

QUALITATIVE RISK ASSESSMENT FOR THE INTRODUCTION OF PESTE DES PETITS RUMINANTS (PPR) IN THE ASEAN REGION

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Navneet K Dhand, Madhuchhanda Mahapatra and Balbir B Singh

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Executive summary

Peste des petits ruminants (PPR) is a transboundary animal disease characterised by high fever, nasal discharge, respiratory distress and diarrhoea. The PPR virus is highly contagious and mainly spreads through contact with infected animals, but it can also be transmitted indirectly through contaminated feed, water, and equipment. It is one of the most important small ruminant viral diseases causing significant morbidity and mortalities in small ruminants, particularly in naïve populations not previously exposed to the PPR virus. PPR is a significant threat to small ruminant populations and has been estimated to cause over 37 million deaths in sheep and goats each year in endemic countries, resulting in a loss of USD 1.48 billion per year (Jones et al., 2016).

The South-East Asian region is largely free of PPR. However, serological evidence has been detected in Laos and Vietnam, and an incursion was reported in Thailand due to the importation of live animals. Further, the region is surrounded by India, Bangladesh and China, where PPR is present. PPR remains a significant concern for the region because, if introduced, it can significantly impact small ruminant health and production and have adverse repercussions for farmer livelihoods, rural economy and food supply. Considering the importance of the disease to the region, the ASEAN Sectoral Working Group for Livestock (ASWGL) decided to develop a regional PPR Preparedness Strategy in its 2021 meeting to strengthen the capacity of the member countries to prevent, detect and contain PPR and enhance coordination and information sharing in the ASEAN region.

This risk assessment was conducted to inform the development of the ASEAN preparedness strategy. Specifically, its aim was to assess the likelihood of the introduction of PPRV into the ASEAN Member States to determine risk mitigation options for protecting the vulnerable small ruminant populations and farmer livelihoods in the region. The qualitative risk analysis followed the WOAHP guidelines described in Chapter 2.1 of the WOAHP Terrestrial Animal Health Code (23) and the Handbook on Import Risk Analysis for Animals and Animal Products (24). We also referred to the recommendations for importing animals and their products presented in Chapter 4.7 of the WOAHP Terrestrial Animal Health Code (25).

We based our inferences on the official trade data and a survey of the ASEAN Member states. We started by defining risk questions and then developed risk pathways for introducing PPR into the ASEAN region via formal or informal trade in live sheep and goats, their meat and meat products, semen and embryos in consultation with regional representatives. Official trade data were collected from the FAOSTAT Food and agriculture database, and information about the PPR status of exporting countries was sourced from WOAHP's WAHIS information system. Additional data about import practices followed in ASEAN countries were obtained by surveying country representatives using a custom-designed questionnaire. Linking trade data with the PPR status and survey data enabled us to make objective inferences about the risk of various import activities from various countries.

The results presented in this report indicate that the ASEAN region has a non-negligible risk of introducing PPR through the trade of small ruminants and their products and because of the potential incursion of the disease from the neighbouring countries. However, most risks can be managed by changing the source of small ruminants and their products, requiring the presentation of an international veterinary certificate, and strengthening border quarantine, veterinary and laboratory facilities, and services by participating in PVS evaluations and implementing the recommendations.

Based on the findings of the risk assessment, we make the following recommendations:

- **Import from low-risk countries:** Purchase small ruminants and their products from countries/zones certified free of PPR or at least where PPR has been historically absent. To further reduce the risk of importing PPR, make sure that the exporter selects farms that have not observed any case of PPR at least in the past 21 days.

- **Insist on the provision of an international veterinary certificate:** Ask the exporter to provide an international veterinary certificate meeting the requirements described in Chapter 4.7 of the WOAHP Terrestrial Animal Health Code (25), e.g., confirming that the selected animals showed no clinical signs of PPR in the past 21 days, the donor animals for semen/embryo were kept in a PPR-free country or zone for at least 21 days before collection, or the consignment of meat comes from animals that showed no clinical sign of PPR within 24 hours before slaughter. Requesting this certificate would also ensure that animals are slaughtered in an approved abattoir and are subjected to ante- and post-mortem inspections, the semen and embryos are collected, processed, and stored following WOAHP standards.
- **Ensure pre-quarantine arrangements:** Require the exporting country to keep animals in pre-export facilities for at least 21 days prior to shipment and discard the entire consignment if any animal shows clinical signs during this period. Ensure that the pre-export facilities have SOPs that are duly followed by animal attendants and veterinarians and that the veterinarians are qualified and trained in diagnosing PPR. Ask for mandatory testing of animals in pre-export facilities with a PPR diagnostic test with high diagnostic sensitivity.
- **Strengthen quarantine facilities and workforce:** Keep animals in the quarantine station for at least 21 days, particularly if they were not kept in pre-export facilities for this duration. Prepare SOPs for the quarantine station to ensure that animals in the quarantine station are carefully examined and tested with a test of high diagnostic sensitivity. Ensure that veterinarians operating the quarantine station are trained in diagnosing PPR and collecting and submitting samples. It is also important to ensure the quality of the laboratory facilities and training of the laboratory personnel in testing for PPR. Participating in external PVS evaluations to advance laboratory quality would also be helpful in this regard.
- **Strengthen border biosecurity:** Train border and quarantine workforce to ensure adequate border surveillance to prevent illegal trade of small ruminants and their products. They should follow SOPs to confiscate and euthanise illegally smuggled animals and destroy illegally smuggled raw animal products.

These risk management strategies are expected to reduce the risk of PPR incursion into ASEAN Member States, besides strengthening their capacity to tackle other transboundary diseases while continuing trade in small ruminants and their products.

It would be valuable to further extend this work. We aimed to conduct a regional risk assessment, but the processes may differ between countries. We tried to achieve as much national granularity in our estimates as possible while maintaining the regional perspective, but further fine-tuning of risk pathways would be essential for implementing the pathways in a particular country or a specific context. Similarly, it was beyond the project's scope to conduct exposure and consequence assessments. The current assessment can be extended by conducting these additional assessments to have a more comprehensive estimate of risk by integrating the results from the entry, exposure, and consequence assessments to produce overall measures of risks.

Introduction

Peste des petits ruminants (PPR) is a transboundary animal disease affecting wild and domestic small ruminants. First reported from Côte d'Ivoire in 1942, PPR now occurs in about 70 countries in Africa, Asia and the Middle East, with another 50 countries at risk (1). PPR causes high morbidity and mortality in the affected populations, which can be up to 90% – 100% in naïve populations. Although not zoonotic, the disease causes significant economic losses (USD 1.45 to 2.1 billion annually) and threatens global food security, human nutrition, and farmer livelihoods (1).

Sheep and goats are the primary hosts of PPR. Although several other species, including wildlife, have been reported to be infected, their precise role in PPR epidemiology is unclear. Of the primary hosts, goats are more susceptible (2), and some breeds are more susceptible than others (3). PPR virus (PPRV) also causes subclinical infections in cattle (4-6), buffaloes (7), dogs and lions (*Carnivora* order) (8; 9). Experimental infection of PPRV in pigs and wild boars has been reported (10), but pigs only develop a subclinical infection without excreting the virus (11) and thus are not considered important in the epidemiology of the virus. While PPR disease outbreaks in camels (Saeed et al., 2015, Khalafalla et al., 2010, Kwiatek et al., 2011) and subclinical infections in various wildlife species, sheep and goats continue to play a significant role in the transmission and global spread of PPRV.

In most cases, the incubation period of PPR is 4-5 days, though it may range between 3 and 14 days. During the acute stage of the disease, animals show high fever (up to 41 °C), which may last for 3–5 days, often accompanied by depression, anorexia and dryness of the muzzle. The disease progresses with the development of ocular, nasal and mucosal discharges. Watery oculo-nasal discharges gradually become mucopurulent with excessive salivation. Erosive lesions formed in the oral cavity may become necrotic. In severe cases, these necrotic lesions progress with the appearance of a deposit of fibrin on the tongue. Eventually, animals develop diarrhoea and cough with laboured breathing. The affected animal may become dyspnoeic, suffering progressive weight loss and emaciation, ultimately leading to death, usually between 5 to 10 days of the onset of the disease. In some cases, particularly in mild infections, animals may convalesce, returning to a pre-infection health status within 10–15 days of illness and developing lifelong immunity. The extent of clinical signs, morbidity and mortality can depend on the virulence of the viral strain, the environment and the immune status of the affected animal (9; 12; 13).

PPR is spreading globally and has been frequently reported in countries across Africa, the Middle East, Asia and some parts of the European Union. PPR is a World Organisation for Animal Health (WOAH) listed notifiable terrestrial animal disease. The Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) has classified the disease as a priority transboundary disease. The Food and Agriculture Organization of the United Nations (FAO) and WOAH have established a control and eradication program with the goal of PPR global eradication by 2030. Control of PPR is expected to improve food security and reduce poverty in the most vulnerable communities globally, besides helping to achieve the 2030 Agenda for Sustainable Development Goals.

PPR is endemic in South Asia and East Asia. China was free of PPR until the first outbreak occurred in Tibet in 2007, possibly due to the importation of goats from Pakistan and Tajikistan (14; 15). Stamping out policy along with effective vaccination programs and surveillance strategies led to the eradication of PPR in China by 2010 (15) until the second outbreak occurred in 2013-14. This outbreak was much more extensive and spread to 32 other counties, including the Yunnan province of Laos, a thoroughfare for trade between Southeast Asian countries (15-17). Molecular epidemiological studies suggest this outbreak was likely due to the transboundary movement of animals into China (17). Currently, Australia, Chinese Taipei, South Korea, New Caledonia, New Zealand, Philippines and Singapore are officially recognised as PPR-free (18).

The Association of Southeast Asian Nations (ASEAN) Member States (Figure 1) are at a risk for emerging infectious and transboundary diseases. Several emerging infectious diseases have been reported from Southeast Asia, such as bird and swine flu, COVID-19, African swine fever, and severe acute respiratory syndrome (19). There are a few reports of the occurrence of PPR in this region. PPR antibodies were detected in apparently healthy mountainous goats in northern Vietnam; however, attempts to identify the virus were not successful (20). Seroprevalence of PPR indicates past exposure to PPRV, possibly due to the informal movement of animals to the region. Secondly, in 2021, Thailand reported an outbreak in goats imported from Western Africa (21) which raises concerns and the threat of incursion of the disease to the ASEAN region. Moreover, low seropositivity in goats was reported in Lao PDR, indicating that the goat populations are largely naïve in Lao PDR (22).

