FARMERS' KNOWLEDGE AND INCENTIVE IN REPORTING INFECTIOUS ANIMAL DISEASE: THE CASE OF AFRICAN SWINE FEVER IN MADAGASCAR

T. N. Randrianantoandro[1], S. Kubota[2], and H. Kono[2*]

[1]Graduate School of Obihiro University of Agriculture and Veterinary Medicine,
[2]Department of Animal and Food Hygiene, Obihiro University of Agriculture and Veterinary Medicine, 2-11 Inada, Obihiro, Hokkaido 080-8555, Japan.
[*]Correspondence Author E-mail: kono@obihiro.ac.jp

ABSTRACT

One issue in the control of infectious animal disease is adverse selection, meaning farmers have information about the health status of their animals during an outbreak, but are unwilling to report it to the government. The objectives of our study are, first, to elicit farmers' knowledge about African swine fever (ASF) and, second, determine farmers' willingness to accept (WTA) compensation as an incentive for reporting ASF cases. To evaluate their knowledge about the disease, 201 pig farmers were interviewed using questions related to ASF. The contingent valuation (CV) technique was used to estimate their WTA compensation for culled pigs. The results show that the majority of the farmers answered questions regarding ASF correctly. The CV results also show that, as compensation increases, more farmers are willing to report ASF cases. However, the probability of reporting depends on certain farm-related characteristics, namely, farmers' knowledge about ASF, administration of the classical swine fever vaccine, and experiences with ASF. The results indicate that providing adequate financial compensation is important for incentivizing the reporting of ASF outbreaks. Even so, it is necessary to also conduct an awareness campaign on ASF's economic impact to prevent farmers who know that ASF is not harmful to human health from rejecting compensation. In addition, farmers' knowledge about ASF transmission should be improved.

Key words: African swine fever, farmers' knowledge, Madagascar, willingness to accept compensation.

INTRODUCTION

Animal disease reduces farm output (Bennett, 2003). Several studies have been conducted to assess the impact of different animal disease outbreaks on farms (Tisdell *et al.*, 1999; Perry and Rich, 2007; Fasina *et al.* 2012; Rich and Hamza, 2013) Indeed, animal disease is a burden for African countries (Rich and Perry, 2012).

African swine fever (ASF) was first detected in Madagascar in 1998 (Rousset *et al.*, 2001). ASF is an infectious viral pig disease with a mortality rate up to 100%. One of the key elements in controlling the spread of ASF is stamping out (culling of all sick and contaminated animals, destruction of their carcasses, and cleansing and disinfection of premises) or modified stamping out (for example, culling of sick animals only) (Office International des Epizooties (OIE), n.d.). Despite control measures, ASF has been endemic in Madagascar (Penrith *et al.*, 2013). Among the control measures, there is a law (Ministerial Decree No. 960/98, Article 2) that stipulates compulsory and immediate reporting of infectious animal disease suspicion. However, farmers having information about the health status of their animals during an outbreak might be unwilling to report it to the government due to the cost reporting might incur (Hennessy and Wolf, 2015). This unwillingness to report is considered adverse selection. In fact, farmers in Madagascar illegally sell the ASF infected pigs instead of reporting any ASF suspicion (Randrianantoandro *et al.,* 2015). According to Penrith *et al.* (2013), in ASF-endemic areas, farmers are less likely to report ASF, which poses an important challenge for disease control of the. Additionally, public veterinarians in Madagascar mainly inspect animals before slaughter and the meat after slaughter (Meslin, n.d.) rather than monitor farms. Therefore, obtaining information about disease occurrence depends on farmers' willingness to report it. Presumably, one of the reasons for not reporting ASF infections in Madagascar is the lack of incentives, such as a compensation system for infected pigs to be culled. According to Penrith and Thomson (2004), farmers in developing countries accept stamping out as long as market-related compensation is available. Additionally, the Food and Agriculture Organization (FAO, n.d.) recommends financial compensation as a fair way to deal with the issue of stamping out.

Another fact that cannot be ignored in the control of infectious animal disease is that farmers only possess private information about the level of biosecurity[1] they adopt in the farm before the disease

[1] Examples of biosecurity measures are usage of pigpens, absence of pets on the farm, insect control, and feed without domestic waste.

outbreak. If compensation is available, farmers may decrease the level of biosecurity in their farm, resulting in an increased risk of infection, which is a moral hazard[2] issue (Hennessy and Wolf, 2015). Although compensation is currently unavailable, Costard *et al.* (2009) reported that limited biosecurity measures were applied in smallholder pig farms in Madagascar. However, these might become inexistent if compensation is made available.

Farmers' knowledge about the disease is very important for an effective animal disease control program (Martin *et al.*, 1994). Consequently, this study hypothesizes farmers' knowledge about ASF to be a factor that influences their attitude towards reporting and the level of biosecurity they adopt on the farm. That is, we hypothesize that farmers' knowledge along with compensation mitigate adverse selection and moral hazard issues.

