0 | 4 |
| Interfarrowing interval | 59[f] | 235.5 (218.8, 252.2) | 219 (180.3, 265.5) | 128[g] | 466 |
| Liveborn piglets per litter | 189[h] | 6 (5.7, 6.3) | 6 (4, 7) | 1 | 13 |
| Liveborn piglets per sow per year | 50[i] | 8.8 (7.5, 10.1) | 8.7 (5.3, 11.6) | 0 | 18 |
| Pre-weaning productive[j] offtake per litter | 142[k] | 0.9 (0.7, 1.1) | 0 (0,1.8) | 0 | 6 |
| Pre-weaning productive offtake per litter (%) | 142 | 15 (11, 19) | 0 (0, 27) | 0 | 100 |
| Pre-weaning non-productive[l] offtake per litter | 142 | 1.8 (1.4, 2.2) | 1 (0, 3) | 0 | 10 |
| Pre-weaning non-productive offtake per litter (%) | 142 | 30(24, 36) | 20 (0, 46) | 0 | 100 |
| Piglets weaned per litter | 142 | 3.3 (2.9, 3.7) | 3(1, 5) | 0 | 11 |
| Piglets weaned per litter (%) | 142 | 56 (49, 62) | 60 (21, 100) | 0 | 100 |
| Weaning age (days) | 107 | 111 (104, 118) | | 19 | 251 |
| Productive offtake per litter at any age | 142 | 2 (1.7, 2.3) | 2 (0, 3) | 0 | 7 |
| Productive offtake per litter at any age (%) | 142 | 34 (29, 39) | 33 (0, 60) | 0 | 100 |
| Days from birth to productive offtake at any age | 306 | 153 (143, 163) | | 7 | 480 |
| Days from birth to non-productive offtake at any age | 368 | 73 (65, 81) | | 1 | 320 |
| Days from enrolment to death/loss (females enrolled as adults) | 27 | 174 (130, 218) | | 11 | 401 |

[a] 95% confidence intervals

[b] Shown only for those variables which were not normally distributed

[c] Interquartile range

[d] Minimum

[e] Maximum

[f] Includes farrowing events before the start of the study where the sow concerned was nursing piglets at enrolment

[g] This figure was the result of adjustment to one farrowing date estimated by the farmer which would have given the sow concerned an interfarrowing interval of 106 days

[h] Includes litters that were born before but unweaned at the start of the study

[i] Sows that were in the study for at least 1 year

[j] Productive offtake: gifted, sold, eaten, used for family obligations

[k] Includes all 107 litters weaned during the study plus 35 litters that had 100% loss to non-productive and/or productive offtake before weaning

[l] Non-productive offtake: found dead or was permanently lost from herd and was not gifted, sold, eaten or used for family obligations

**Table 1.3:** Descriptive statistics for observation time, pig ownership, and pig production and mortality, for client farms in a study of reproduction and mortality of pigs raised by smallholder farmers in Samoa

| Variable | n | Mean (95% CI[a]) | Median[b] (IQR[c]) | Min[d] | Max[e] |
|---|---|---|---|---|---|
| Clients | 10 | | | | |
| Observation time per farm (months) | 10 | 13.1 (11.6, 14.6) | 13.1 (12.2, 14.4) | 9.8 | 16.7 |
| Visits per farm | 10 | 5.2 (4.6, 5.8) | 5.0 (5.0, 6.0) | 4 | 6 |
| Sows per farm | 10 | 6.6 (4.2, 9.0) | | 1 | 11 |
| Boars per farm | 10 | 1.3 (0.5, 2.1) | 1 (0, 1) | 0 | 4 |
| Interfarrowing interval | 20[f] | 251 (220, 283) | 261 (198, 274) | 149 | 466 |
| Liveborn piglets per litter | 83[g] | 5.2 (4.7, 5.6) | 5 (4, 6.8) | 1 | 12 |
| Liveborn piglets per sow per year | 34[h] | 6.9 (5.6, 8.2) | 8.7 (5.3, 11.6) | 0 | 18 |
| Pre-weaning productive[i] offtake per litter | 62[j] | 0.5 (0.2, 0.9) | 0 (0,1) | 0 | 6 |
| Pre-weaning productive offtake per litter (%) | 62 | 10 (5, 15) | 0 (0, 0) | 0 | 100 |
| Pre-weaning non-productive[k] offtake per litter | 62 | 1.8 (1.2, 2.3) | 1 (0, 3) | 0 | 10 |
| Pre-weaning non-productive offtake per litter (%) | 62 | 34(24, 44) | 20 (0, 55) | 0 | 100 |
| Piglets weaned per litter | 62 | 3 (2.3, 3.6) | 3 (0, 5) | 0 | 9 |
| Piglets weaned per litter (%) | 62 | 56 (46, 66) | 60 (0, 100) | 0 | 100 |
| Weaning age (days) | 45 | 107 (93, 122) | 119 (61, 135) | 19 | 251 |
| Productive offtake per litter at any age | 62 | 1.7 (1.2, 2.1) | 1 (0, 3) | 0 | 7 |
| Productive offtake per litter at any age (%) | 62 | 32 (23, 41) | 20 (0, 59) | 0 | 100 |
| Days from birth to productive offtake at any age | 105 | 172 (152, 192) | | 7 | 480 |
| Days from birth to non-productive offtake at any age | 146 | 54 (42, 67) | | 1 | 280 |
| Days from enrolment to death/loss (females enrolled as adults) | 8 | 203 (118, 289) | | 32 | 401 |