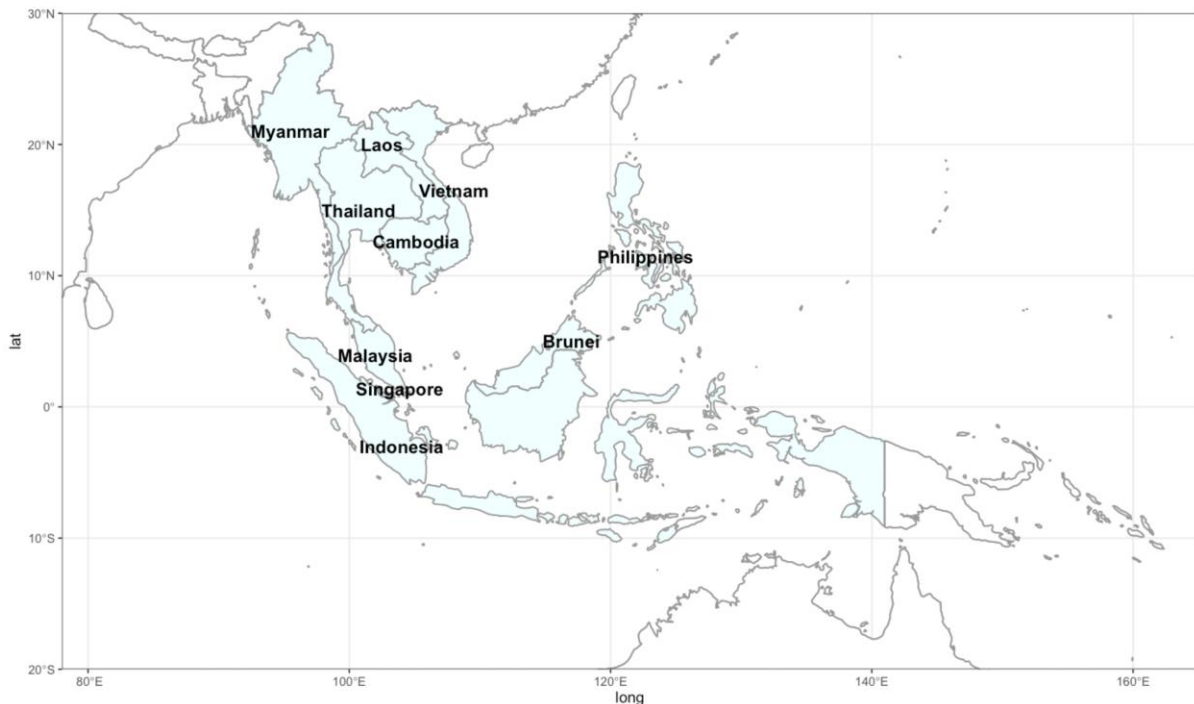


Figure 1. Countries in the Association of Southeast Asian Nations (ASEAN) region. Map produced with R using ggplot2, sf and rnaturalearth packages.

Several ASEAN Member States, especially Myanmar, Lao PDR and Vietnam, are neighbours of China, India and Bangladesh, which are currently endemic for PPR (Figure 2). The porous borders between these countries, accompanied by existing livestock trade between the Member States, the relatively poor veterinary infrastructure, and the suboptimal capacity to detect and respond to emergency and emerging disease outbreaks, enhance the risk of PPRV incursion in the ASEAN region.

Therefore, a qualitative risk assessment was undertaken to estimate the likelihood of PPR introduction in the ASEAN Member States. This information will be helpful in evaluating the risk of PPR in the region and to develop a PPR preparedness strategy for the region. Specifically, the objectives of the study were to:

1. Identify major risk pathways of the introduction of PPRV into the ASEAN region.
2. Evaluate data on sheep/goat trade of ASEAN countries with their trading partners.
3. Conduct a survey with the ASEAN Member States to collect additional data.
4. Estimate the risk of incursion of PPR into the region in order to develop risk mitigation approaches.

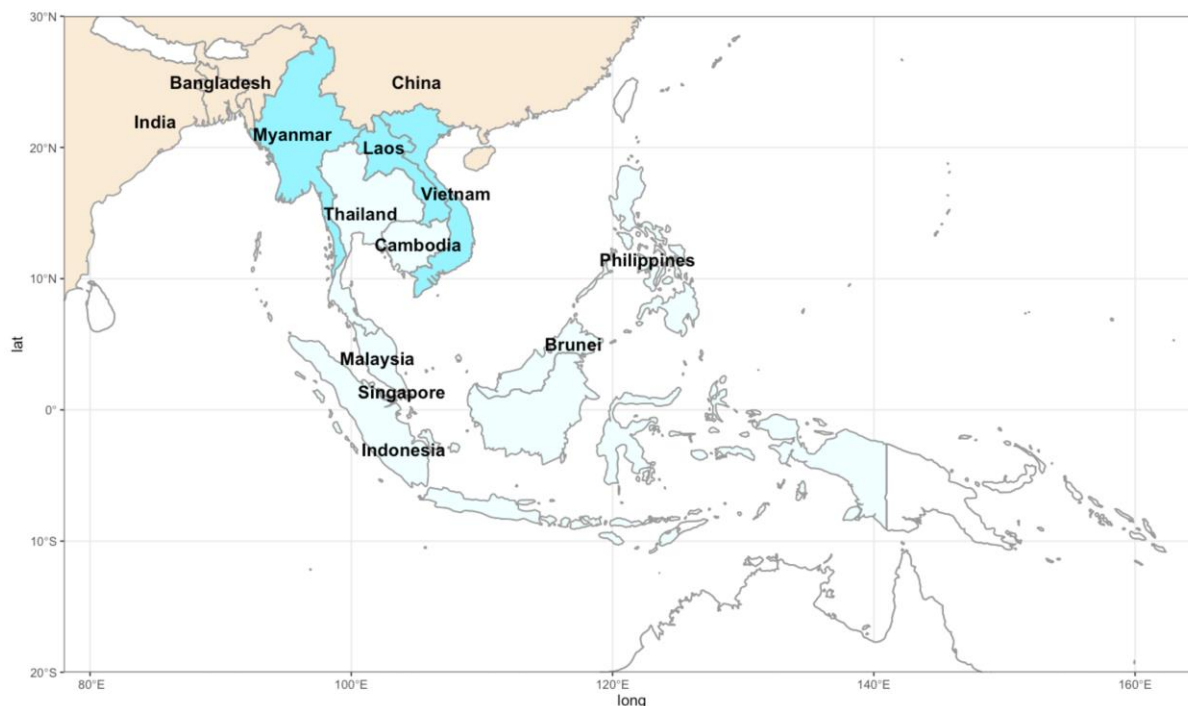


Figure 2. Neighbouring countries where PPR is present (Bangladesh, China and India) surround the countries in the ASEAN region and share borders with Myanmar, Lao PDR and Vietnam. Map produced with R using ggplot2, sf and rnaturalearth packages.

Methods

The qualitative risk assessment followed the WOAHP guidelines described in Chapter 2.1 of the WOAHP Terrestrial Animal Health Code (23) and the Handbook on Import Risk Analysis for Animals and Animal Products (24). We also referred to the recommendations for importing animals and their products presented in Chapter 4.7 of the WOAHP Terrestrial Animal Health Code (25). This risk assessment also benefited from the advice from the African Swine Fever Cross-Border Risk Assessment Manual for Southeast Asia (26).

Participants

The risk assessment was conducted by a technical team supported by an Advisory Committee. In addition, the participants in the risk assessment workshop provided input into identifying the risk pathways. Appendix 1 lists the names of the participants in the technical team, advisory committee and the risk assessment workshop who contributed to this risk assessment.

Purpose

Southeast Asia has been free from PPR historically, but engages in sheep and goats trade with several countries. In addition, Thailand has recently seen an introduction of PPRV from Africa, reinforcing the region's vulnerability to transboundary diseases. Further, the region is bordered by three countries endemic to the disease. The incursion of PPR from these countries is possible as the ASEAN region has experienced outbreaks of several transboundary animal diseases, such as African swine fever, lumpy skin disease, avian influenza and foot-and-mouth disease after their spread from South Asia and China.

As a result of this concern about a potential incursion of PPR in the region, the ASEAN Sectoral Working Group for Livestock (ASWGL) decided to develop a preparedness strategy to strengthen the capacity of the member countries to prevent, detect and contain PPR. Therefore, this risk assessment was conducted to inform the development of this preparedness strategy. Specifically, the risk

assessment was conducted to assess the likelihood of the introduction of PPRV into the ASEAN Member States to determine risk mitigation options for protecting the vulnerable small ruminant populations and farmer livelihoods in the region.

Scope

The risk assessment assessed the likelihood of PPRV introduction into the following ten ASEAN Member States: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

The risk assessment focused on small domestic ruminants, i.e. sheep (*Ovis aries*) and goats (*Capra aegagrus hircus*). Although we considered wild sheep and goats and other species that can be infected clinically or subclinically by PPRV (cattle, buffalo, camel, dog and lion) but they were not included in the risk assessment because of their role in the epidemiology and spread of PPR is not yet clear.

Besides live sheep and goats, we also considered their meat and meat products, semen and embryos. However, semi-processed hides and skins processed through the standard chemical and mechanical processes in the tanning industry were not considered for formal risk assessment following the WOAHP advice that such products are considered safe and “should not require any PPR-related conditions regardless of PPR status of the exporting country or zone” (25).

This risk assessment was conducted between July and December 2022 and considered the information available up to 31 December 2022.

Hazard identification

The PPRV belonging to the genus *Morbillivirus* and family Paramyxoviridae is the hazard for this risk analysis. The virus has a single strand of negative-sense RNA genome that codes for six structural (N, P, M, F, H and L) and two non-structural proteins (V and C). PPRV is a single serotype but has four lineages (I-IV) based on the partial genome sequence of either the nucleocapsid (N) or the fusion protein (F) gene (27; 28). Historically, lineages I-III were found in Africa and were numbered according to the apparent spread of the virus from West Africa (I and II) to East Africa (III). Lineage IV was previously mainly restricted to the Middle East and Asia with a few exceptions but has now established its presence across the PPR endemic areas causing frequent outbreaks in Africa (12; 29). Therefore, all lineages were considered for this risk assessment.

PPRV is primarily transmitted through close contact, with inhalation being a fundamental mode of transmission. Infected animals remain infectious during the incubation period. All bodily secretions and excretions of infected animals are contagious throughout the course of the disease. PPRV is not stable in the environment and long-range aerosol transmission is not possible. Temperature above 70 °C would likely inactivate PPRV, whereas the virus could survive long periods in chilled and frozen tissues (30). The incubation period of the virus was considered to be 21 days as per the WOAHP Terrestrial Animal Health Code (25).

Following the WOAHP guidelines (25), PPRV infection was defined as (a) the isolation of PPRV other than vaccine strains from a domestic sheep/goats or their products, (b) identification of PPRV antigen or RNA in samples from a domestic sheep/goats showing clinical signs of PPR or epidemiologically linked to an outbreak/case of PPR and (c) the detection of antibodies to PPRV antigens in a domestic sheep/goats showing clinical signs of PPR or epidemiologically linked to an outbreak/case of PPR.

Although the WOAHP Terrestrial Animal Health Code provides sanitary measures for the hazard (25), the risk assessment was conducted to determine risk mitigation approaches specific to the South-East Asia region in support of developing a regional preparedness strategy.