Therefore, the objectives of our study are, first, to elicit farmers' knowledge about ASF and, second, determine farmers' willingness to accept (WTA) compensation as an incentive for reporting ASF cases. That is, if farmers report ASF cases, the government will cull the infected pigs and provide financial compensation for the farmers' loss.

Literature review: Studies show that stamping out is economically worthwhile. Examples are that of McInerney and Kooij (1997) for Aujeszky's disease, the study of Smith *et al.* (2007) for bovine tuberculosis control, and that of Bech-Nielsen *et al.* (1993), who analyzed the cost and benefit of ASF eradication in Spain. However, farmers' cooperation is needed for a feasible stamping out. To the best of our knowledge, few studies (Gramig *et al.,* 2009; Hennessy and Wolf, 2015) have focused on designing compensation for animal disease control. Moreover, such studies are mainly theoretical in nature. For instance, the study of Gramig *et al.* (2009) suggested compensation to incentivize farmers to invest in biosecurity. However, as they are mainly small scale, pig farmers in Madagascar are unable to invest in biosecurity *(Costard et al.*, 2009). Hence, this study considers compensation as an incentive to report infection status. As for the study of Hennessy and Wolf (2015), it concludes on the need to provide sufficient compensation to ensure reporting, but not so large as to decrease the appropriate levels of biosecurity. However, the cited study does not specify the amount of compensation to be given to farmers. As such, our study also measures farmers' WTA compensation for a successful stamping out. Additionally, Penrith *et al.* (2013) showed that the successful eradication of ASF in Côte d'Ivoire in 1996 was partly due to an awareness campaign that helped limit the dangerous practices of pig farmers that spread ASF. Moreover, Hennessy and Wolf (2015) consider compensation to mainly induce reporting, but our study also identifies if, in addition to the unavailability of compensation, lack of knowledge may be a barrier for reporting.

The contingent valuation (CV) technique is employed to estimate the minimum WTA compensation or the maximum willingness to pay (WTP). The CV method is widely used to estimate the value of non-market goods that have no market price, and has previously been used to estimate farmers' willingness to contribute in terms of money and/or labor to control the population of the tsetse fly in Kenya and Burkina Faso (Echessah *et al.,* 1997; Kamuanga *et al.,* 2001). McCluskey *et al.* (2005) estimated Japanese consumers' WTP a premium for bovine spongiform encephalopathy (BSE)-tested beef, including knowledge about BSE as a variable to explain consumers' WTP for BSE-tested beef. This knowledge was self-reported by respondents and did not significantly affect their WTP for BSE-tested beef. Conversely, our study measures farmers' knowledge and uses it for the WTA model estimation, assuming its statistical significance.

Pig production and pig diseases in Madagascar: In 2012, there were an estimated 1,500,000 pigs in Madagascar (SAIGS/DSI/MINEL, n.d.). According to the Ministry of Agriculture, Livestock and Fisheries (MAEP, 2007), pig production is the major activity at small-scale farms (70% of pig farms have less than 10 pigs). The predominance of small-scale farms means that a significant proportion of households in Madagascar (20%) owns at least one pig, and pig farming constitutes a significant source of income or saving for Malagasy pig producers (INSTAT, 2011).

Classical swine fever (CSF), porcine cysticercosis, and ASF are pig diseases listed by the World Organization for Animal Health (OIE). These three diseases also pose threats to pig production in Madagascar. Figure 1 indicates the number of outbreaks of each disease. ASF was selected as the focus of this study, because it is the most important pig disease in terms of the number of outbreaks, as shown in Figure 1. Moreover, unlike CSF, which can be prevented through vaccination (OIE, n.d.), and porcine cysticercosis, which can be treated effectively with oxfendazole (Gonzalez *et*

[2] According to de Janvry and Sadoulet (2016), adverse selection corresponds to hidden information about the characteristics of a person or a product, which gives room for opportunistic behavior. On the other hand, moral hazard corresponds to asymmetrical information allowing opportunism under the form of hidden action. In our context, adverse selection is hidden information after the ASF outbreak, while moral hazard is hidden action prior to the ASF outbreak.

al., 1997), there is no vaccine or treatment available for ASF (OIE, n.d.). Therefore, ASF control needs the intervention of the government more than the other two diseases. Figure 2 shows how pig farmers can report suspected cases of ASF. Once this information reaches the Animal Health and Phytosanitary Directorate, the veterinarian is ordered to take a blood sample and send it to the national laboratory, which is the only location that tests such cases. While waiting for official confirmation of the presence of ASF, the government may cull all pigs within a 1,000-meter radius around the farm suspected of housing the infected animal, to prevent the spread of the disease. If the presence of ASF is confirmed, Article 3 of Ministerial Decree No. 396/99, which stipulates that infected pigs must be culled, is enforced (MAEP, 2009).