[a] 95% confidence intervals

[b] Shown only for those variables which were not normally distributed

[c] Interquartile range

[d] Minimum

[e] Maximum

[f] Includes farrowing events before the start of the study where the sow concerned was nursing piglets at enrolment

[g] Includes litters that were born before but unweaned at the start of the study

[h] Sows that were in the study for at least 1 year

[i] Productive offtake: gifted, sold, eaten, used for family obligations

[j] Includes all 45 litters weaned during the study plus 17 litters that had 100% loss to non-productive and/or productive offtake before weaning

[k] Non-productive offtake: found dead or was permanently lost from herd and was not gifted, sold, eaten or used for family obligations

**Table 1.4:** Descriptive statistics for observation time, pig ownership, and pig production and mortality, for non-client farms in a study of reproduction and mortality of pigs raised by smallholder farmers in Samoa

| Variable | n | Mean (95% CI[a]) | Median[b] (IQR[c]) | Min[d] | Max[e] |
|---|---|---|---|---|---|
| Non clients | 13 | | | | |
| Observation time per farm (months) | 13 | 11.2 (10.9, 11.5) | 11.1 (11, 11.1) | 11 | 13 |
| Visits per farm | 13 | 4.7 (4.4, 5) | 5 (4, 5) | 4 | 5 |
| Sows per farm | 13 | 5.5 (4.2, 6.7) | | 2 | 8 |
| Boars per farm | 13 | 0 (0, 0) | 0 (0, 1) | 0 | 0 |
| Interfarrowing interval | 39[f] | 226 (207, 246) | 211 (178, 246) | 128[g] | 406 |
| Liveborn piglets per litter | 107[h] | 6.6 (6.2, 7) | 7 (5, 8) | 1 | 13 |
| Liveborn piglets per sow per year | 16[i] | 12.7 (10.8, 14.6) | 12.4 (9.9, 16.0) | 7.3 | 18 |
| Pre-weaning productive[j] offtake per litter | 80[k] | 1.1 (0.8, 1.5) | 0 (0,2) | 0 | 6 |
| Pre-weaning productive offtake per litter (%) | 80 | 19 (13, 25) | 0 (0, 38) | 0 | 100 |
| Pre-weaning non-productive[l] offtake per litter | 80 | 1.8 (1.3, 2.3) | 1 (0, 3) | 0 | 8 |
| Pre-weaning non-productive offtake per litter (%) | 80 | 26(19, 33) | 20 (0, 38) | 0 | 100 |
| Piglets weaned per litter | 80 | 3.6 (3.0, 4.2) | 4(2, 5) | 0 | 11 |
| Piglets weaned per litter (%) | 80 | 55 (47, 63) | 60 (28, 84) | 0 | 100 |
| Weaning age (days) | 62 | 114 (109, 120) | | 50 | 188 |
| Productive offtake per litter at any age | 80 | 2.3 (1.9, 2.7) | 2 (0, 3) | 0 | 7 |
| Productive offtake per litter at any age (%) | 80 | 37 (30, 43) | 38 (0, 60) | 0 | 100 |
| Days from birth to productive offtake at any age | 201 | 143 (132, 154) | | 28 | 404 |
| Days from birth to non-productive offtake at any age | 222 | 85 (76, 95) | | 1 | 320 |
| Days from enrolment to death/loss (females enrolled as adults) | 19 | 162 (106, 217) | | 11 | 327 |