Risk questions

The following risk questions were drafted.

1. What is the likelihood of introducing at least one animal infected with PPRV of any lineage during the legal/formal or illegal/informal importation of live domestic sheep or goats into a South-East Asian country in the next year?
2. What is the likelihood of introducing at least one meat or meat product of domestic sheep or goats contaminated with viable PPRV of any lineage during their legal or illegal importation, including via travellers into a South-East Asian country, in the next year?
3. What is the likelihood of importing semen or embryos of domestic sheep or goats infected with viable PPRV of any lineage into a South-East Asian country in the next year?

Risk pathways

The following risk pathways were studied for PPRV introduction into ASEAN countries based on an understanding of the epidemiology of the virus, a review of the literature, and a discussion with representatives from the member countries at a risk assessment workshop conducted on 29 November 2022.

1. Importation of live domestic sheep and goats via a legal trade
2. Importation of live domestic sheep and goats through illegal trade
3. Importation of sheep/goats meat and tissues through a legal trade
4. Importation of sheep/goats meat and tissues through illegal trade
5. Importation of sheep/goats meat by travellers
6. Importation of sheep/goats semen and embryos (via legal trade)

Semi-processed hides and skins processed through the standard processes in the tanning industry were not considered for risk assessment as such products are considered safe (25).

Risk assessment was not conducted for the importation of wild small ruminants and their products or cross-border movements of wildlife from PPR endemic countries to South-East Asian countries because wildlife has limited epidemiological importance according to the WOAHA Terrestrial Animal Health Code (25): “Even if some wild small ruminants can be infective, only domestic sheep and goats play a significant epidemiological role.”. Therefore, the Code defines PPR as “an infection of *domestic sheep and goats* with PPRV”, which was followed in this risk assessment.

The risk assessment workshop was attended by 30 participants from 7 countries: Brunei Darussalam (1), Cambodia (1), Indonesia (5), Malaysia (4), Myanmar (8), Philippines (6) and Thailand (5). Each ASEAN Member State was requested to nominate representatives to participate in the workshop. The participants were introduced to the risk assessment process and then split into working groups to develop and refine draft risk pathways. Finally, a representative of each working group presented updated pathways to all workshop participants.

Risk estimation

The criteria used to estimate the likelihood and assign the level of uncertainty were adapted from the Tripartite Joint Risk Assessment Operational tool (Tripartite, 2020) and are presented in Tables 1 and 2 below. The likelihood was estimated for each risk question outlined above and defined as the likelihood of the event described in the risk question to occur. It was estimated based on the analysis of available data, the opinion of the risk assessment team and the participants in the risk assessment workshop. Uncertainty surrounding the likelihood estimate was based on the availability, quality and quantity of data, the opinion of the risk assessment team and discussions in the risk assessment workshop.

Table 1. Criteria used to estimate the likelihood adapted from the Tripartite Joint Risk Assessment Operational tool (31).

Risk category*	Definition
Negligible	The event is almost certain not to occur except in exceptional circumstances.
Very low	The event is very unlikely to occur.
Low	The event is unlikely to occur.
Moderate	The event may occur.
High	The event is highly likely to occur.

*Risk was considered be 'unknown' if sufficient information was not available to estimate the risk.

Table 2. Criteria for assigning the level of uncertainty adapted from the Tripartite Joint Risk Assessment Operational tool (31).

Uncertainty level	Definition
High	Lack of data or reliable information; results based on speculation.
Moderate	Some gaps in availability or reliability of data and information; results based on limited consensus.
Low	Reliable data and information are available based on empiric evidence, factual information or expert consensus.

Data sources

Data requirements for each probability event in the risk pathways described above were identified. Existing data were sourced from FAOSTAT (32), WOA's World Animal Health Information System (WAHIS) (33) and scientific publications. In addition, data gaps were identified, and a questionnaire was designed to obtain data from the target countries.

Sheep and goat production

Available data about sheep and goat populations and products were sourced from the FAOSTAT database (32) and summarised.

Livestock trade

A list of countries exporting live domestic sheep and goats to South-East Asian countries and the trade volume was obtained from the FAOSTAT food and agriculture dataset (32). Information about the PPR status of exporting countries was based on (a) the 17th Resolution of the World Assembly of Delegates of WOA held on 24 May 2022 (34) and (b) the evaluation of PPR status reports submitted to WOA by the exporting countries between 2005 and 2020 (33). Based on this information, we classified the PPR status into four categories:

1. **Free:** Countries certified by WOA as PPR-free, i.e., meeting the requirements included in Chapter 14.7. of the Terrestrial Code (25).
2. **Absent:** Countries that have never reported the disease but have not received WOA's PPR-free status.
3. **Present:** Countries reporting the presence of PPR in at least one report submitted to WOA in the past 15 years (from 2005 – 2020).

4. **Suspect:** Countries not reporting any confirmed case or outbreak of PPR in the past 15 years (from 2005 – 2020) but reporting a suspected case/outbreak of PPR which has not been confirmed. Countries with suspect status were clubbed with those where the disease is present in colour coding.

Survey

A questionnaire was designed to obtain information from the ASEAN Member States regarding the data gaps identified (Appendix 2). It contained questions about the import requirements of the Member States and the procedures conducted at the border to reduce the risk of importation of PPRV into the country. WOAHA circulated a link to the online questionnaire and MS Word to the Member States, requesting them to complete the survey. Two reminders were sent to complete the survey.

Data from the online and returned MS Word questionnaires were collated and tabulated using the Statulator online statistical program (35).

Results

Likelihood of PPR introduction through the legal importation of live sheep and goat

Risk pathway

A risk pathway for the introduction of PPRV through the importation of domestic live sheep and goats through formal trade is illustrated in Figure 3 below. The risk of introduction of PPRV would depend on the PPR status of the exporting country/farm and the subsequent survival of the virus, testing, transportation and quarantining of the animal.

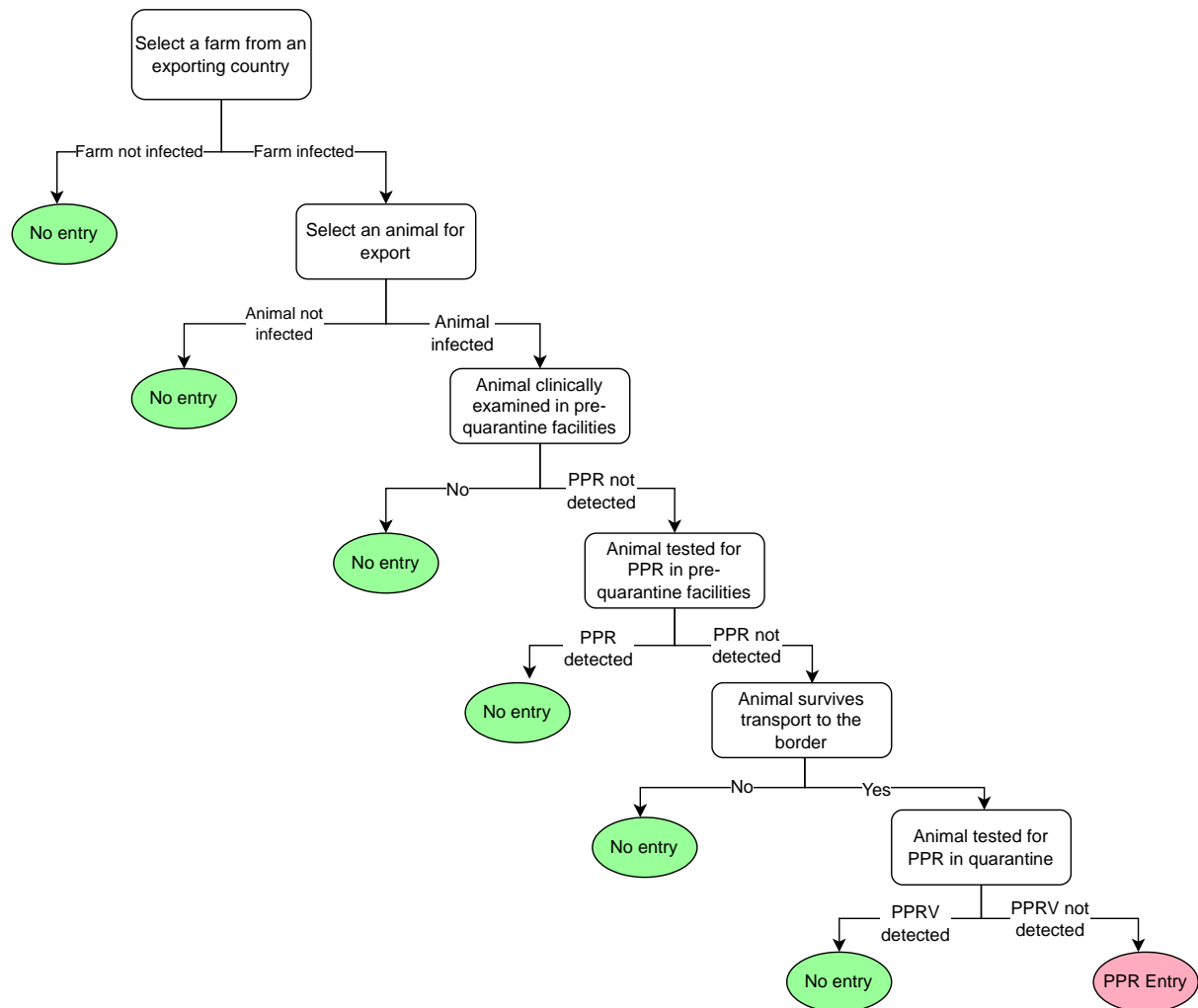


Figure 3. Risk pathways for the entry of PPRV via legal importation of live sheep and goats into South-East Asian countries.

Selecting an infected farm from an exporting country

The likelihood of selecting an infected farm from an exporting country for a specific consignment would depend on the country's PPR status and farm-level disease prevalence. As we aimed to conduct a regional-level risk assessment and as farm-level prevalence data from exporting countries were unavailable, we used the following information as surrogate indicators of the likelihood of this node:

- Data about the volume and frequency of live small ruminant trade of ASEAN Member States with their trading partners, available from the FAOSTAT database, summarised in Table 3 and Appendix 3 (32).
- The PPR status of exporting countries determined based on WOAHP data presented in Table 4 and Appendix 3 (33).

Over the past 20 years, more than 2.5 million live sheep and goats were imported into the ASEAN countries for which data are available. Malaysia imported the largest number of live sheep and goats (1737 thousand) followed by Thailand (365 thousand), Singapore (362 thousand) and Indonesia (48 thousand). However, Singapore only imported small ruminants from certified free countries, whereas Malaysia, Thailand and Indonesia imported from a mix of countries, including those where PPR is present (Table 3). In addition, some other ASEAN countries imported live sheep and goats from countries that have never reported PPR but are not certified free from PPR (Table 3). Please note that these are only the officially reported data available from FAOSTAT and excluding informal/illegal importation of livestock discussed in the next section.