MATERIALS AND METHODS

Study area and sample: The study was conducted in the Antananarivo Avaradrano district of the Analamanga region (Figure 3), which recorded the highest numbers of annual ASF outbreaks from 1998 to 2004 compared to other districts within this region. Although this region has the second largest number of pigs (157,000 heads) after the Vakinankaratra region (188,000 heads), more ASF outbreaks were recorded in Analamanga (34 outbreaks) than in Vakinankaratra (18 outbreaks) during the same period (1998 to 2004) (OIE data, 2013). Because district-level data on the number of pigs were not available, a livestock specialist in the Antananarivo Avaradrano district helped us identify the most appropriate locations for our study, namely, the Ambohimangakely and Sabotsy Namehana communes. These locations are the most suitable for the study because of the high probability of finding pig farmers here. We referred to the map of these communes and selected 12 out of 26 *fokontany* (smallest administrative units), including the closest and farthest ones from the national route. We conducted face-to-face interviews in the Malagasy language with respondents in households rearing pigs in their backyard.

A pre-survey of 20 farmers in the study area was conducted in October 2013 to test the questionnaire and determine the price of contaminated meat. The main survey was conducted in December 2013, when 201 farmers were interviewed, 175 of which had experience with ASF infection and 26 did not.

Farmers' knowledge about ASF: Five true-or-false questions were asked to ascertain the farmers' knowledge about the severity, transmission, and symptoms of ASF. The results were included as variables in the model devised to explain farmers' attitude towards compensation. For example, if the farmer knows that ASF can be transmitted easily by ticks, it is assumed that he/she is more likely to accept compensation. Additionally, since farmers who have not experienced ASF were included in the sample, the proportion answering correctly each question was compared between farmers with and without experience; farmers who have not experienced ASF were assumed to have less knowledge than those with experience. This difference was ascertained using a modern and robust binomial test (Wilcox, 2005), which tests the null hypothesis that proportions from two independent groups are equal.

The questions were as follows. The correct answers are provided in parentheses.

Q1. ASF is the same as CSF (False)
Q2. ASF can affect humans (False)
Q3. ASF is transmitted by ticks from pig to pig (True)
Q4. ASF is not transmitted by direct contact between infectious and susceptible pigs (False)
Q5. Blisters on the upper edge of the hoof and in the cleft are symptoms of ASF (False)

Contingent valuation: For animals that are traded (broilers and fattened pigs), the compensation should be based on farm gate price (FAO, n.d.). The compensation rate that farmers can receive is given by Equation 1.

$$I = F \quad \times r, \qquad (1)$$

where *I* is the amount of compensation, *FP* the farm gate price, and *r* the compensation rate to be given for culling pigs, which is the percentage of the farm gate price that the government is willing to pay.

Securing the farm gate price is relatively easy, but it is important to determine the percentage the government is willing to pay, because, the lower the compensation, the lower the likelihood of farmers reporting the disease. Therefore, CV was used to determine the appropriate percentage that would encourage farmers to report the disease. The CV method also helps identify the factors influencing farmers' WTA compensation and verify the hypothesis that farmers' knowledge about ASF might be a contributing factor.

The single-bounded dichotomous-choice CV approach is used to elicit WTA or WTP. The single-bounded version was used in this study because of the respondents' familiarity with it compared to other CV methods, owing to its similarity to market conditions (Desvousges *et al.,* 1983). According to the CV procedure, respondents were first asked whether they are willing to accept a certain amount as compensation after describing the following scenario, to which they answered with "yes" or "no":

"As you might already know, ASF exists in our country. Almost 100% of infected pigs die from the disease. Additionally, there is no treatment or vaccination available for ASF. Hence, slaughtering infected pigs and then burying their bodies is the only way to control the spread of the disease in case of an outbreak. This can be done if farmers report suspected cases of ASF to the veterinary office or local authorities. Unfortunately, to date, pig farmers are not compensated by the government if a veterinarian culls and buries their ASF-infected pigs."

Subsequently, they were asked if they would be willing to report ASF cases to the veterinary office or local authorities if they would receive money as compensation every time they report an ASF infection. If their response was "yes," the following question was presented to them: "Would you be willing to accept a compensation of [a random bid] less than the farm gate price of uncontaminated meat?" Then, respondents answered with "yes" or "no." The procedure is summarized in Figure 4.

To avoid moral hazard, the burden of an outbreak should be shared between the government and farmers, and, consequently, the compensation would have to be less than 100% of the farm gate price. Additionally, we selected random bids based on the results of the pre-survey, because farmers must be compensated at least as well as they would earn from the alternative of selling infected meat. During the pre-survey, farmers were asked the price of uncontaminated meat and then requested to state the price at which they would sell the pig meat if it were contaminated in any infectious way. The value of ASF-contaminated pig meat ranged from a minimum of 53% to a maximum of 94% of the farm gate price for uncontaminated meat. Whittington (1998) suggested that, to obtain a reliable estimate, the highest price should be rejected by 90–95% of respondents in developing countries. Hence, a bid of 60% less than the farm gate price for uncontaminated meat was included in the analysis. The random bids and related compensation rates are presented in Table 1. Bids were presented randomly, as one level per respondent as shown in Table 1.

