Qualitative risk assessment for the transmission of African swine fever to Thailand from Italy, 2015

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Summary

African swine fever (ASF) is a highly contagious disease that infects porcine species and has a major impact on the pig industry. Thailand imported approximately 4 million kilograms of pig products from Italy in 2015 during the same time as an ASF outbreak was occurring on the island of Sardinia in Italy, thereby posing a potential risk of introduction of African swine fever virus (ASFV) into Thailand. To estimate whether or not importing pig products from Italy is a risk for

Thailand and to identify gaps in control and prevention measures, risk analysis was performed. The objective of this study was to estimate the risk of the introduction of ASFV through imported pig products from Italy into Thailand in 2015, utilising qualitative risk assessment approaches, with the aim to define specific control and preventive measures. The framework used to analyse risk in this study was composed of hazard identification, qualitative risk assessment and risk mitigation. Qualitative risk assessment revealed that the likelihood of introduction of ASFV into Thailand was negligible, while the level of consequence of virus introduction was high. The overall risk was determined to be negligible. Risk mitigation recommendations were framed to minimise the risk. In addition, this study provided a baseline qualitative risk of ASFV introduction and a systematic approach to a qualitative risk analysis.

Keywords

African swine fever – Estimation of risk – Italy – Pork product – Qualitative risk assessment – Thailand.

Introduction

African swine fever (ASF) is an infectious disease that affects pig populations and is caused by the African swine fever virus (ASFV). The ASFV is a double-stranded deoxyribonucleic acid virus in the genus *Asfivirus*, family Asfarviridae (1, 2) that affects the Suidae family such as domestic pigs and wild boars. Based on the World Animal Health Information System (WAHIS), current outbreak areas are mainly located in Africa and some countries in Europe (3). However, ASF is a disease for which both Member Countries of the World Organisation for Animal Health (OIE) and non-Member Countries need to develop strategies to monitor, control, prevent and eliminate, by focusing on the trade of live pigs and pig products (4). The ASFV can be transmitted by direct and indirect contact and is easily spread within a susceptible population. It is also vector-borne, with *Ornithodoros* spp. ticks being responsible for sustaining the sylvatic cycle of the disease (5). The ASFV can also be spread via commodities such as pork products, owing to the stability of the virus in the environment (1, 5). Clinical signs of ASF include high fever, abortion, leucopenia, anorexia, bloody diarrhoea, thrombocytopenia, and erythemic skin or cyanosis (6). The mortality rate is approximately 30–70%, while the case-fatality rate can be as high as 100% depending on the virulence of the virus strain and the susceptibility of the population (1, 6).

To minimise the likelihood of introduction of the virus via international trade, risk analysis with the development of a risk management or mitigation plan is the recommended approach. The World Trade Organization (WTO) has developed the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS agreement) (7), which protects the right of WTO members to provide a level of food safety, animal health, or plant health (8). Accordingly, the OIE has promoted risk analysis for imported products, which is composed of hazard identification, risk assessment, risk management and risk communication (8, 9).

Thailand has a large pig industry. Commercial pig farms are located mainly in the central part of the country; small pig farms, which average fewer than 50 pigs each but possess 90% of the pigs in Thailand, are scattered throughout the country (10). In 2014, Thailand produced 5,916,596 fattening pigs and 978,032 breeding pigs (internal information, Department of Livestock Development [DLD], 2015). In 2013, Thailand exported 250,145 live pigs and 16,988 tonnes of pig products, with a value of approximately US$ 130 million (10, 11). Fortunately, Thailand has never had ASFV, as confirmed (internal DLD information) by zero seroprevalence during a survey carried out in 2015 by the National Institute of Animal Health (NIAH). Given that Thailand is a Member of the OIE and needs to prevent ASF from being introduced via live pigs or pig products, risk analysis is important for determining gaps in disease prevention measures in the country, such as inefficient border controls or farmers' lack of disease awareness.

Based on the expert opinion of Thai DLD officers, the highest likelihood for ASFV introduction into Thailand is from pork and pork products because preventive methods at quarantine stations are more focused on screening imported live pigs and less on screening imported pork products. According to the DLD trading database and the WAHIS, ASF outbreaks were detected on the island of Sardinia, Italy, in both wild boars (January to June 2015) and domestic pigs (July to December 2015) (3). According to the internal DLD trade database, Thailand imported approximately four million kilograms of pork products from Italy during the time period of the outbreaks on Sardinia. Thailand did not import live pigs or pork products from other ASFV outbreak countries during that time period. The DLD attempts to intercept the illegal movement of pigs and pork products, using dogs to detect such transgressions, with the aim of preventing the introduction of the virus into the country. However, data from these interception activities are scattered and are not available for use to assess the risk of ASFV introduction.