Detailed reports of live sheep and goat imports presented in Appendix 3 indicate that

- Indonesia has not imported live sheep and goats from risky countries after 2010 as all of the imports since then are from PPR free countries (Table 17).
- Malaysia has not imported live sheep and goats from PPR-endemic countries since 2011, although it has imported from countries that have never reported PPR but are not confirmed PPR-free, i.e., Brunei, Indonesia, Myanmar and Thailand (Table 18).
- In contrast, Thailand has continued to import live sheep and goats from PPR-endemic countries including Bangladesh, Benin, Ethiopia, Ghana, Saudi Arabia and Togo (Table 19). Moreover, it has imported a large number of live sheep and goats from Myanmar that has never reported PPR but its PPR free status was suspended by WOAHP in 2017 (36).
- Other ASEAN countries, i.e., Brunei (Table 20), Cambodia (Table 21), the Philippines (Table 22), Singapore (Table 23), and Vietnam (Table 24), generally used a cautious approach.

Based on the above information, we inferred that the likelihood of selecting an infected farm from an exporting country is:

- **High** for Thailand as it continues to import live sheep and goats in large numbers from PPR positive countries.
- **Low** for Indonesia and Malaysia as they stopped importing live sheep and goats from risky countries about a decade ago.
- **Negligible** for Brunei, Cambodia, the Philippines, Singapore, and Vietnam as they import primarily from countries that are historically free or have a certified disease-free status.
- **Unknown** for Lao PDR and Myanmar, as trade data were not available.

Table 3. Number of live sheep and goats imported by South-East Asian countries in 20 years between 2001 and 2020 based on the analysis of officially reported livestock trade data obtained from FAOSTAT (32). The PPR status was determined based on the data sourced from WOA's WAHIS information system (33). Detailed information about the volume of trade over time is presented in Appendix 3. Colour coding indicates the PPR status of the country.

Exporting country	Importing Country								PPR status
	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam	
Bangladesh				12			28		Present
Benin							21		Present
China			1498	24026			2360		Present
Ethiopia							16		Present
Ghana							65		Present
India				602					Present
Saudi Arabia							132		Present
Tanzania							54		Present
Togo							172		Present
Thailand		883	35716	2755					Absent*
Namibia				1748					Absent*
Brunei Darussalam				222					Absent
Hong Kong			7						Absent
Indonesia	1517			125577					Absent
Japan			0				1		Absent
Lao PDR							20		Absent
Malaysia	1934		1	1801			69		Absent
Myanmar		2		5479			321900		Absent
Australia	11878		9799	1566138	9393	358826	8115	147	Free
Austria								0	Free
Belgium								0	Free
Brazil							105		Free
Canada							6		Free
Cyprus	3			496			1140		Free
Czech Republic			10						Free
France				204			12122	0	Free

Exporting country	Importing Country								PPR status
	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam	
Germany				900			17		Free
Netherlands	2		834	87			70	0	Free
New Zealand				2007		1110	1231	0	Free
Philippines							1		Free
Singapore	4		0	155					Free
South Africa				2892		1814	11878		Free
South Korea		1	5	460					Free
Spain							107		Free
Sweden							5200		Free
Taiwan	1								Free
UK		2							Free
USA	1	318	1	1183	5948		339	309	Free
Grand Total	15340	1204	47873	1736744	15341	361750	365169	456	

Table 4. PPR status of countries exporting domestic sheep and goats and their products to the ASEAN member nations based on WOAHP reports (33; 36). The detailed status for each years since 2005 is presented in Appendix 3 in Table 16. The list of exporting countries is based on the FAO STAT database (32).

PPR status	ASEAN country trading partners
Present	Bangladesh, Benin, Bulgaria, China, Ethiopia, Georgia, Ghana, India, Iran, Israel, Kenya, Mauritania, Mongolia, Pakistan, Saudi Arabia, Senegal, Tanzania, Thailand, Togo, Turkey, Uganda and United Arab Emirates.
Suspect	Lebanon
Absent	Brunei Darussalam, Hong Kong, Indonesia, Japan, Lao PDR, Malaysia, Mozambique, Myanmar, Namibia, Serbia, Ukraine and Viet Nam.
Free	Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Cyprus, Czech Republic, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Madagascar, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, UK, Uruguay and USA.
No data	Niue

Selecting an infected animal for export

The likelihood of selecting an infected animal for export would depend on the disease prevalence of the exporting farm and the procedures implemented to reduce the chance of selection of an infected animal. Without information about the animal level prevalence of the exporting farm for this risk assessment, we based our estimate on the measures taken by the importing country to reduce the risk of selecting an infected animal following WOAAH's guidelines. Box 1 lists the requirements for importing live domestic sheep and goats from PPR- free and infected countries or zones as presented in Chapter 14.7 of WOAAH's Terrestrial Animal Health Code (25).

Box 1. WOAAH's recommendations for importation of live sheep and goats from PPR free and infected countries and zones. Reproduced with permission from (25).

Recommendations for importation from PPR free countries of zones

Veterinary authorities should require the presentation of an international veterinary certificate attesting that the animals:

1. showed no clinical sign of PPR on the day of shipment;
2. were kept in a PPR free country or zone since birth or for at least the past 21 days.

Recommendations for importation from countries of zones considered infected with PPRV

Veterinary authorities should require the presentation of an international veterinary certificate attesting that the animals:

1. showed no clinical sign suggestive of PPRV infection for at least the 21 days prior to shipment;
2. Either
 - a. were kept since birth, or for at least the 21 days prior to shipment, in an establishment where no case of PPR was reported during that period, and that the establishment was not situated in a PPRV infected zone; or
 - b. were kept in a quarantine station for at least the 21 days prior to shipment;
3. Either
 - a. were not vaccinated against PPR and were submitted to a diagnostic test for PPRV infection with negative result no more than 21 days prior to shipment; or
 - b. were vaccinated against PPR with live attenuated PPRV vaccines at least 21 days prior to shipment.

We collected data about these requirements imposed by the importing country in the survey conducted with the ASEAN Member States. The results presented in Table 5 indicate that all countries responding to the survey impose some requirements. All countries require them to provide an international veterinary certificate meeting the requirements of the WOAAH Terrestrial Animal Health Code, both for importing from a PPR-free country or zone and from a country or zone considered to be PPR infected.

Assuming that the issuing veterinarian strictly follows the standard operating procedures (SOPs) in issuing the certificate and considering the responses for questions #2 to #6 in Table 5, we inferred the qualitative likelihood of selecting an infected animal to be:

- **Very low** for Brunei Darussalam, Cambodia, Indonesia, Myanmar, Malaysia and the Philippines.
- **Moderate** for Thailand.
- **Unknown** for Lao PDR, Singapore, and Vietnam.

Table 5. Requirements imposed for the import of live domestic sheep and goats by the ASEAN member nations responding to the survey based on WOA's Terrestrial Animal Health Code (25).

Number	Questions	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Thailand
1	Are any requirements imposed on the import of live domestic sheep and goats?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Requirements imposed for import from a PPR free country or zone</i>								
2	Presentation of an international veterinary certificate meeting the requirements of the WOA's Terrestrial Animal Health Code	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	The animals showed no clinical signs of PPR in the past 21 days.	No	Yes	Yes	Yes	Yes	Yes	No
4	The animals were kept in a PPR free country or zone for at least the past 21 days	Yes	Yes	Yes	Yes	Yes	Yes	No
<i>Requirements imposed for import from a country or zone considered to be PPR infected</i>								
5	Presentation of an international veterinary certificate meeting the requirements of the WOA's Terrestrial Animal Health Code	Yes	Yes	Yes	Yes	Yes	Yes	No
6	The animals showed no clinical signs of PPR in the past 21 days.	No	Yes	Yes	Yes	Yes	Yes	Yes
7	The farm had no case of PPR in the past 21 days.	No	Yes	Yes	No	Yes	Yes	Yes
8	The animals were kept in a quarantine station for at least 21 days prior to shipment.	No		Yes	Yes	Yes	Yes	Yes
9	The animals were negative for a PPR diagnostic test conducted within 21 days prior to shipment	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	The animals were vaccinated against PPR at least 21 days prior to shipment	No	Yes	Yes	No	Yes	No	No

Failing to clinically detect PPR in pre-quarantine facilities

After an infected animal has been selected, further measures can be put in place to detect it before it reaches the importing nation. One such measure is pre-quarantining in the country of origin and only importing animals that do not show clinical signs and are test-negative.

Most of the countries that responded to our survey require that the animals for import should be kept in a quarantine station for at least 21 days before shipment (Table 5, question # 8). The likelihood of an infected animal not showing clinical signs for 21 days would depend on the proportion of PPR cases presenting in the sub-clinical form of the disease and the ability of veterinarians to detect PPR. The appearance of clinical signs depends on the virulence of the virus, age and breed of the animal, vaccination and nutritional status of the animal, etc. In experimental infections, different strains of PPRV exhibit varied virulence even for the same breed of goat (3), and different breeds of goat respond differently to infection with the same virus (37). Animals infected with the virulent strain may show

severe clinical signs while those infected with less virulent strains may show mild clinical signs which may go undetected. Young animals are more susceptible and goats are more susceptible than sheep. Given that clinical signs of PPR are quite obvious, we can assume that a qualified veterinarian is very unlikely to miss PPR cases if animals are quarantined for 21 days. Therefore, the likelihood of an animal being infected but not detected in the quarantine would be:

- **Very low** for Indonesia, Malaysia, Myanmar, Philippines and Thailand – the countries that require pre-export quarantine. This likelihood would increase if the veterinarians are not trained in diagnosing PPR, or there is a laxity in observing animals in the pre-quarantine facilities.
- **High** for Brunei Darussalam as they do not impose this requirement.
- **Unknown** for Cambodia, Lao PDR, Singapore, and Vietnam.

Obtaining a false negative test result in pre-quarantine facilities

All countries that responded to our survey require that the animals for import should be negative to a PPR diagnostic test conducted within 21 days before shipment (Table 5 , question # 9). Therefore, the chance of testing an infected animal and finding it negative would only depend on the diagnostic sensitivity of test used. The N-protein based cELISA used to detect PPR-specific antibody has been reported to have 94.5% sensitivity and 99.4% specificity in sheep and goats (38). Therefore, assuming that the sensitivity of the diagnostic test used for PPR is high (95%), the probability of a false negative result would be <5%.

Based on the above information, we inferred that the likelihood of testing an infected animal for PPR in pre-quarantine facilities and finding it to be negative would be:

- **Very low** for Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Thailand and the Philippines that require testing.
- **Unknown** for Lao PDR, Singapore, and Vietnam.

Animal surviving transport to the border

The probability of an infected animal surviving transport to the border would be a product of two probabilities: (a) the probability of a sheep or goat surviving PPR infection and (b) the probability of a sheep or goat surviving transport.