Each farmer's response can be categorized into two possible outcomes: he/she accepts the bid offered or rejects it. A farmer is willing to accept compensation ($D_i = 1$) if his/her true WTA is less than or equal to the bid offered, and he/she will not accept it ($D_i = 0$) otherwise.

$$D_i = \begin{cases} 1 \text{ if WTA} \le B_i \\ 0 \text{ if } B_i < \text{WTA} \end{cases} \qquad i = 1, 2, \ldots, n, \qquad (2)$$

where B_i is the bid presented to the i^{th} farmer.

Farmer i's WTA function for the compensation of each infected pig to be culled is as follows:

$$\text{WTA}_i = \alpha + \rho C_i + \mu Z_i + \varepsilon_i \qquad i = 1, 2, \ldots, n, \qquad (3)$$

where WTA_i is pig farmer i's unobservable true WTA (which is a percentage of the farm gate price for uncontaminated meat), and C_i is the compensation rate that farmer i can receive. The latter is obtained by subtracting the bid farmer i faces from 100. Z_i is a column vector of observable characteristics of farm i and ε_i is the error term.

The probability that a farmer accepts the offered compensation, given the bid and the value of explanatory variables, is

$$\Pr(D_i = 1|B_i, Z_i) = \Pr(\text{WTA}_i \le B_i)$$
$$= \Pr(\alpha + \rho B_i + \mu Z_i + \varepsilon_i \le B_i)$$
$$= \Pr(\varepsilon_i \le B_i - \alpha + \rho B_i + \mu Z_i). \qquad (4)$$

According to Lopez-Feldman (2012), Equation (3) can be estimated using a probit model. Because a coefficient of a probit model cannot be interpreted by itself, the marginal effect is calculated to determine the impact of variables on the probability of the pig farmer accepting the bid offered to him/her.

Additionally, the mean sample WTA was estimated as a function of the average of explanatory variables, according to Equation (5).

$$\text{mean WTA} = -(\hat{\alpha} + \hat{\mu}\bar{Z})/\hat{\rho}, \qquad (5)$$

where $\hat{\alpha}$ is the estimate of the intercept, $\hat{\mu}$ the estimate of factors associated with the WTA (coefficients of the bid and farmer characteristics in the probit model), $\bar{Z}$ the mean of farmer characteristics, and $\hat{\rho}$ the estimate of the compensation rate coefficient.

The data were analyzed using the statistical software Stata® 12.0. To estimate the marginal effect, the Stata® commands *dprobit* and *inteff* were used for the marginal effect of a single variable and for the interacted variable, respectively (Norton *et al.*, 2004).

RESULTS AND DISCUSSION

Descriptive statistics of the sample: Table 2 shows the farm characteristics included in the probit model. Around 87% of interviewed farmers have reportedly experienced ASF at least once. Regarding the type of production, farms are fattening, farrow-to-finish, breeding, or boar farms, with the majority (47%) being fattening farms. A high percentage of farmers (75%) have administered vaccines against CSF despite both pig diseases having the same symptoms.

The characteristics of farmers with and without experience were also compared to check sample bias. Table 3 shows that there is no statistical difference among subsamples regarding farm ownership, administration of CSF vaccine, type of production, and herd size. Therefore, the sample is homogeneous.

Farmers' knowledge about ASF

The percentage of pig farmers who answered each question correctly is given in Table 4.

More than 50% of farmers, irrespective of whether they have experienced ASF, believe that ASF and CSF are the same disease. Additionally, around 28% of farmers incorrectly believe that ASF can be harmful to human health, most of these farmers having never experienced an ASF outbreak ($p < 0.05$).

Regarding ASF transmission (Q3 and Q4), there is no significant difference between the proportion of farmers with and without experience with ASF who answered correctly. Additionally, almost half of respondents did not know that ticks are an important means of transmitting the ASF virus in Madagascar (Ravaomanana *et al.*, 2010). This situation partly explains the low biosecurity level identified by Costard *et al.* (2009). Fortunately, almost all respondents knew that ASF is transmitted by direct contact between infected and susceptible pigs (Q4). Therefore, they are likely to separate the infected pigs for culling from the non-infected ones, while waiting for professional assistance from veterinarians. A relatively high proportion of farmers who have experienced ASF (53.71%) were aware that the presence of blisters on hooves is not an indication of ASF. This proportion was significantly lower for farmers without ASF experience ($p < 0.001$).

Farmers' WTA compensation: All approached farmers were willing to respond to the questionnaire. Only one out of 201 farmers, who also experienced ASF, was unwilling to report ASF cases even if he were to receive compensation for the meat of the culled pigs, citing lack of familiarity with the veterinarian as the main reason. Consequently, that respondent was classified as not willing to accept compensation. The fact that 99.5% of respondents are willing to report ASF indicates that compensation can solve the adverse selection issue.

The percentage of farmers' WTA is shown in Figure 5. As expected, the proportion of pig farmers willing to accept compensation decreases with the decrease in compensation. A compensation of 90% of the farm gate price of uncontaminated meat is acceptable to all farmers, indicating their agreement that the value of contaminated meat is less than that of uncontaminated meat. This indicates that moral hazard may not arise. In other words, farmers may adopt the same minimum biosecurity level as in the current situation to prevent ASF infection, although compensation is available, to avoid receiving a compensation less than the income from non-infected pigs.