[a] 95% confidence intervals
[b] Shown only for those variables which were not normally distributed
[c] Interquartile range
[d] Minimum
[e] Maximum
[f] Includes farrowing events before the start of the study where the sow concerned was nursing piglets at enrolment
[g] This figure was the result of adjustment to one farrowing date estimated by the farmer which would have given the sow concerned an interfarrowing interval of 106 days
[h] Includes litters that were born before but unweaned at the start of the study
[i] Sows that were in the study for at least 1 year
[j] Productive offtake: gifted, sold, eaten, used for family obligations
[k] Includes all 62 litters weaned during the study plus 18 litters that had 100% loss to non-productive and/or productive offtake before weaning
[l] Non-productive offtake: found dead or was permanently lost from herd and was not gifted, sold, eaten or used for family obligations

**Table 1.5:** Intracluster correlation ($\rho$) for the number of liveborn piglets at farm and sow level

| Level of clustering | Number of clusters | $\rho$ |
|---|---|---|
| Farm | | |
| Overall | 23 | 0.17 |
| Clients | 9 | 0.08 |
| Non clients | 13 | 0.10 |
| Sow | | |
| Overall | 123 | 0.62 |
| Clients | 46 | 0.46 |
| Non clients | 58 | 0.23 |

**Table 1.6:** Poisson model for liveborn piglets per sow year, using the log of sow years at risk as an offset

| Variable | Coefficient (SE$^a$) | IRR$^b$ | IRR 95% CI$^c$ | $p$ | PSY$^d$ |
|---|---|---|---|---|---|
| Non client, Free range, Not supplemented (Referent) | 2.30 (0.09) | 10.00 | 8.41, 11.90 | $< 0.01$ | 10.0 |
| Client and Non client, Confined, Not supplemented | -0.99 (0.20) | 0.37 | 0.25, 0.55 | $< 0.01$ | 3.7 |
| Client, Free range, Not supplemented | -0.47 (0.19) | 0.63 | 0.44, 0.91 | 0.01 | 6.3 |
| Client, Confined, Supplemented | -0.60 (0.17) | 0.55 | 0.39, 0.78 | $< 0.01$ | 5.5 |

$^a$Standard error
$^b$Incidence rate ratio
$^c$95% confidence intervals of the Incidence rate ratio
$^d$Piglets per sow-year

went on to farrow during the study period.There were no farrowing events in one of the 'Client/Confined/Supplemented' farms during the study period. Descriptive statistics for all farms, client farms and non-client farms are presented in Tables 1.2, 1.3 and 1.4 respectively.

Table 1.6shows the results from the final regression model of farm management and sow factors associated with number of liveborn piglets per sow per year. Sow was included as a random effect in the model ($\rho = 0.61$, Table 1.5). The $R^2$ value for the model was 0.13.

Non-client free range herds produced significantly more piglets than client free range herds, client confined supplemented herds, and client/non-client confined herds that were not fed a protein supplement. The worst reproductive performance was seen in pigs raised in confined systems with no protein supplementation.

### 1.3.2 Pre-weaning Mortality

The descriptive statistics for pre-weaning mortality are shown in Tables 1.2 and 1.3. A total of 1132 piglets from 189 litters were enrolled in the study. This included piglets from 30 litters that were born before but were unweaned at the start of the study and for which complete data on number born live and mortalities could be obtained. There were 47 litters that were unweaned at last observation and 20 litters (104 piglets) in the study that had 100% pre-weaning mortality. The same 'Client/Confined/Supplemented' farm that did not experience a farrowing event during the study period also did not contribute any piglets to the pre-weaning mortality analysis. Results were clustered at all levels but especially at litter level (rho = 0.44) (Table 1.7). Litter was therefore used as a random effect in the logistic model.