Considering the supporting evidence, Thailand may be at risk for the introduction of ASFV. This qualitative risk analysis will provide initial information for estimating the risk of ASFV introduction into Thailand via the importation of pork products from Italy in 2015 and provide recommendations for decreasing the risk of the introduction and spread of the virus in Thailand. This study is the first to estimate the risk of ASFV introduction and spread in Thailand.

Materials and methods

Risk analysis steps

The risk analysis framework to examine the introduction, release and spread of ASFV in Thailand included hazard identification, physical pathways and scenario trees, risk assessment and risk mitigation. The hazard identification, physical pathways and scenario trees and nodes were determined in previous research (12). Qualitative risk assessment was performed (using the data described below) with the release assessment beginning in Sardinia and continuing through the border of Thailand. Exposure assessment began from the DLD quarantine station and included domestic pig farms. Nodes, or critical control points for transmission of ASFV in this scenario, included: the island of Sardinia, Italian pig farms, slaughter and processing plants and livestock departments, importing company storage, transportation and shipment, DLD quarantine stations, waste sent from Thai markets and restaurants to pig farms, and waste products used on domestic pig farms. Risk matrices were used to determine the likelihood of each release and exposure and were combined to obtain the overall likelihood of introduction. In addition, a consequence assessment provided the level of impact of the hazard entering Thailand, in terms of negative and positive consequences. In order to obtain the overall risk, the level of likelihood of introduction was combined with the level of consequence using risk estimation. In addition, a risk mitigation plan was developed by listing recommendations for minimising risk at the nodes with high likelihood and uncertainty.

Data collection

Internal data on trade between Italy and Thailand and information about ASFV outbreaks in Italy during 2015 were the main sources of data for analysing risk. The trade and ASFV control and prevention documents used included European Union (EU) Commission Decision 2005/363/EC (13, 14), the EU legislation and regulation programme (15, 16), EU Council Directives (17, 18), export and import requirements (19, 20) and government guidelines (21). Scientific literature (22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35) was used to validate the data collected from these documents; expert opinion was used when published literature was not available. Expert opinion was collected using four separate online questionnaires (available upon request from the authors). The questionnaires were developed to gain knowledge of ASFV, swine management practices, and possible risk factors for disease spread in Thailand and Sardinia. Experts were chosen on the basis of their experience, veterinary degree and government position. Italian veterinary officers from the National Reference Laboratory for African and Classical Swine Fever and Thai DLD veterinary officers from three different divisions (Bureau of Disease Control and Veterinary Services, Bureau of Livestock Standards and Certification, and Division of Veterinary Inspection and Quarantine) completed the questionnaires.

The level of consequence was determined on the basis of the Performance of Veterinary Services (PVS) gap analysis undertaken by the OIE in 2012, including DLD background information, DLD laboratory and human capacity, DLD control measures for preventing and controlling diseases (36), characteristics of pig farms (10, 11), veterinary legislation (36), expert opinion and information, scientific literature (37), internal DLD data on the exportation of pigs and their products, and basic economic concepts.

Table of likelihood and uncertainty categories

Once the risk pathway and scenario trees had been developed, the likelihood of occurrence and the uncertainty of the supportive evidence were determined, based on available data and multiple risk factors. The level of likelihood that ASFV would be able to pass each node was categorised using the definitions outlined in Table I. The level of uncertainty for each node was categorised on the basis of the definitions in Table II. Uncertainty levels were determined in order to prevent misinterpretation and overconfidence.

Insert Tables I and II near here

Combination risk matrix and risk estimation

After determining the level of likelihood of risk for each node, the risk matrix (Table III) was used to combine each level of likelihood to obtain the level of the likelihood for release and exposure, and these estimates were then combined to obtain the likelihood of introduction of ASFV. After determining the likelihood of introduction and the level of consequence of the risk, Table IV was used to combine these estimates to describe the overall risk of ASFV entering Thailand. Finally, recommendations were developed for risk mitigation, based on the weak nodes that were likely to allow the virus to pass.