The hypothetical scenario was designed to deter farmers from accepting a compensation lower than their true WTA. Therefore, we did not stress the positive externality of reporting, which the National Oceanic and Atmospheric Administration(NOAA) panel defines as "warm glow" (Arrow *et al.*, 1993), but showed that reporting without receiving compensation is disadvantageous to the farmer.

Factors that affect the WTA compensation of pig farmers are presented in Table 5.

McFadden's adjusted R^2 of the model is 0.190, which is relatively close to 0.2 and shows a good fit (McFadden, 1978). Additionally, the model passed the post-estimation tests for multicollinearity.

As expected, the coefficient of the variable compensation rate is positive and statistically significant. This means that farmers are more likely to accept compensation as the compensation rate increases. A 1% increase in compensation increases the likelihood of farmers accepting the bid by 0.013. A similar tendency was observed by Kuchler and Hamm (2000) when examining the history of a program intended to eradicate scrapie in sheep in the United States. They found that, when compensation payments were reduced, the incentive to find infected animals decreased, leading to fewer confirmations of scrapie cases.

Pig farmers who correctly understand that ASF cannot affect humans (Q2) are less likely to accept compensation. Their WTA is 0.16 less than that of pig farmers who are mistaken about ASF infecting humans. This means their true WTA is higher than the bid presented to them during the survey. Farmers who answered Q2 incorrectly were willing to accept compensation up to 51% less than the farm gate price for uncontaminated meat, while farmers who provided the correct answer were willing to accept a compensation of only 37% less than the farm gate price. For those farmers, compensation can probably be an incentive, if set higher than the price at which they can sell the infected pigs, since it was estimated that not only do around 70% of such pig farmers sell ASF-infected pigs, but they also consider it as non-sensitive behavior (Randrianantoandro *et al.*, 2015). The results of the pre-survey and the fact that a percentage of farmers is willing to accept a compensation of 10% less than the farm gate price for uncontaminated meat (Figure 5) allow us to conclude that farmers are aware that contaminated meat's farm gate price is lower than that of uncontaminated meat. Therefore, it must be explained to farmers that, although ASF is not harmful to humans and, as long as the disease is not eradicated, their pigs are always at risk. Therefore, the chance of losing income because of an ASF infection will always be present.

As for Q3, which states that "ASF can be transmitted by ticks from pig to pig," farmers who know this to be true are also more likely to accept compensation with a higher probability by 0.14 ($p < 0.1$). This indicates that knowing the risk of ASF spreading within the herd because of ticks makes farmers more favorable to reporting even when compensation rates are low. Therefore, the ASF control policy should also focus on informing farmers about the high risks related to the presence of ticks in the pigpen and the need of at least regularly cleaning the pigpen if they cannot afford disinfecting products.

However, we see no effect on WTA even for farmers who have experience with ASF. The WTA of farmers with and without ASF experience does not differ significantly; these are 41% and 42% less than the farm gate price of meat, respectively.

Farmers who have administered the vaccine against CSF are less likely to accept compensation. The probability that they accept the bid is 0.5 less than for farmers who did not administer the vaccine. These results indicate that all pig farmers may wrongly believe that the CSF vaccine will protect their pigs from ASF. When they do not administer the vaccine, they think that they did not prevent the ASF infection and, therefore, they accept the low compensation rate. Consequently, farmers should be encouraged to administer the CSF vaccine to prevent income loss due to CSF. Meanwhile, they should be warned that the CSF vaccine does not protect their pigs from ASF. Hence, they need careful ASF prevention, such as avoid being in contact with infected farms. However, farmers who have experienced ASF and administered the vaccine against CSF are more likely to accept compensation than others, with the probability being 0.37 higher. This shows that their experience made them risk-averse and, therefore, they protect their pigs from CSF and also accept compensation for the damage caused by ASF. In other words, although the compensation scheme is to be established, it is not likely that farmers will decrease the level of biosecurity practices, such as stopping the CSF vaccine administration.

Knowing that ASF is different from CSF (Q1) does not influence farmers' WTA. However, farmers who are aware that ASF differs from CSF (Q1) and who were offered a higher bid (*Q1 × bid*) are more likely to accept compensation, the probability being 0.007 higher.

Including all the explanatory variables mentioned in Table 5 in Equation (5), the estimated WTA mean for compensation is 41% less than the farm gate price for uncontaminated meat. In other words, pig farmers are willing to accept a compensation of 59% of the market value of the farm gate price for uncontaminated meat. This mean value is almost the same as the estimated cost of pig fattening production operations (Andriamparany, 2012).