The non-significant but confounding variables 'Frequency of feeding' (confounder for 'Time per sow' and 'Client/Confined/Supplement') and 'Improved breed' (confounder for 'Client/Confined/Supplement') were included (but not shown) in the final model (Table 1.8). The $R^2$ value for the model was $0.21$.

As shown, pigs born in the wet season had lower odds of pre-weaning mortality than those born in the dry season. Pigs in semi-commercial farms had more than 10 times the odds of death of pigs in non-commercial farms. Where farm management time per sow was 37 to 48 minutes, the odds of death were about 10% that of pigs in farms where the management time was less than 37 minutes or greater than 48 minutes. Pigs in client and non client farms that were confined and not supplemented had more than 8 times the odds of death of pigs in non client farms that were free range and not supplemented. The odds of pre-weaning death in client farms that were free range and not supplemented and client farms that were confined and supplemented were not significantly different from that in non client/free range/non-supplemented farms. Farms that reported 2 or more cases of illness in their pigs had close to 80% higher odds of pre-weaning mortality compared to farms that only reported one case of illness or none at all.

### 1.3.3 Post-weaning Mortality

Of the 1132 piglets (from 189 litters) that were enrolled in the study, 470 (from 122 litters) were weaned. Of these, 438 were used for the analysis after the exclusion of all weaner

**Table 1.7:** Intracluster correlation ($\rho$) for pre-weaning mortality at farm, sow and litter level

| Level of clustering | Number of clusters | $\rho$ |
|---|---|---|
| Farm | | |
| Overall | 22 | 0.10 |
| Clients | 9 | 0.13 |
| Non clients | 13 | 0.07 |
| Sow | | |
| Overall | 124 | 0.27 |
| Clients | 58 | 0.36 |
| Non clients | 66 | 0.18 |
| Litter | | |
| Overall | 189 | 0.44 |
| Clients | 82 | 0.52 |
| Non clients | 107 | 0.37 |

**Table 1.8:** Logistic model for pre-weaning piglet mortality

| Variable | Coefficient (SE[a]) | Odds ratio (OR) | OR 95% CI[b] | $p$ |
|---|---|---|---|---|
| **Constant** | -1.40 (0.97) | 0.25 | 0.04 - 1.65 | 0.15 |
| **Season born** | | | | |
| Dry | Referent | | | |
| Wet | -1.15 (0.46) | 0.32 | 0.13 - 0.78 | 0.01 |
| **Commercial activity** | | | | |
| Non-commercial | Referent | | | |
| Semi-commercial | 2.38 (0.72) | 10.85 | 2.66 - 44.28 | $< 0.01$ |
| **Management time per sow[c] (minutes)** | | | | |
| $\leq 12$ | Referent | | | |
| $> 12 \leq 36$ | 0.35 (0.95) | 1.42 | 0.22 - 9.21 | 0.71 |
| $> 36 \leq 48$ | -2.21 (1.05) | 0.11 | 0.01 - 0.87 | 0.04 |
| $> 48$ | 1.12 (0.96) | 3.06 | 0.47 - 20.11 | 0.24 |
| **Client status / Management** | | | | |
| Non-client, free range, not supplemented[d] | Referent | | | |
| Client & Non-client, confined, not supplemented | 2.13 (0.94) | 8.45 | 1.35 - 52.97 | 0.02 |
| Client, free range, not supplemented | 0.96 (1.11) | 2.62 | 0.30 - 22.90 | 0.38 |
| Client, confined, supplemented | -0.17 (0.87) | 0.85 | 0.15 - 4.64 | 0.85 |
| **Disease reports[e]** | | | | |
| $< 2$ | Referent | | | |
| $\geq 2$ | -1.71 (0.76) | 0.18 | 0.04 - 0.80 | 0.02 |

[a] Standard error
[b] 95% confidence intervals of the odds ratio
[c] Total time spent per day working in the pig holding, divided by the number of sows
[d] Specifically, supplemented with extra protein
[e] Total number of cases of ill animals reported during the study

pig observations (n = 32) from one 'Client/Confined/Supplemented' farm. On exploratory analysis, it was noted that observations from the pigs on this farm were extreme outliers because the three post-weaning deaths it contributed to the analysis all occurred very soon after weaning, unlike the other farms where post-weaning death occurred at various times; thus it had an unusually low mean time to failure. Table 1.9 shows the significant results of the Cox Proportional hazards model, which had a Schemper and Stare $R^2$ value of $0.32$. Not shown is the confounding but non-significant variable 'Season born' ($p = 0.24$). Due to clustering at farm level ($\rho = 0.12$) the model included a farm random effect.