Insert Tables III and IV near here

Results

Hazard identification

The major goal of this step was to identify supportive evidence regarding whether or not ASFV in pork products imported from Italy could be a risk for Thailand. According to WAHIS, ASF was an endemic disease in Sardinia, Italy with two outbreaks occurring in 2015 (3). Therefore, the first item of supportive evidence was that ASFV was present in Italy. Second, Thailand has never reported ASFV: as mentioned earlier, zero seroprevalence was shown in a survey by the NIAH, DLD in 2015, and ASFV is therefore an exotic virus in Thailand. The third piece of evidence was that, in 2015, Thailand imported 4,210,425 kilograms of pig products from Italy (internal DLD trade database). Finally, pork products can be a vehicle for ASFV transmission (39). When all of the supportive evidence was considered, ASFV in imported pork products from Italy was identified as a hazard for Thailand.

Physical risk pathway and scenario trees

Hazard movement for ASFV originating in Sardinia to domestic pig farms in Thailand is shown in Figure 1. The tree nodes were developed and revised on the basis of Thai and Italian expert opinion. Given that ASFV could move from the island of Sardinia to the Italian mainland, infect exporting pig farms, pass through the slaughtering and processing steps, meet Thai DLD import requirements and EU export requirements, and pass the DLD quarantine station to enter Thailand, these items were included in the release assessment pathway. After passing the Thai DLD quarantine station, ASFV could move to the importing company and storage facility where it might then be present in products placed for sale at markets and restaurants. Passing the DLD quarantine station was categorised as an exposure assessment, and was divided into two scenarios to demonstrate how animals might be exposed to ASFV. In the first scenario, pig farmers were able to buy products from markets or restaurants, with those products contaminating pig farms at the household level. In the second scenario, waste products from the importing company and storage facility, as well as from markets and restaurants, could contaminate water that might be used on domestic pig farms. The consequence assessment then evaluated the impact of an ASFV outbreak at the domestic pig farm level. The scenario trees allowed assessment of the movement of the hazard to determine the level of likelihood of the virus passing each node (Fig. 1).

Insert Figure 1 near here

Risk assessment

The level of likelihood that ASFV could pass each node, along with the level of uncertainty, is shown in Table V. Briefly, ASFV control measures on the island of Sardinia and the mainland of Italy are very good and reflect the EU Commission Decision (13, 14), EU legislation/regulation (15, 16) and EU Council Directive (17, 18). In addition, based on the EU regulation and the EU Council Directive, biosecurity and management of exporting pig farms and slaughtering plants are good (15, 16, 17, 18). In Thailand, DLD importation requirements are strong (20), so the levels of the likelihood for the virus to pass these nodes are very low or low, with low or medium uncertainty. On the other hand, there are no specific quarantine measures to detect ASFV at the border of Thailand. As pork products are processed, shipped, stored and transported, they are always kept either chilled or frozen; however, evidence shows that the virus is able to survive in chilled and frozen meat for a long period of time (39). Moreover, because of weak biosecurity and poor management in small-scale pig farming (10, 11), the virus could easily infect domestic pigs if they were exposed. Therefore, these nodes were identified to have high or moderate likelihoods with high or medium uncertainty.

Insert Table V near here

Negative biological consequences could result from the introduction of ASFV for a number of reasons (9). Domestic pigs do not have antibodies to ASFV and 90% of pig farms in Thailand are small scale, without good management or biosecurity measures in place (10). In addition, persistence of ASFV in the environment could lead to rapid spread over a large area, resulting in infected and carrier animals and endemic disease (1, 2, 5). Finally, Thailand lacks an adequate monitoring or surveillance programme for ASFV.

Other negative consequence at the farm level would be factors affecting costs, for example lower live weight sold, and increased incidence of other diseases, with increased veterinary costs and medicine use. Moreover, negative consequences at the country level would be of high impact because all exportation of pork products would be banned (estimated as a loss of US$ 130 million) if ASFV were present in Thailand (10). Also, the DLD would need to greatly increase their budget in order to control ASFV, and when ASFV affected farms the supply of pork would decrease, causing the market price of pork to increase, affecting the whole society. On the other hand, according to the PVS Gap analysis by the OIE, Thailand has very strong Veterinary Services, an established international animal health policy, and a good relationship between the DLD and stakeholders including industries and veterinary schools. Animal movement controls are effective, and ASFV is currently included in the Act of Animal Epidemic 2015 (36), meaning that the DLD is able to restrict an outbreak effectively should it occur. Overall, however, although the Thai Veterinary Services are good and ASFV control is supported by legislation, the impact of the disease in terms of biological and socio-economic consequences would still be high. Therefore, the level of consequence assessment is high, with medium uncertainty.