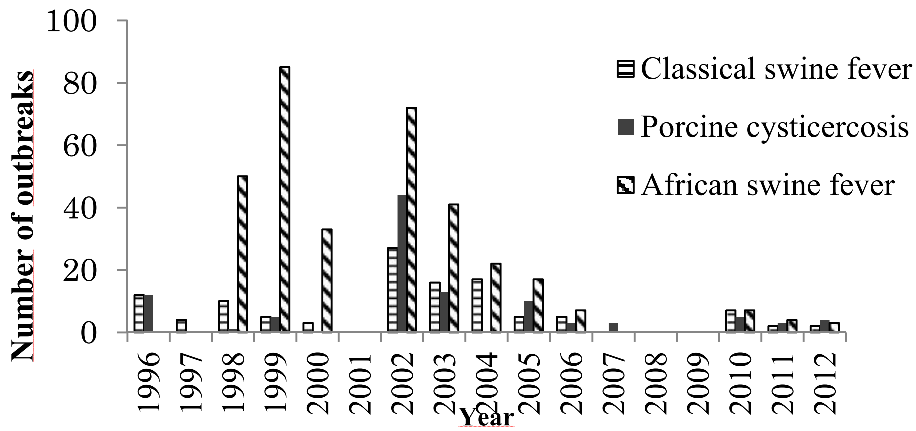

Figure 1. OIE-listed pig diseases notifiable in Madagascar
Source: OIE data (2015).
Note: Missing bars indicate that data were unavailable rather than the absence of the diseases.

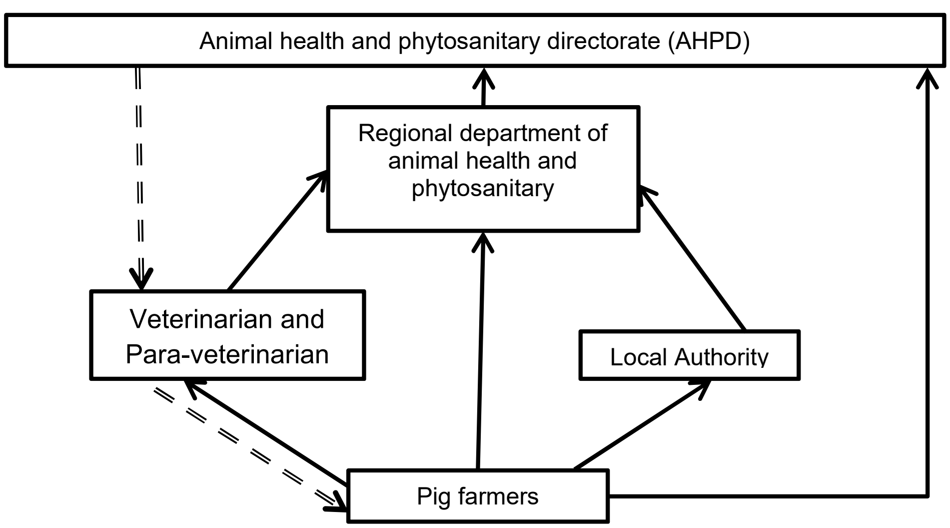

Figure 2. Framework for ASF control in Madagascar
Source: Modified from MAEP (2009)
Information received from farmers (reports)