The first probability would depend on the PPR case fatality rate. In a naïve population, mortality from PPR infection can be very high. As the small ruminants in Southeast Asia has not been exposed to PPR infection yet, they may be considered as naïve/unexposed.

The second probability would depend on the mode of transport, transportation conditions, and transportation duration. While reports on mortality rate in sheep and goats because of long distance transport of animals are scant, a recent study in Italy reported 0.012% mortality and morbidity in sheep/goats and 0.084% and 0.019% in lambs, respectively (39). However, several factors such as distance traveled, journey duration, space allocation per animal, pre-journey and post-journey factors can contribute to variation in morbidity and mortality of the transported animals. Without information about transport conditions, we assumed the likelihood of animals surviving transport to the border to be **low** with high uncertainty for all countries. However, further information would be required to estimate this risk better.

Failing to detect a case in the quarantine station

Assuming that an infected animal has arrived at the border, the risk of importation of PPRV would depend on the procedures followed at arrival at the border inspection post in the importing country. These quarantine procedures would enable the detection of an infected animal prior to entry into the country and prevent the infection of the local stock, thus reducing the risk of introducing PPR in a country.

The probability of this node is a product of two independent probabilities: (a) the probability of not detecting a clinical PPR case in the quarantine centre and (b) the probability of receiving a false negative test result.

The first probability depends on the country's quality of veterinary and quarantine services. Data from WOA's Performance of Veterinary Services (PVS) reports summarised in Table 6 indicate that the quarantine and veterinary services may not be able to detect a clinical case of PPR except for Myanmar, Philippines and Thailand unless they are trained specifically for this purpose. Further, our survey asked the respondents if they quarantined imported animals. Six of the seven countries responding to the survey indicated that they quarantine live sheep and goats on arrival though the quarantine period varied from 3 to 30 days instead of the 21 days recommended by WOA.

The probability of receiving a false negative test would depend on the sensitivity of the diagnostic test used and the quality of laboratory facilities and resources. All except one of the six countries responding to our survey reported testing the animals with PCR and/or ELISA, generally having high sensitivity and specificity (Table 7). The PVS data about laboratory quality assurance is summarised in Table 6.

Based on the above information, the likelihood of failing to detect PPR in quarantine was inferred to be:

- **Negligible** for the Philippines that quarantine animals for 30 days and have relatively better quarantine and border security systems and laboratory facilities.
- **Very low** for Myanmar, which quarantines animals for 30 days but could benefit from improving veterinary services and laboratory facilities.
- **Low** for Malaysia quarantining for 14 days.
- **Moderate** for Indonesia, Malaysia, Brunei Darussalam and Thailand, either due to a low number of quarantining days or a modest quality of veterinary/quarantine workforce.
- **Unknown** Cambodia Lao PDR, Singapore, and Vietnam as no information on quarantining was available.

Table 6. Levels of advancement of the ASEAN countries based on the WOA's Performance of Veterinary Services (PVS) Critical Competencies (data courtesy WOA).

	Cambo dia 2007	Indon esia 2007	Lao PDR 2011	Myan mar 2009	Philipp ines 2008	Thail and 2012	Viet nam 2010
Quarantine and border security	1	2	2	3	3	3	2
Staffing: Veterinary and other professionals	NA	NA	1	2	3	2	3
Staffing: Veterinary para-professionals and other technical staff	NA	NA	2	2	3	3	3
Professional competencies of veterinarians	1-2	2	1	2	3	4	1
Competencies of veterinary para-professionals	1-2	1	2	1	4	2	2
Access to veterinary laboratory diagnosis	1-2	2	2	2	3	5	5
Laboratory quality assurance	1-2	2	1	2	1	5	2

Table 7. Requirements imposed for the import of live domestic sheep and goats by the ASEAN member nations responding to the survey based on WOAH's Terrestrial Animal Health Code (25).

Questions	Brunei Darussalam	Indonesia	Malaysia	Myanmar	Philippines	Thailand
Are live sheep and goats quarantined on arrival?	Yes	Yes	Yes	Yes	Yes	Yes
Quarantine period		14	14		30	3
Are animals tested during quarantine?	No	Yes	No	Yes	Yes	Yes
Diagnostic test used		PCR or ELISA	c-ELISA	ELISA	None specific	RT-PCR
Sensitivity and specificity of the test		95-100%	SE: 88 SP: 99	SE: 95 SP: 98		High
Proportion of animals tested		Proportional sample	all	30	all	10%

Box 2. Survey respondents' notes about the quarantine procedure followed in their countries.

<p>Brunei Darussalam: Animal are inspected for any clinical sign.</p> <p>Indonesia: The Animal Quarantine Center has issued various Guidelines and Technical/Implementation Guidelines in the Animal Quarantine Sector, Instructions for the Implementation of Quarantine Measures Against the Importation of Carcass, Meat and/or Offal Into the Territory of the Republic of Indonesia; Guidelines for Animal Quarantine Actions Against the Importation and Exportation of Animal Products within the Territory of the Republic of Indonesia; Guidelines for Determining Animal Quarantine Installations.</p> <p>Malaysia: All animals destined for export shall be kept and observed for twenty-one (21) days at a collection centres/holding yards located at the country of origin which has been inspected and approved by the authority of the exporting country. Upon entry into Malaysia the animal will be quarantine at the designated quarantine stations for 14 days under the authority of MAQIS.</p> <p>Myanmar: Monitoring, recheck certificate, test the notifiable disease certificate; Quarantine station; AQS team</p> <p>Philippines: Animals should comply with a number of requirements for importation, such as: (a) Be apparently healthy, (b) Be tested within the last 30 days, and have ear tags, (c) Dewormed prior to arrival, (d) d. Take part in vector control while in quarantine, (e) Accompanied by a Health Certificate issued by a Veterinary Officer from its origin, (f) Complete details of importer, (g) Tested for diseases such as CAE, brucellosis, etc.</p> <p>Thailand: Clinical examination, quarantine and sample collection</p>
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Risk estimation

The overall estimate of the likelihood introducing PPR via the trade of live sheep and goats is presented in Table 8 below. Likelihood could not be estimated for Lao PDR, Myanmar, Singapore and Vietnam due to missing data for some of the nodes in the risk pathway. Singapore and Vietnam may have a negligible risk as they only import live sheep and goats from PPR-free countries.

Uncertainty was determined based on the amount of information available for various nodes. It was considered high for Cambodia due to missing data about two nodes and for Thailand, as further details would be required for their requirements for pre-quarantine and quarantine.

These risk estimates should be interpreted with caution as we have only conducted a generic risk assessment for the region. Each country should conduct its own risk assessment by adopting this approach and incorporating other information they may have to refine the estimates and reduce the uncertainty. For Thailand, with a moderate likelihood of selecting an infected farm, the reduction of risk is entirely dependent on the remaining nodes, i.e., the processes followed after the selection of a consignment. Therefore, care should be taken in following these procedures to reduce the risk.

Table 8. Summary of likelihood estimates for various nodes in the risk pathway for legally importing live sheep and goats into the ASEAN Member States. The estimates were based on analysis of FAOSTAT data (32), WAHIS (33) and the results of a survey conducted with member countries in 2022.

Node	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Philippines	Thailand
Selecting an infected farm	Negligible	Negligible	Low	Low	Negligible	High
Selecting an infected animal	Very low	Very low	Very low	Very low	Very low	Moderate
Failing to detect in pre-quarantine	High	Unknown	Very low	Very low	Very low	Moderate
Obtaining a false negative result in pre-quarantine	Very low	Very low	Very low	Very low	Very low	Low
Animal surviving transport to the border	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Failing to detect in quarantine	Moderate	Unknown	Moderate	Low	Negligible	Moderate
Overall risk	Negligible	Negligible	Very low	Very low	Negligible	Low

Risk mitigation measures

Importing countries can take several steps to reduce the risk of importing infected animals. They could purchase live sheep and goats from a country/zone certified free of PPR (preferable) or where PPR has been historically absent. If it is not feasible, the risk can be reduced by selecting a farm that has not observed/reported any case of PPR in the past or at least in the past 21 days. The risk of selecting an infected animal from an infected farm can be further reduced by requiring the exporting country to provide an international veterinary certificate confirming that the selected animals showed no clinical signs of PPR in the past 21 days. The risk of not detecting PPR in pre-quarantine facilities can be reduced by ensuring that:

- the exporting country keeps animals in the pre-quarantine station for at least 21 days prior to shipment to exclude chances of the animal being in the incubation phase of the disease;
- the veterinarians handling the pre-quarantine facilities are qualified and trained in diagnosing PPR; and
- the SOPs are duly followed in the pre-export facilities.

Similarly, the risk of not detecting PPR in quarantine facilities can be reduced by ensuring that animals are kept in the quarantine station for at least 21 days so that any animal in the incubation period of the disease can be detected. Further, the veterinarians operating the quarantine station should be qualified and trained in diagnosing PPR and collecting and submitting samples. The eLearning module developed in this project for this purpose can be used to train veterinarians. Animals in the quarantine station should be carefully examined following the SOPs for the duration of their stay.

The risk of getting a false negative result in pre-quarantine facilities can be reduced by mandatory testing of animals before export with a test with high diagnostic sensitivity. Of course, you want to avoid false positives by testing animals with a test with low specificity, but the specificity is less critical as any animal found to be positive can be further tested with a high-specificity test. The sensitivity of the testing system can be increased by using two tests in parallel (preferably measuring a different biological indicator), i.e. considering an animal to be positive if it tests positive to either test. Similarly, the risk of getting a false negative result in quarantine facilities can be reduced by testing with high diagnostic sensitivity. Laboratory facilities should be appropriate and managed by experienced personnel trained in testing for PPR.

Likelihood of PPR introduction through the illegal importation of live sheep and goats

Risk pathway

The risk pathways for introducing PPRV through the illegal importation of live sheep and goats are presented in Figure 4. The risk of introducing PPRV would depend on the volume of illegal trade with PPR positive countries, the likelihood of the animal surviving shipment and the likelihood of intercepting the animal at the border.

Survey results

Only two countries participating in our survey – Indonesia and Malaysia – indicated that the illegal importation of live domestic sheep and goats had been reported into the country in the past five years. Malaysia reported 12 incidents of illegal import in 2021, with Thailand being the predominant country of origin for live sheep and goats. Border authorities in Malaysia seized 420 goats and 238 sheep at the border in 2021. The predominant mode of transportation was land (animal crossing the river) and sea (small boats) though the respondent was unaware of the duration of transport. The Indonesian respondent could not provide details about illegal trade, though mentioned that illegal trade of goats and sheep does occur. Although not reported, illegal import is likely in several ASEAN countries sharing land and maritime borders with PPR-positive countries (Figure 2).