The variables 'Own land' and 'Client status/management' were transformed into time-dependent covariates. After accounting for its variability over time, the time-dependent covariate 'Own land' was no longer significant and was thus removed from the model. Management time played a role in the hazard of death where farms with a daily management time of 13 - 36 minutes per sow had a significantly better survival time (hazard of death 0.28 times that of the referent category) as did those with a daily management time of over 48 minutes per sow (hazard of death 0.54 times that of the referent category). There was no significant difference in post-weaning mortality between farms in the referent category and those with a daily management time of 37-48 minutes. The different levels of the 'Client status/management' variable had significantly different effects on survival past 50 days post-weaning; according to the classification order of the 'Client status/management variable', the hazard of death became significantly lower in the client, confined herds with protein supplement provided (category 4) when compared with non-client, free range herds with no protein supplement (category 1, referent).

**Table 1.9:** Cox Proportional Hazards model for post-weaning mortality (up to 200 days) with adjustment for farm-level clustering

| Variable | Coefficient (Robust SE[a]) | Hazard ratio (HR) | HR 95% CI[b] | $p$ |
|---|---|---|---|---|
| **Time per sow[c] (minutes)** | | | | |
| $\leq 12$ | Referent | | | |
| $> 12 \leq 36$ | -1.27 (0.43) | 0.28 | 0.14 - 0.96 | $< 0.01$ |
| $> 36 \leq 48$ | -0.02 (0.26) | 0.98 | 0.80 - 2.05 | 0.93 |
| $> 48$ | -0.62 (0.35) | 0.54 | 0.39 - 1.21 | 0.07 |
| **Time-dependent covariate: Client status / Management[d]** | | | | |
| Up to 50 days post-weaning | 0.08 (0.25) | 1.08 | 6.23 - 29.10 | 0.74 |
| 51 - 100 days post-weaning | -0.87 (0.39) | 0.42 | 1.87 - 6.47 | 0.03 |
| 101 - 200 days post-weaning | -3.20 (1.01) | 0.04 | 0.59 - 2.29 | $< 0.01$ |

[a] Standard error
[b] 95% confidence intervals of the hazard ratio
[c] Total time spent per day working in the pig holding, divided by the number of sows
[d] Client or Non-client, management system and supplementation with extra protein

## 1.4 Discussion

In this study the reproductive performance of sows and piglet mortality levels were examined separately rather than combining the variables into a productive output of piglets weaned per sow-year. The reason for this was two-fold. Firstly the interest was in obtaining baseline data on the number of piglets born alive per sow year and on pre- and post-weaning mortality of piglets. Having this information facilitates the assessment of future changes to these parameters that may indicate the introduction of disease that is largely manifest at a sub-clinical level. Secondly, identifying management factors associated with these parameters separately may enable more targeted advice to be provided to farmers. While improving productivity is not a major objective of smallholder pig farmers in Samoa, farmers are being encouraged to apply what are perceived by many to be 'improved' farming methods that involve confining pigs and it is useful to identify factors that affect reproduction and mortality under these conditions.

The reproductive performance of sows in Samoa, as measured by liveborn piglets per sow-year is comparable with that reported from smallholder pig farms in other countries (median 9 piglets per litter and median of 1 litter per sow year in Kenya (Wabacha et al. 2004)). This parameter is affected by a combination of litter size and interfarrowing interval, with a mean litter size of 6.1 piglets and a mean interfarrowing interval of 235 days hence sows are producing a mean of 3 litters every 2 years. The interfarrowing interval for sows in Samoa was similar to that recorded for sows in the Philippines (Lanada et al, 1999) and better than sows in Bolivia (Paterson et al., 2001) although mean litter size was smaller than the 8.4 - 8.5 and 8.1. reported for each country respectively.