Table VI shows the results of the combination of levels of likelihood of all nodes for release assessment and exposure assessment. The likelihood of introduction resulting from a combination of both release and exposure assessments, estimated by using the risk matrix, is shown in the same table. The results show that the level of likelihood for release is negligible and that for exposure is moderate, so the likelihood of introduction is negligible. Although the level of consequence is high, the overall risk of the introduction of ASFV into Thailand by importing pork products from Italy in 2015 is found to be negligible when combining the likelihood of introduction and the level of consequences by risk estimation.

Insert Table VI near here

Risk mitigation recommendations

In order to minimise the likelihood of introduction of ASFV into Thailand, and because there is no process to destroy ASFV in production, Italian processing plants should irradiate pork products to destroy the virus before it leaves the country; however, irradiation is not practical for some commodities or countries. In addition, because the Thai DLD does not have specific methods to detect ASFV in pork products at its quarantine stations, a screening laboratory should be in place to detect ASFV at the border. Kits such as the QIAamp® Viral RNA Mini Kit (QIAGEN) (43) that have been used for screening live pigs in Thailand can also be used for pork products before release from quarantine (NIAH, DLD).

Once pork products are released from quarantine stations, risk mitigation should address the gaps in ASFV surveillance and biosecurity. Because of a division of labour between the DLD (responsible for control of live animals and animal products before they are sent to market) and the Food and Drug Administration (FDA) of Thailand (responsible for animal products once they are in the market and ready to sell) there is currently no veterinary regulation, screening or control of pork products once they are released from quarantine stations. The DLD should be tasked with developing and implementing a surveillance plan to survey meat for ASFV at markets and restaurants in Thailand.

The DLD should collaborate with other stakeholders, including the Thai FDA, local administrations and public health organisations, to develop regulations and waste water management systems to destroy ASFV and prevent it from contaminating the environment. Swill feeding is currently banned in Thailand, so was not considered as a mitigation strategy in this study. Finally, the DLD should improve the fundamental knowledge of farmers on basic biosecurity and ASFV. In the long term the DLD could promote an increase in the size of small-scale farms (to increase capacity to invest money in biosecurity) and develop certification programmes in farm standards and biosecurity to improve animal health and decrease disease. To reduce the consequences of ASFV, the DLD would benefit from a control and prevention strategy specific to the disease, involving for example national monitoring, improving the knowledge of DLD officers about ASFV specifically, and increasing and improving the research on and modelling of ASFV in Thailand. These recommendations can be adapted to minimise the level of likelihood for both exposure and consequence pathways for ASFV as well as other animal diseases of concern.

Discussion

Although the risk of introduction of ASFV by importing pork products from Italy into Thailand in 2015 was negligible, the question remains whether negligible is acceptable. The OIE Members use the term acceptable to reflect a balance between a country's wishes and what it achieves. The acceptable level differs among countries (8). According to Table I, negligible means that the likelihood that the event will occur is insignificant and is not worth considering. Generally, a decision maker needs to ensure that the risk is mitigated to an acceptable level, and the negligible level is often lower than the acceptable level (40). Therefore, negligible is always acceptable in these terms.

Risk analysis, however, can also be used as gap analysis because the results show that there are high levels of likelihood of risk at some nodes and high consequences of the disease. Risk mitigation, which primarily identifies gaps and provides information on how to reduce the level of risk based on each gap (40), is suitable in this case. To improve the performance of a DLD control and prevention programme for ASFV, and also as a precautionary measure, the DLD should implement risk mitigation strategies, which would also aid in the prevention of other animal health risks.

Given the limited time and resources available, a quantitative risk assessment was not practical; however, a semi-quantitative risk assessment could have been considered to evaluate risk in this study. Instead of categorising the risk by qualitative terms such as low or high, a semi-quantitative study, using probability ranges such as low equals 10^{-3} to 10^{-4} or high equals 10^{-1} to 10^{-2} (40, 44), could have been used. However, a semi-quantitative risk assessment would provide a numerical probability value for risk that may not be easy for officers to interpret in the field. For example, if the risk of introduction was 10^{-2} (or 0.01) this number might not seem significant, but it actually means that the risk is high.