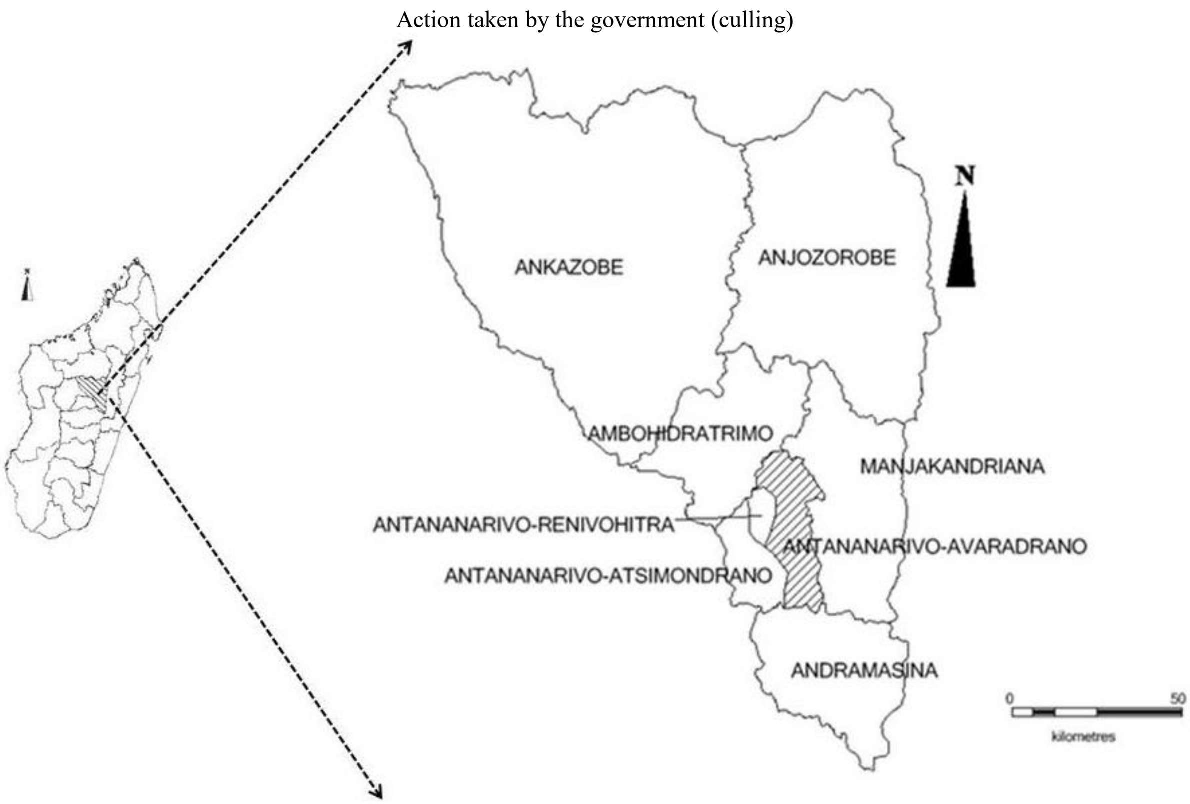

Figure 3. Map of Analamanga Region

Note: Created by the author using MapInfo software (http://www.pitneybowes.com) based on the BD500 database from the Madagascar National Institute of Geography and Hydrography (Foiben-Taosarintanin'i Madagasikara or FTM).

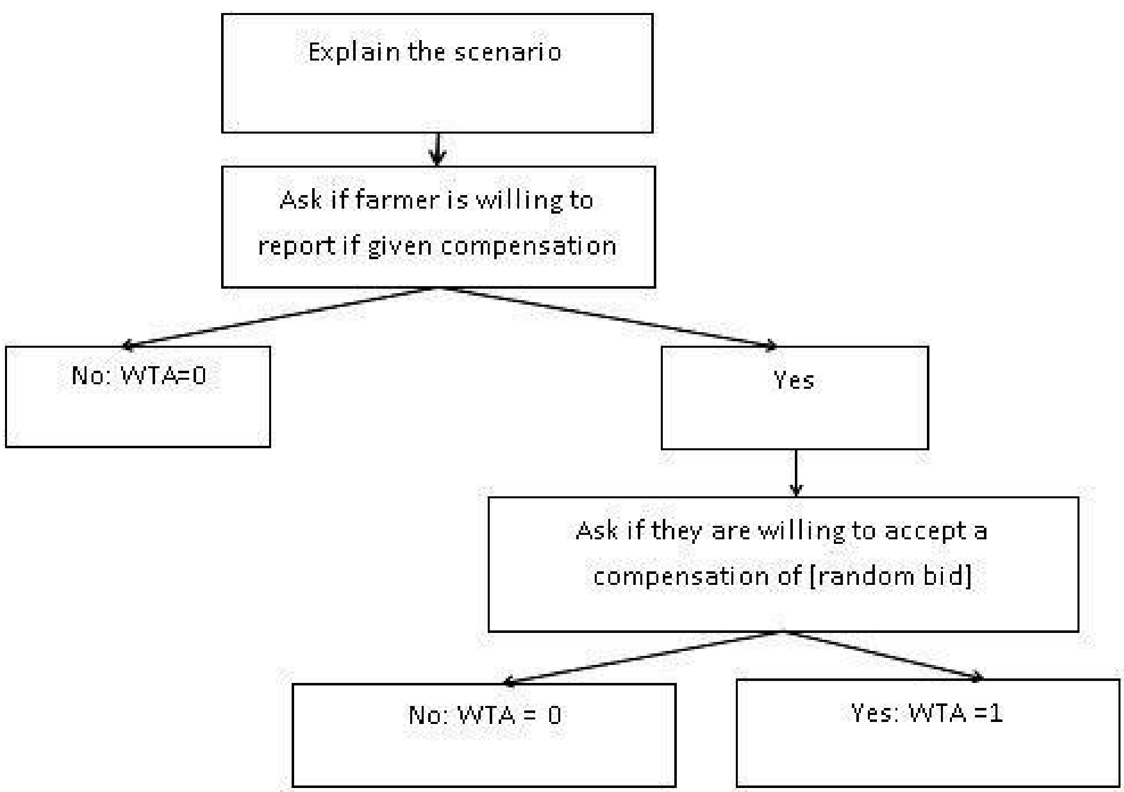

Figure 4. Process of eliciting WTA

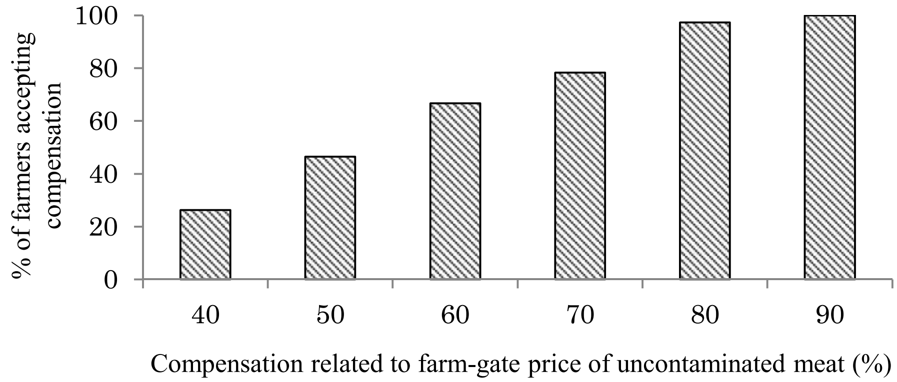

Figure 5. Distribution of farmers' WTA for each level of compensation

Table 1. Bid, related compensation rate, and respondents per bid.