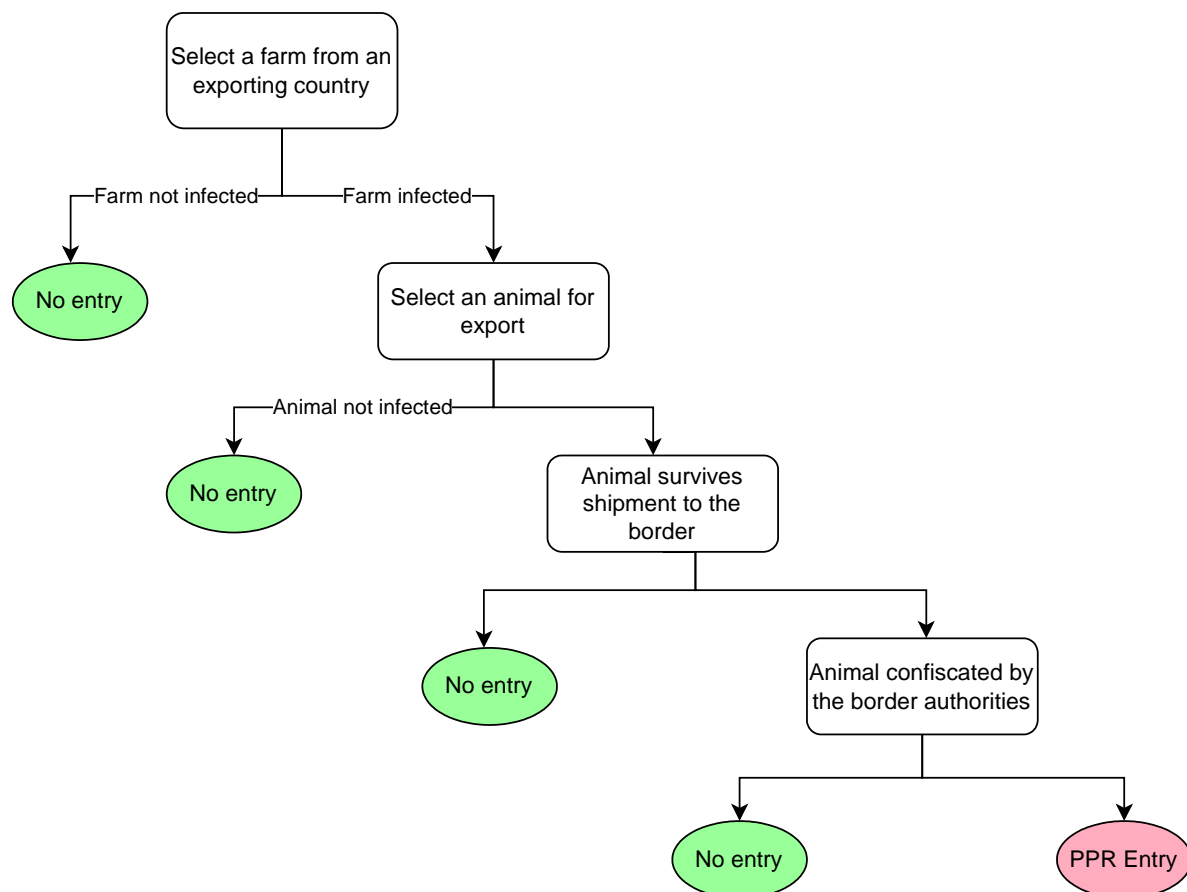


Figure 4. Risk pathways for the entry of PPRV via illegal importation of live sheep and goats into South-East Asian countries.

Similar to the scenario for the legal importation of live sheep and goats, the probabilities of selecting an infected farm and animal would depend on the country's PPR status and disease prevalence. In contrast to that scenario, the procedures to reduce the chance of selection of an infected animal are unlikely to be implemented.

The two other factors that influence the likelihood of PPR introduction via illegal import are the likelihood of survival of the infected animal in shipment and the likelihood of interception of the illegally imported animal at the border. We could assume a moderate risk of surviving to the border, similar to the scenario of legal trade of live sheep and goats, but it is not possible to estimate the likelihood of interception due to the availability of very limited data.

Overall risk estimate

Due to the limited data availability, we cannot estimate the likelihood of PPR introduction through the illegal importation of live sheep and goats for any country in the region. However, the risk of importation could be considered to be high in Lao PDR, Myanmar and Vietnam, sharing borders with PPR endemic countries (China, Bangladesh and India). Lao PDR and Vietnam are likely to have a higher risk on the basis of their quarantine and border security PVS score (Table 1).

Risk mitigation measures

Of the nodes of the scenario tree, the only factor under the control of the animal health authorities is the interception of the animals at the border. Therefore, they should make sure that there is adequate border surveillance and that the personnel are trained in intercepting and seizing consignments of live sheep and goats. Countries in the region could also work with the neighbouring countries to reduce the cross-border illegal movements and trade of live animals.

Likelihood of PPR introduction through the importation of sheep and goat meat

Risk pathway

The risk pathway for the importation of sheep and goat meat shown in Figure 5 below suggests that the risk of PPR introduction via this means would depend on ante- and post-mortem inspections conducted, meat processing, and pre- and post-border checks performed, besides the prevalence of the disease in the exporting country.

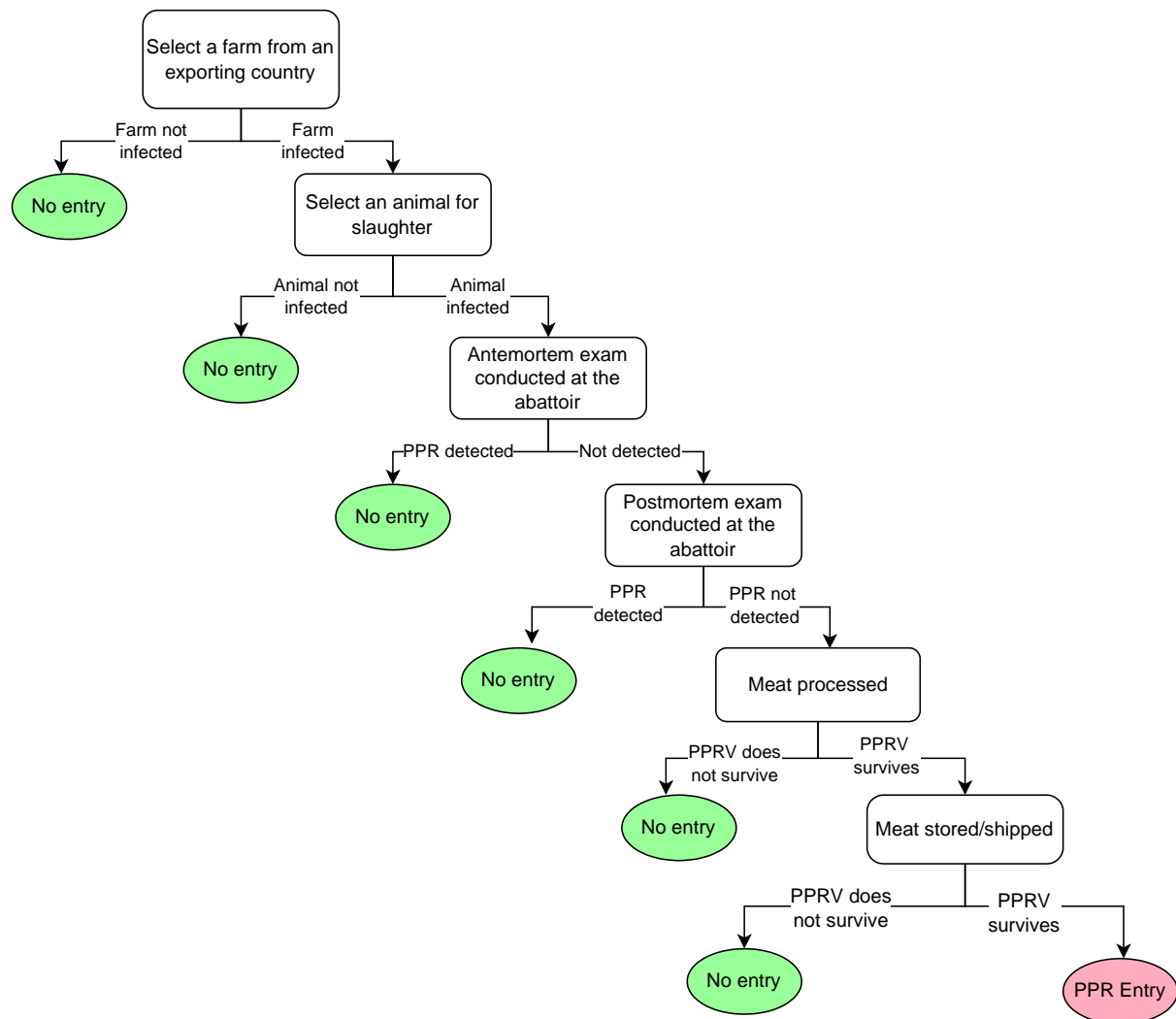


Figure 5. Risk pathways for the entry of PPRV via legal importation of sheep and goat meat or meat products into South-East Asian countries.

Selecting an infected farm

Similar to the previous risk pathways, the likelihood of selection of an infected farm would depend on the PPR status of the country or zone and the prevalence of the disease in that country or zone. However, we determined this likelihood based on data about the volume and frequency of trade, available from the FAOSTAT database, summarised in

Table 9 and Appendix 3, along with the PPR status of the exporting country determined based on WOA data (33; 34), presented in Table 4 and Appendix 3.

The ASEAN countries imported 760 kilotonnes of sheep and goat meat and meat products from their trading partners in the past 20 years. Malaysia was the single largest importer importing 473 kilotonnes of meat and meat products, followed by Singapore (216 kilotonnes). Relatively smaller quantities were imported by Indonesia (27 kilotonnes), Thailand (19) and the Philippines (11) and even smaller quantities by Brunei, Vietnam and Cambodia (

Table 9).

Detailed reports presented in Appendix 3 indicate that:

Malaysia frequently imported meat and meat products in large quantities from PPR-positive countries, such as India, China and Saudi Arabia (

- Table 9 below and Table 25 in Appendix 3).
- The Philippines (Table 26) and Thailand (Table 27) imported small ruminant meat and meat products from PPR-endemic countries in the past, but it appears to have stopped this practice since 2014.
- Indonesia only imported meat and meat products from PPR endemic countries until 2001. Since then, it has generally been importing small ruminant meat from PPR-free countries. (Table 28).
- Cambodia did not have any history of import of meat and meat products from PPR endemic countries prior to 2017, when it started to import meat and meat products from China (Table 29).
- Singapore (Table 30) and Vietnam (Table 31) generally imported meat and meat products from less risky sources. Brunei can also be classified in this group though it imported meat from Thailand in 2002-03.

Based on the above information, we inferred that the likelihood of selecting an infected farm from an exporting country is:

- **High** for Malaysia as it continues to import meat and meat products in large quantities from countries where PPR is present.
- **Moderate** for Cambodia as it has started importing meat and meat products from countries where PPR is present, though in smaller quantities.
- **Low** for Indonesia, the Philippines and Thailand as they stopped importing meat and meat products from risky countries.
- **Negligible** for Brunei Darussalam, Singapore, and Vietnam as they import primarily from countries that are historically free or have a certified disease-free status.
- **Unknown** for Lao PDR and Myanmar as data about meat and meat product trade was not available for these countries.