The determination of the level of consequence of ASFV introduction in this study was subjective because the supportive evidence was descriptive. To better determine biological consequences, disease spread models and habitat suitability models should be developed to show how and where the virus might spread over a susceptible population, and the resulting biological impacts. Similarly, to evaluate economic consequences, risk-based benefits and costs or cost–benefit analysis is preferable to identify the acceptable levels of risk, and tools in economics such as life cycle cost analysis, farm level analysis, partial budgeting, time value of money and basic microeconomic ideas should be applied to achieve better results (45). Decision-making on the most appropriate methods of analysis should involve detailed discussions with stakeholders.

The limitations of this study were related to time, resources, long-distance communication, government limitations, and lack of previous research on the topic. Input data for this study were limited owing to the constraints of long distance communication with data holders. As a result, misunderstandings, and use of untrue or missing data may have occurred. Qualitative risk assessment requires less time and fewer resources than quantitative risk assessment or semi-quantitative assessment, so it is normally chosen as the first step in risk evaluation. Given that Thailand has never found ASFV within its borders, and there has been no risk analysis of ASFV conducted in Thailand previously, qualitative risk analysis was the most suitable approach for this study.

This qualitative analysis has provided a baseline; a quantitative risk analysis with improved data quality, including economic data, should be the next step. In this quantitative analysis, researchers should consider changing scenarios based on risk mitigation options to determine how each type of mitigation affects the overall risk and which type is the most effective for preventing the introduction of ASFV into Thailand in the future.

Conclusions

African swine fever is a hazard to Thailand because of the potential presence of the virus in pork products imported from Italy. The risk analysis revealed that the likelihood of release of the hazard into Thailand was negligible, while the likelihood of exposing domestic pigs to the hazard, if it were introduced, was moderate. In addition, the level of consequence of the virus in Thailand was high, based on the estimation of negative biological consequences, negative economic consequences, and positive consequences such as increased funding for animal health. The overall risk of the introduction of ASFV in pig products imported from Italy to Thailand in 2015 was negligible.

Despite this negligible risk, and to maintain Thailand's disease-free status, the DLD and importers should mitigate the risk by continuing to practise and enforce existing laws related to animal health and implementing new protective measures. Such measures might include irradiation of imported pork products, developing a screening diagnostic test for ASFV, collaborating with the Thai FDA and local administrations to develop regulations to control and screen for the disease in markets, and improving biosecurity and management of small-scale pig farms. Moreover, the DLD should continue this study while minimising its limitations, to maximise the accuracy of future results.

Last-minute addendum

Recently, China reported the first detection of ASF on a backyard farm in Shenyang City, Liaoning Province, China, on 3 August 2018. The presence of ASF was confirmed on the basis of clinical findings, pathological changes and a positive result on nucleic acid testing, and ASFV was identified by the National Research Centre for Exotic Animal Disease (46).

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Table I

Qualitative likelihood scale categories for risk assessment, modified from (38)

Category	Definition
High	The event has more than an even chance of occurring
Moderate/medium	The event does occur but is unlikely to
Low	The event is very unlikely to occur (39)
Very low	The event is very rare, but cannot be excluded (40)
Negligible	The likelihood the event will occur is insignificant: not worth considering (39)

Table II

Uncertainty scale categories for risk assessment, modified from (41)

Level of uncertainty	Characteristics of evidence
Low	Solid and complete data available Strong evidence provided in multiple references; authors report similar conclusions
Medium	Some but not complete data available; evidence provided in a small number of references; authors report conclusions that vary from one another
High	Scarce or no data available; evidence not provided in references but rather in unpublished reports or based on observations or personal communication; authors report conclusions that vary considerably between them

Table III

Matrix of rules for combining descriptive likelihoods, modified from (42)

A matrix of rules for combining descriptive likelihoods [(a)]					
	High	**Moderate**	**Low**	**Very low**	**Negligible**
High	High	Moderate	Low	Very low	Negligible
Moderate		Low	Low	Very low	Negligible
Low			Very low	Very low	Negligible
Very low				Negligible	Negligible
Negligible					Negligible

a) See Table I for the definitions of high to negligible risk

Table IV

Table of risk estimation, modified from (42)

Risk estimation (rules for combining level of likelihood and consequence)						
Level of likelihood of entry of and exposure to the hazard	High likelihood	Negligible	Very low	Low	Moderate	High
	Moderate	Negligible	Very low	Low	Moderate	High
	Low	Negligible	Negligible	Very low	Low	Moderate
	Very low	Negligible	Negligible	Negligible	Very low	Low
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
		Negligible	Very low	Low	Moderate	High impact
		Level of consequence of the hazard				