Bid (%)	10	20	30	40	50	60
Compensation rate (%)	90	80	70	30	50	40
Number of respondents	11	37	42	49	43	19

Note: Compensation rate is the percentage of the farm-gate price of meat that farmers will get as compensation. It is obtained by subtracting the bid value from 100%.

Table 2. Descriptive statistics of the sample.

Variable	Description	Mean ± SD
Asfexp	Dummy, 1 = with experience of ASF, 0 = without experience of ASF	0.87 ± 0.33
Q1	Dummy, 1 = correct answer for question 1, 0 = false answer	0.57 ± 0.50
Q2	Dummy, 1 = correct answer for question 2, 0 = false answer	0.72 ± 0.45
Q3	Dummy, 1 = correct answer for question 3, 0 = false answer	0.52 ± 0.50
Prodtype	Dummy, 1 = fattening only, 0 = otherwise	0.47 ± 0.50
Csfv	Dummy, 1 = administered CSF vaccine, 0 = otherwise	0.75 ± 0.45

Table 3. Comparison of farmers with and without ASF experience.

Variables	Number of farmers with experience of ASF	Number of farmers without experience of ASF	*p*-value
Ownership[a)]	25	164	0.735
CSF vaccine	18	132	0.479
Production type[b)]	9	89	0.112
Herd size (3 or fewer pigs)	25	151	0.175

Note: [a)] All the pigs belong to the respondent. [b)] Farmers with fattening farms only.

Table 4. Proportion of farmers who gave correct answers to the questions pertaining to knowledge about ASF.

	Question	Total (%)	Farmers without experience of ASF (%)	Farmers with experience of ASF (%)	*p*-value of binominal test
Q1	ASF is the same as CSF	56.72	53.85	57.14	0.756
Q2	ASF can affect humans	71.64	53.85	74.29	0.031**
Q3	ASF is transmitted by ticks from pig to pig	52.24	65.38	50.29	0.154
Q4	ASF is not transmitted by direct contact between infectious and susceptible pigs	95.02	100.00	94.29	0.218
Q5	Blisters on the upper edge of the hoof and in the cleft are symptoms of ASF	49.25	19.23	53.71	0.001***

Note: ** and *** denote statistical significance at the 5% and 1% level respectively. *p*-value represents the difference between the proportion of farmers who gave the correct answer from the subsets of farmers with and without experience with ASF.

Table 5. Factors associated with WTA (probit model).

Dependent variable: WTA (1 = accept the bid, 0 = do not accept the bid)					
Parameter	Variables	Estimate		Marginal effect	
		Coefficient	SE	Coefficient	SE
α	Intercept	1.982	0.713	-	-
ρ	Compensation rate	0.036^{***}	0.012	0.013^{***}	0.004
$\mu(Z_1)$	*Asfexp*	-0.027	0.525	-0.009	0.186
$\mu(Z_2)$	*Q1*	1.109	0.759	0.383	0.243
$\mu(Z_3)$	*Q2*	-0.479^{*}	0.258	-0.160^{**}	0.080
$\mu(Z_4)$	*Q3*	0.384^{*}	0.231	0.137^{*}	0.081
$\mu(Z_5)$	*Prodtype*	0.277	0.225	0.095	0.079
$\mu(Z_6)$	*Csfv*	-1.394^{**}	0.598	-0.497^{**}	0.214
$\mu(Z_7)$	*Asfexp × Csfv*	1.476^{**}	0.652	0.371[a)]	-
$\mu(Z_8)$	*Q1 × bid*	0.034^{*}	0.018	0.007[b)]	-

Note: SE stands for Standard Error.
Number of observations = 201, Log likelihood = -96.307, LR $\chi^2(9)$ = 69.88, Pr > χ^2 = 0.000, Pseudo R^2 = 0.266, McFadden's adjusted R^2=0.19.
*, **, and *** denote statistical significance at the 10%, 5%, and 1% level respectively.
[a)] and [b)] were calculated using the Stata command i*nteff* while *dprobit* was used for single variables.

Conclusion: Compensation can be an incentive for farmers in Madagascar to avoid adverse selection. Additionally, with the current low biosecurity measures, moral hazard may not arise if the compensation is set at a maximum of 90% of the farm gate price for pigs. The results also show that farmers' knowledge about ASF affects their WTA compensation and their reporting of ASF cases. The fact that some farmers have the correct knowledge about ASF is a positive factor affecting their WTA. However, ASF not affecting humans and the practice of vaccinating pigs against CSF are barriers against reporting. Therefore, while farmers should be informed that ASF does not affect humans, they should be warned that not reporting outbreaks contributes to the spread of ASF, and an outbreak induces income loss. Additionally, farmers' knowledge about ASF is not perfect, and the government should educate them about good biosecurity practices and symptom identification.

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