Table 9. Sheep and goat **meat and meat products** (tonnes) imported by South-East Asian countries in 20 years between 2001 and 2020 based on analysis of FAO STATS data (32). The PPR status was determined based on the data sourced from WOAHP's WAHIS information system (33; 34). Detailed information about the volume of trade over time is presented in Appendix 3.

Exporting country	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam	PPR status
Lebanon				3					Suspect
China	0	123	77	1869	43	0	23		Present
Ethiopia									Present
Georgia									Present
India				4890	287				Present
Iran							28		Present
Kenya									Present
Mauritania									Present
Mongolia				87					Present
Pakistan									Present
Saudi Arabia				956					Present
Senegal									Present
Thailand	35	2		28	27				Present
Uganda									Present
United Arab Emirates				58					Present
Tanzania									Present
Turkey							0		Present
Brunei Darussalam				2					Absent
Hong Kong			1	110	7	6			Absent
Indonesia				0	13				Absent
Japan			1	14					Absent
Malaysia	24	22				35	9		Absent
Mozambique				7					Absent
Namibia							9		Absent
Ukraine				25					Absent
Viet Nam		6		87	25				Absent
Argentina				56		170		97	Free
Australia	7384	392	25911	30309	8314	18401	1020	5358	Free
Austria			10	49				7	Free
Belgium				1	29				Free
Brazil				53	13	85			Free
Canada				232	93	0			Free
Chile						24			Free
Czechia			1						Free

Denmark				723		83			Free
France		2	31	36	0	76	1		Free
Germany				74	24	9	0		Free
Iceland				3					Free
Ireland					1	121			Free
Italy			0	27		1533			Free
Madagascar									Free
Netherlands			0	80	3	112	11		Free
New Zealand		317	588	15969 8	1237	28267	8274	949	Free
Norway			1	18		203			Free
Peru						14			Free
South Korea			2		16	21			Free
Romania						168			Free
Russia			0						Free
Singapore	43	59	120	20			0		Free
South Africa		0				0			Free
Spain		0				234			Free
Sweden							3		Free
Switzerland					0				Free
Taiwan			5	50	0				Free
UK	2			48	0	225	48		Free
USA		58	2	260	370	148	18	0	Free
Uruguay				54		45			Free
Niue		8							NA
Total	7488	989	26750	47271 0	10502	21559 4	1863 1	6411	

Selecting an infected animal

The likelihood of selecting an infected animal for slaughter would depend on the animal level prevalence of the source farm. Importing countries can reduce this risk by requiring the presentation of an international veterinary certificate attesting that the animals did not show clinical signs as per WOAH guidelines. Box 3 lists the requirements for importing meat and meat products from sheep and goats as presented in Chapter 14.7 of WOAH's Terrestrial Animal Health Code (25).

Box 3. WOAH's recommendations for the importation of fresh meat and meat products from sheep and goats. Reproduced with permission from (25).

Veterinary Authorities should require the presentation of an international veterinary certificate attesting that the entire consignment of meat comes from animals which:

1. showed no clinical sign of PPR within 24 hours before slaughter;
2. have been slaughtered in an approved slaughterhouse/abattoir and have been subjected to ante- and post-mortem inspections with favourable results.

We collected some data about the WOAH requirements in the survey conducted with the ASEAN Member States. The results presented in Table 10 indicate that all countries that responded to the survey impose some requirements. For example, Indonesia, Myanmar and Malaysia require them to provide an international veterinary certificate. Besides this requirement, Cambodia, Malaysia and Thailand require that animals should not show clinical signs of PPR within 24 hours before slaughter.

Table 10. Requirements imposed for the import of live domestic sheep and goats by the ASEAN member nations responding to the survey based on WOAH's Terrestrial Animal Health Code (25).

N u m	Questions	Brunei Daruss alam	Ca mb odi a	Ind one sia ¹	Ma lay sia	My an ma r	Phil ippi nes	Th ail and
1	Are any requirements imposed on the establishment exporting sheep and goat meat to your country?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	<i>Requirements imposed for import</i>							
2	Presentation of an international veterinary certificate meeting the requirements of the WOAH Terrestrial Animal Health Code.	No	No	Yes	Yes	Yes		No
3	The animals showed no clinical signs of PPR within 24 hours before slaughter.	No	Yes	Yes	Yes	Yes		Yes
4	The animals were slaughtered in an approved slaughterhouse/abattoir.	Yes	Yes	Yes	Yes	Yes		Yes
5	The animals were subjected to ante- and post-mortem inspections with favourable results.	No	No	Yes	Yes	Yes		Yes
6	The meat was chilled or frozen before shipping.	Yes	No	Yes	Yes	Yes		No

¹Instructions for the Implementation of Quarantine Measures Against the Importation of Carcass, Meat and/or Offal Into the Territory of the Republic of Indonesia

Assuming that the issuing veterinarian followed the SOPs in issuing the certificate and considering the responses for questions # 1 to 3 in Table 10, we inferred the likelihood of selecting an infected animal to be:

- **Very low** for Indonesia, Malaysia and Myanmar
- **Low** for Cambodia and Thailand
- **Moderate** for Brunei Darussalam
- **Unavailable** for Lao PDR, Philippines, Singapore and Viet Nam.

Failing to detect PPR in ante- and post-mortem examinations

Ante- and post-mortem examinations conducted in accredited slaughterhouses are expected to detect infected animals and, thus, reduce the chance of infected sheep and goats being slaughtered. This would, of course, depend on the quality of the examination and the ability of the attending veterinarians and meat inspectors to detect a case/lesions of PPR.

We asked the target countries if they require the exporting countries to attest that the animals were slaughtered in an approved slaughterhouse/abattoir and were subjected to ante- and post-mortem inspections with favourable results (Table 10, # 4 and 5). Of the countries that responded to the survey, Indonesia, Myanmar, Malaysia and Thailand required both conditions to be met, whereas Brunei Darussalam and Cambodia only required the animals to be slaughtered in an approved slaughterhouse/abattoir.

The detection of a PPR-infected animal in ante- and post-mortem examination would be a factor of the animal showing clinical signs and lesions and the ability of veterinarians and meat inspectors to detect them. Although precise information about the sensitivity of meat inspection for PPR is not available, it can be assumed to have high sensitivity as clinical signs and post-mortem lesions of PPR are quite obvious, particularly if veterinarians and meat inspectors are trained to detect them. Therefore, assuming that only <5% of the PPR-infected animals are subclinical and that meat inspection has high sensitivity, we inferred the likelihood of not detecting PPR in ante- and post-mortem examinations to be:

- **Low** for Indonesia, Malaysia, Myanmar and Thailand.
- **Moderate** for Brunei Darussalam and Cambodia.
- **Unknown** for Lao PDR, Philippines, Singapore and Vietnam.

PPRV surviving in meat processing

The PPRV virus has a half-life of 2 hours at 37 °C and is destroyed at 50 °C in one hour. It is stable between the pH of 5.8 and 10.0 and gets inactivated at pH < 4.0 and >11.0. Several chemicals are effective against PPRV, including alcohol, ether, detergents, phenol and sodium hydroxide. Leaving the meat at room temperature for long period of time or treatment of the meat at higher temperature kills the virus. Although, the virus can survive for long periods in chilled and frozen meat, a drop in the pH of meat due to rigor mortis is likely to inactivate the virus. Further, meat processing is likely to inactivate the virus and reduce meat contamination though this would differ depending on the type of meat processing because it is more likely to be effective if it involves heat treatment rather than freezing or chilling. Based on this information, we assumed that processing meat is likely to reduce the level of contamination and inferred that the likelihood of PPRV surviving in meat processing would be:

- **Very low** for Brunei Darussalam, Malaysia, Indonesia and Myanmar – the countries requiring meat to be chilled or frozen before shipping.
- **Moderate** for Cambodia and Thailand as they do not require this.
- **Unknown** for Lao PDR, Philippines, Singapore and Vietnam.

PPRV surviving in meat storage and shipping

Similar to freezing and chilling, storage and shipping of meat under cold conditions are expected to inactivate the virus and thus reduce the chances of importing PPRV. Therefore, we assumed the likelihood of not inactivating PPRV in meat storage and shipping to be low for all countries.

Overall risk estimate

The overall estimate of the likelihood of introducing PPR via meat and meat products of domestic sheep and goats is presented in Table 11 below. A likelihood could not be estimated for Lao PDR, Myanmar, Philippines, Singapore and Vietnam due to missing data for some of the nodes in the risk pathway. Singapore and Vietnam may have a negligible risk as they only import live sheep and goats from PPR-free countries.

Table 11. Summary of likelihood estimates for various nodes in the risk pathway for legally importing meat and meat products from domestic sheep and goats into the ASEAN Member States. The estimates were based on analysis of FAOSTAT data (32), WAHIS (33) and the results of a survey conducted with member countries in 2022.

Event	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Thailand
Selecting an infected farm	Negligible	Moderate	Low	High	Low
Selecting an infected animal	Moderate	Low	Very low	Very low	Low
Failing to detect PPR in ante- and post- mortem examinations	Moderate	Moderate	Low	Low	Low
PPRV surviving in meat processing	Very low	Moderate	Very low	Very low	Moderate
PPRV surviving in meat storage and shipping	Low	Low	Low	Low	Low
Overall risk	Negligible	Low	Very low	Very low	Low

Risk mitigation measures

Importing countries can reduce the likelihood of selecting an infected farm by purchasing meat and meat products from PPR-free countries. They could require that the source farm be situated in a PPR-free zone and has not observed/reported any case of PPR in the past or at least in the past 21 days. The risk of selecting an infected animal from an infected farm can be reduced by requesting an international veterinary certificate confirming that the selected animals showed no clinical signs of PPR within 24 hours before slaughter.

The likelihood of detecting PPR-infected animal in ante- and post-mortem examinations can be increased by requiring exporting countries to present an international veterinary certificate meeting the WOAHA Terrestrial Animal Health Code requirements as outlined in Box 3. Further, training veterinarians and meat inspectors in diagnosing PPR and following SOPs would help in achieving a high sensitivity of detection though further research is required to estimate this parameter under real-life situations.

Countries can ask the exporters to chill or freeze meat before shipping to increase the chances of inactivation of the virus though further research is required to obtain objective data about the impact of freezing and chilling. Further, animals should be rested before slaughter to ensure that muscle pH drops during rigor mortis.

Likelihood of PPR introduction through the illegal importation of sheep and goat meat

Risk pathway

Risk pathways for the illegal importation of sheep and goat meat are presented in Figures 6 and 7. They are quite similar, except that meat is brought in by travellers in the second scenario. The pathways indicate that the risk of importation would depend on the PPR prevalence in the source country, the potential inactivation of the virus as a result of any processing and storage, and the ability of border inspection authorities in the importing country to detect and seize meat and meat products.