The results of this study suggest that nutrition is the major factor limiting sow reproduction rates in Samoa. Pigs raised in confined systems without protein supplement had poorer reproductive performance than confined pigs that were provided with protein supplement. Non client free roaming herds performed best most likely due to unrestricted feeding. Free roaming pigs have the opportunity to scavenge throughout the day, in coconut plantations and other crops; they are then also fed by their owners at least once a day. It was observed during the study that those pigs that were receiving protein supplementation were usually also receiving larger portions of other non-protein feed than those confined pigs that did not receive protein supplementation.

Many farmers believe that the offspring of local pigs and improved breeds - namely the Landrace, Duroc and Large White - produce more piglets and grow faster. Other studies show that crosses of these improved breeds with local breeds have a larger productivity potential than a purely local breed (Jansen et al. 2006, Lemke et al. 2006, de Fredrick & Osborne 1977). There was no effect of breed on productivity in the study although this may have been suppressed by poor management, especially nutrition (Lemke et al. 2006). Access to boars was not a problem on any of the farms that permanently confined pigs: either there was a boar present which mingled freely with the females and was not penned separately, or the enclosure was not fully secure and the herd as well as other pigs could still leave and enter the enclosure.

Again, nutrition appeared to have a major influence on pre-weaning piglet mortality risk, with higher mortality in confined herds that were not fed a supplement. Pre-weaning mortality was also affected by the season in which piglets were born, with better survival of piglets born in the rainy season compared with the dry season. This may be associated with better feed availability in the wet season.

Semi-commercial herds had much higher odds of pre-weaning mortality compared with non-commercial herds. This may be explained to some extent by the different management practices in these herds. One semi-commercial herd penned sows from just before farrowing and kept them in the pen at all times with the piglets until forced weaning. This was the only holding in the study that often reported piglet deaths due to overlaying.

Farmer recall may also be an issue, where semi-commercial farmers with an incentive to minimise losses monitor their herds more closely and remember the causes of losses from the herd - thus more pre-weaning losses are recorded. On the other hand, non-commercial farmers may not pay as close attention and may mistakenly say that a piglet had been lost or died, where it had actually been used as productive offtake.

Herds where farmers spend 37 - 48 minutes per sow per day working on the holding have a lower odds of mortality than if the management time was less than 37 minutes or more than 48 minutes. Farmers indicated that their daily management time was spent on activities like collecting and preparing feed (for example collecting coconuts from the plantation or buying them from another plantation, husking and shelling them) and sometimes in making improvements to the holding infrastructure. Consequently nutrition may be better in these holdings where much time is invested in preparing pig feed and this may show as decreased pre-weaning mortality. However, it is difficult to explain the significance of this management time category as there is no dose-response relationship between management time and the odds of pre-weaning mortality. Furthermore, this group of farms experienced a higher risk of post-weaning mortality compared with the management time group above and below it. It is likely that the effect of this management time group was confounded with an unidentified variable affecting piglet mortality.

Strangely, herds from which there were more reports of ill pigs had reduced odds of pre-weaning mortality compared with those that rarely or never reported disease in their herds. Rather than disease having a protective effect on the pigs, this is more likely an indication of better farm management through improved disease detection whereas those holdings where management is not as good may be experiencing disease but it is either going unnoticed or the farmer is merely not responding to it.

The effect of client status and management system on post-weaning mortality varies with the age of the pigs. As pigs grow older (51 days and older), those weaners in client, confined and supplemented holdings have a lower hazard of death than those weaners in the free range non client herds (lowest order of the composite variable was non client/free range/not supplemented and the highest order was client/confined/supplemented). The hazard was reduced even further after 100 days post-weaning. One explanation for this is that free roaming pigs will be more likely to be stolen, hit by car, attacked by dogs or lost by other means while roaming. Enclosed weaners are not at risk of this, especially if they are fed well in confinement, thus reducing the risk of them escaping the enclosure to scavenge for food, and their better nutrition would also improve their survivability unlike those confined weaners without supplementation.