Table V
Summary of levels of likelihood and uncertainty of each node in the physical risk pathway

Nodes	Likelihood	Uncertainty
1. Island of Sardinia and Italian mainland	Very low	Low
2. Italian pig farms	Very low	Low
3. Italian slaughterhouses	Low	Low
4. Italian processing plants	Moderate	Moderate
5. Italian livestock department and DLD quarantine station	Very low	Low
6. Shipment	High	High
7. DLD quarantine station	High	Low
8. Importing company and storage	High	Moderate
9. Transportation	High	High
10.1. Market/restaurant to pig farms	Moderate	High
10.2. Waste products to domestic pig farms	Moderate	High

DLD: Department of Livestock Development

Table VI
Levels of likelihood of release assessment, exposure assessment, introduction, consequence assessment and overall risk

Pathway	Likelihood
Release assessment	Negligible
Exposure assessment	Moderate
Likelihood of introduction	Negligible
Consequence assessment	High
Overall risk	Negligible

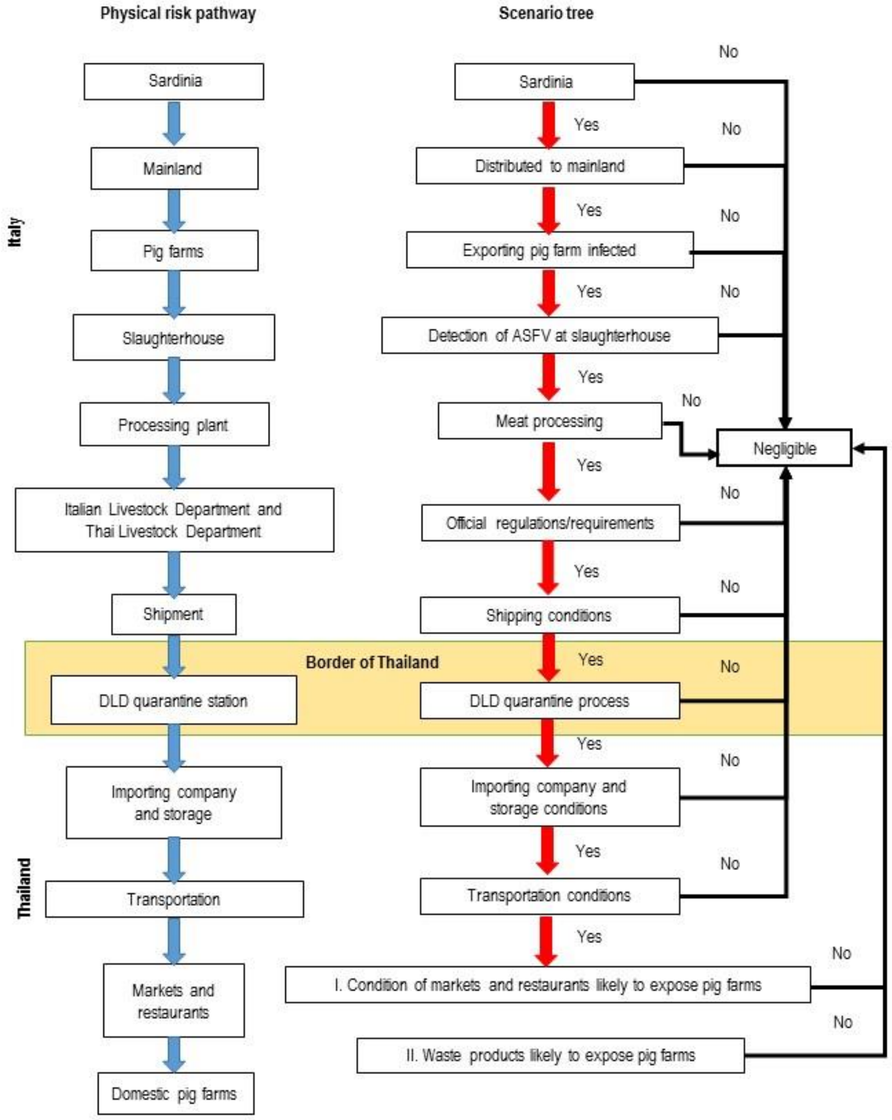

Fig. 1

Physical risk pathway and scenario tree for introduction of African swine fever virus into Thailand by importation of pork products from Italy, 2015