An important finding of this study was that the pig farms that use the Animal Health Service had poorer productivity than non-clients, both in terms of piglets born alive per sow-year and mortality of piglets. The geographical distribution of farms in the study (Figure 1.1) raised the question that perhaps these non client farmers do not utilize the Animal Health Service because of their distance from town and the Animal Health Service office. Almost all non client farms were located on the southern coast of Upolu Island whereas the client farms were more concentrated on the northern coast, around the town area. However the results of the study indicate that the non client farms do not have the problems faced by client farms and this is more likely the reason they do not use the Animal Health Service. This makes the findings of this study important as it provides confidence that non-client farmers have better productivity and health in their pigs and are not in the dilemma of having poor health and productivity but have difficulty contacting the Animal Health Service for assistance. While the majority of pig holdings in Samoa are free range systems more commonly found outside of town, clients of the Animal Health Service are concentrated around the town area and most commonly have confined pig holdings. The reasons for confinement are mainly restrictions to free-roaming pigs in built-up areas not only due to a lack of grazing land but also due to the damage that the pigs can do to residential properties.

Due to a lack of resources, the study was limited to the main island of Upolu, which is more developed and much more built up than the larger island of Savai'i. There are more extensive pig systems on Savai'i than are on Upolu, as commonly experienced by Animal Health staff on Savai'i - these free roaming systems commonly pose a problem when interventions have to be made in sick pigs but they cannot be caught for the Animal Health staff to examine and treat. Disease status is similar on the two islands (Martin 1999) and livestock are often transported across the islands by ferry. However, a similar investigation as has been done on Upolu is still warranted for Savai'i, where the number of sick pig cases attended by the Animal Health staff is about one every two months compared to the average of about 8 cases per month seen on Upolu.

Because of the reliance on farmer recall for information, the extended periods between some visits were problematic in that farmers took longer to recount farrowing and mortality events and sometimes caused confusion by repeating information that was already collected at the previous visit. This sometimes resulted in extensive examination of the data for credibility and a repeat visit or a telephone interview to confirm information. In one case as shown in the tables of descriptive statistics (Tables 1.2 and 1.3), the estimated birthdate of one litter indicated that the sow only had an interfarrowing period of 106 days. Future observational studies of smallholder farms in the country will benefit from more frequent visits to overcome problems that arise from the lack of record keeping overall as well as the lack of close attention of many farmers to the important happenings in their holding. It was difficult to keep farmers interested in participating in the study as most did not see any benefit in it for themselves. Almost all farmers enquired about obtaining free pig fencing and housing materials through the ’study project’. The offer of free veterinary treatment was not an attractive incentive as most farmers did not perceive there was any illness in their pigs.

From the findings of this study, it is believed that nutrition is the most important factor in determining productivity in Samoan pig holdings and this has been previously discussed regarding smallholder pig herds in the Pacific as well as other tropical countries (Saville & Manueli 2002, Lanada et al. 1999, Lanada et al. 2005, Quartermain & Kohun 2002, de Fredrick & Osborne 1977). It has been shown that raw coconut fed with a little protein supplementation can be as good a feed as commercial formulations (Hide 2003). It will be worthwhile in future studies to measure nutrition quantitatively by weighing different food types in the daily feed or by nutritional analysis in order to see a clearer effect of nutrition.

While traditional free range systems are still the most common method of raising pigs, owners face pressure from village councils and other community members to confine their herds for hygienic reasons as well as to protect crops from damage caused by rooting pigs. There are also large losses of pigs to misadventure and thieves. It may be argued that this is an acceptable cost to these free range systems that require very little input from the owner in terms of labour and money whereas currently fully confined, intensive systems are not as productive in terms of piglets produced, yet require much more financial and labour input. However if farmers are to keep up with the changes in Samoan society that require modifications in traditional methods of pig raising, less extensive holdings will have to be considered. It may be enough to practice forced weaning at a certain age, confine these weaners and make efforts to provide adequate nutrition for their growth while the breeding herd remains free roaming thus obtaining most of its feed from scavenging. Pig owners may eventually have to consider confining their entire herd but will always need to focus much more on providing adequate nutrition for these animals.

With the basic information collected from this study, the animal health and extension workers now have better information with which to advise farmers about ways in which they can improve their herds which do not require drastic changes from traditional methods and which are affordable and easy to implement. Furthermore, there is now greater confidence in the value of pig case data recorded by the Animal Health Service as a component of disease surveillance in Samoa as the study had shown that the productivity and health status of pigs on farms that are not using the service is better than those that are using the service, indicating that the Animal Health Service is not missing major health problems amongst pigs in Samoa.

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