Survey results

Only two countries participating in our survey – Brunei Darussalam and Malaysia – indicated that the illegal importation of sheep and goat meat or meat products had been reported into their countries in the past five years (Table 12). The representative from Brunei Darussalam provided no further details, but the Malaysian representative indicated that (a) four incidents were reported last year (2021), (b) Australia and New Zealand were the predominant countries of origin of meat and meat products, (c) 43,907 kg of domestic sheep and goat meat was seized at the border, (d) Vessel and cargo flights were the predominant mode of transportation and (e) the approximate shipment time was between 1 day to 3 months.

The illegal importation of sheep and goat meat or meat products by travellers in the past five years was only reported by Myanmar (Table 12), but no further details were available about the number of incidents, the predominant country of origin, the volume of trade or the amount seized at the border.

Risk estimation

The likelihood of selecting an infected farm and an infected animal would depend on the country of origin of meat and meat products. It is not possible to estimate this likelihood as only very limited information from one country was available. However, if the animal is infected, further procedures such as ante- and post-mortem examinations that increase the chances of detecting an infected animal are unlikely to be conducted (or not enforced by the importing country). However, the likelihood of PPRV survival during slaughter, processing and transportation would be similar to the scenario of the legal importation of meat and meat products. The likelihood of detecting and seizing meat and meat products at the border would have a major influence on the overall risk of importation of contaminated meat and meat products, but additional data are required to determine this likelihood objectively.

Due to the limited availability of data, we cannot objectively estimate the likelihood of PPR introduction through the illegal importation of sheep and goat meat or meat products. However, it is likely to be higher for Brunei Darussalam, Malaysia and Myanmar, which have reported incidents of illegal meat import in the past five years. The risk of importation can also not be considered trivial for Lao PDR and Vietnam sharing borders with PPR endemic countries (China, Bangladesh and India), although data about illegal importation were not available to estimate the risk objectively.

Risk mitigation measures

The primary risk mitigation measure that the importing country can implement is adequate border surveillance and training of quarantine staff to ensure the seizing of illegal meat and meat products. Further, ASEAN countries could also collaborate to reduce illegal trade.

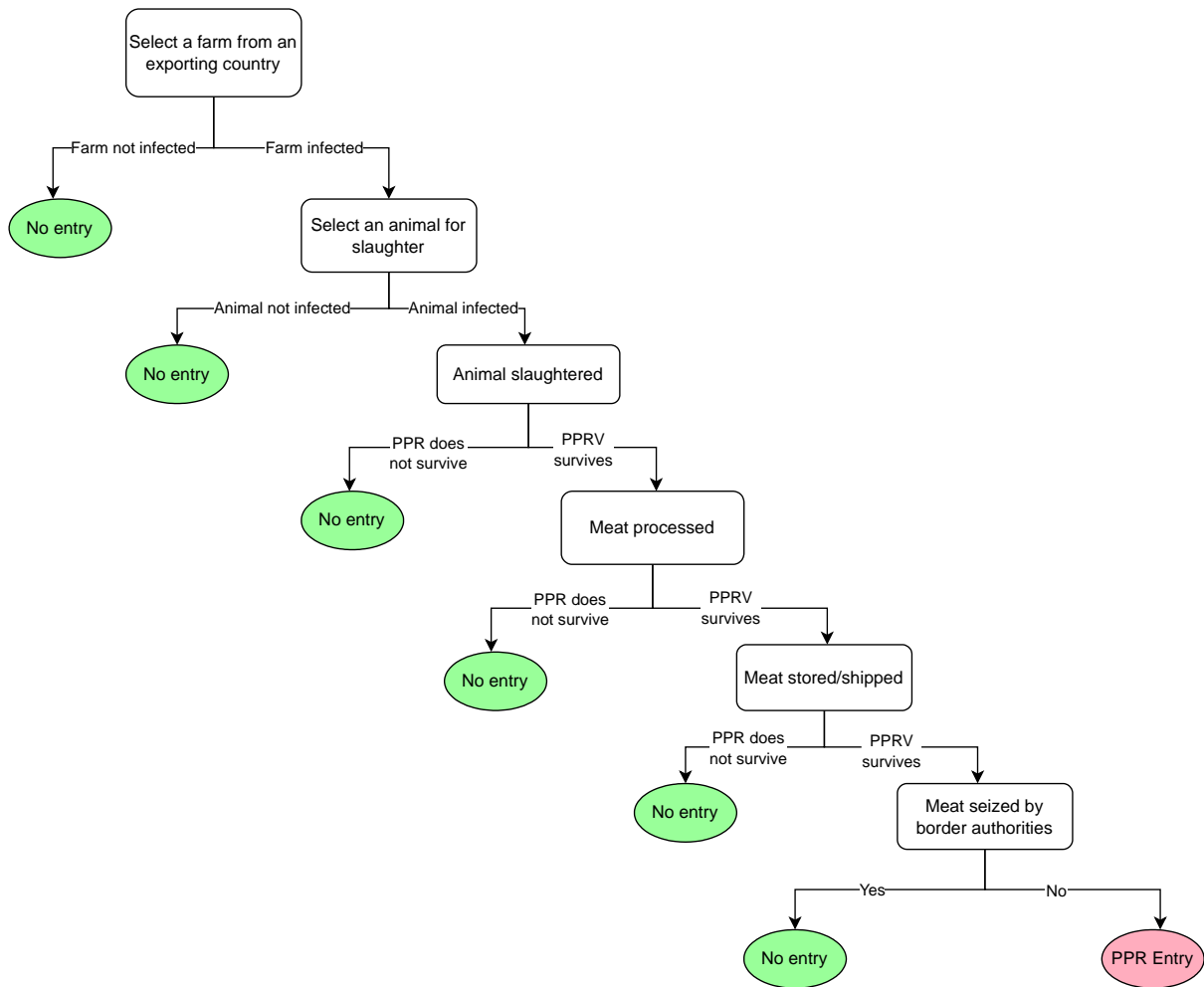


Figure 6. Risk pathways for the entry of PPRV via illegal importation of meat and meat products of sheep and goats into South-East Asian countries.

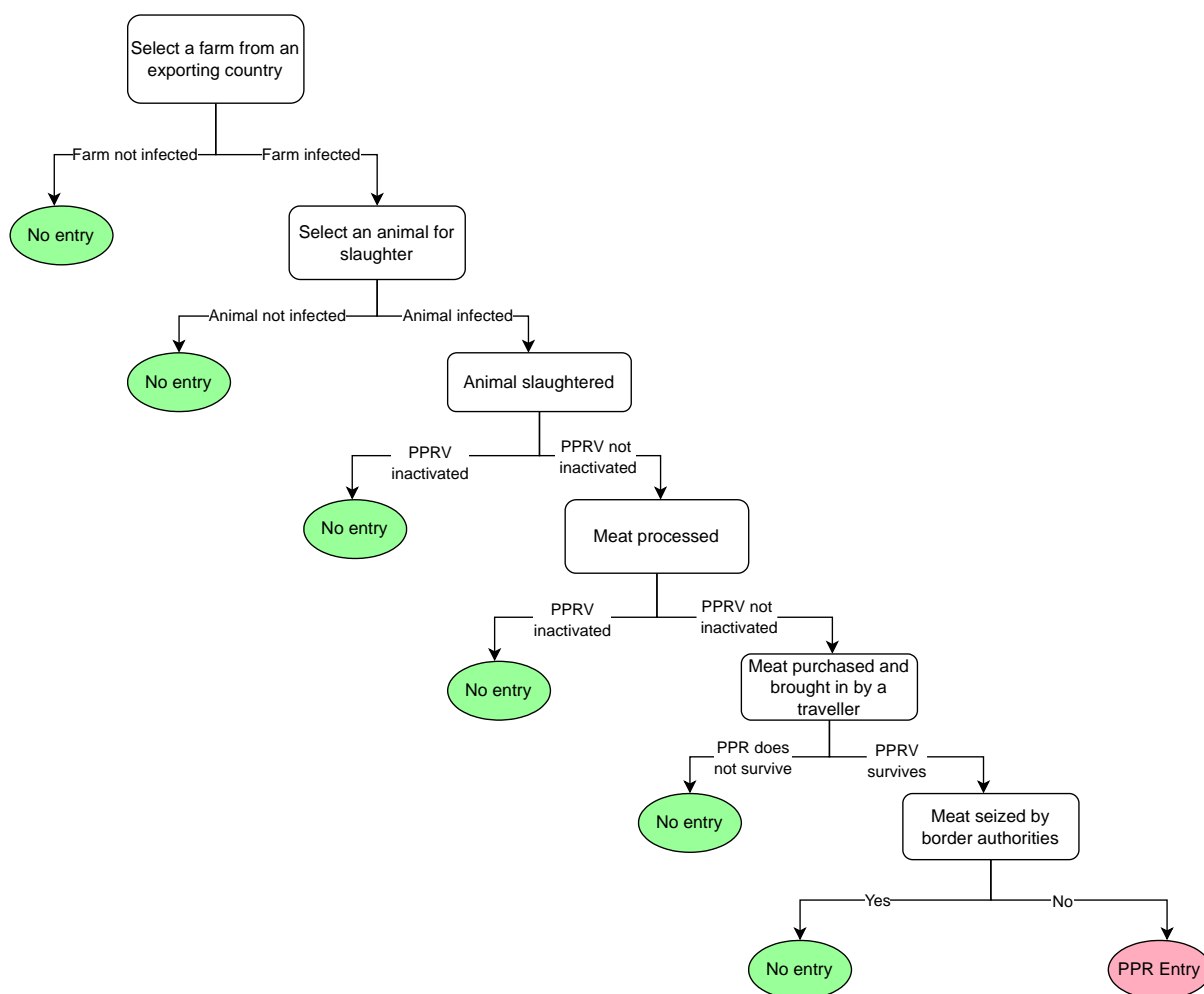


Figure 7. Risk pathways for the entry of PPRV via importation of sheep and goat meat by travellers and via importation of embryos into South-East Asian countries.

Table 12. Reports of illegal importation of meat and meat products of sheep and goats into the ASEAN member nations responding to the survey.

N u m	Questions	Brunei Daruss alam	Ca mb odi a	Ind one sia	Ma lay sia	My an ma r	Phil ippi nes	Th ail and
1	Has the illegal importation of sheep and goat meat or meat products been reported into your country in the past five years?	Yes	No	No	Yes	No	No	No
2	Has the illegal importation of sheep and goat meat or meat products by travellers been reported in the past five years?	No	No	No	No	Yes	No	No

Likelihood of PPR introduction by importing sheep and goat semen and embryos

Risk pathways

Risk pathways for the likelihood of PPR introduction via legal importation of semen and embryos are displayed in Figures 8 and 9, respectively. They indicate that the risk is a factor of the PPR prevalence in the country, zone and the selected farm, the inactivation of the virus in semen/embryo processing and shipping and testing of semen/embryos before export or after importing.

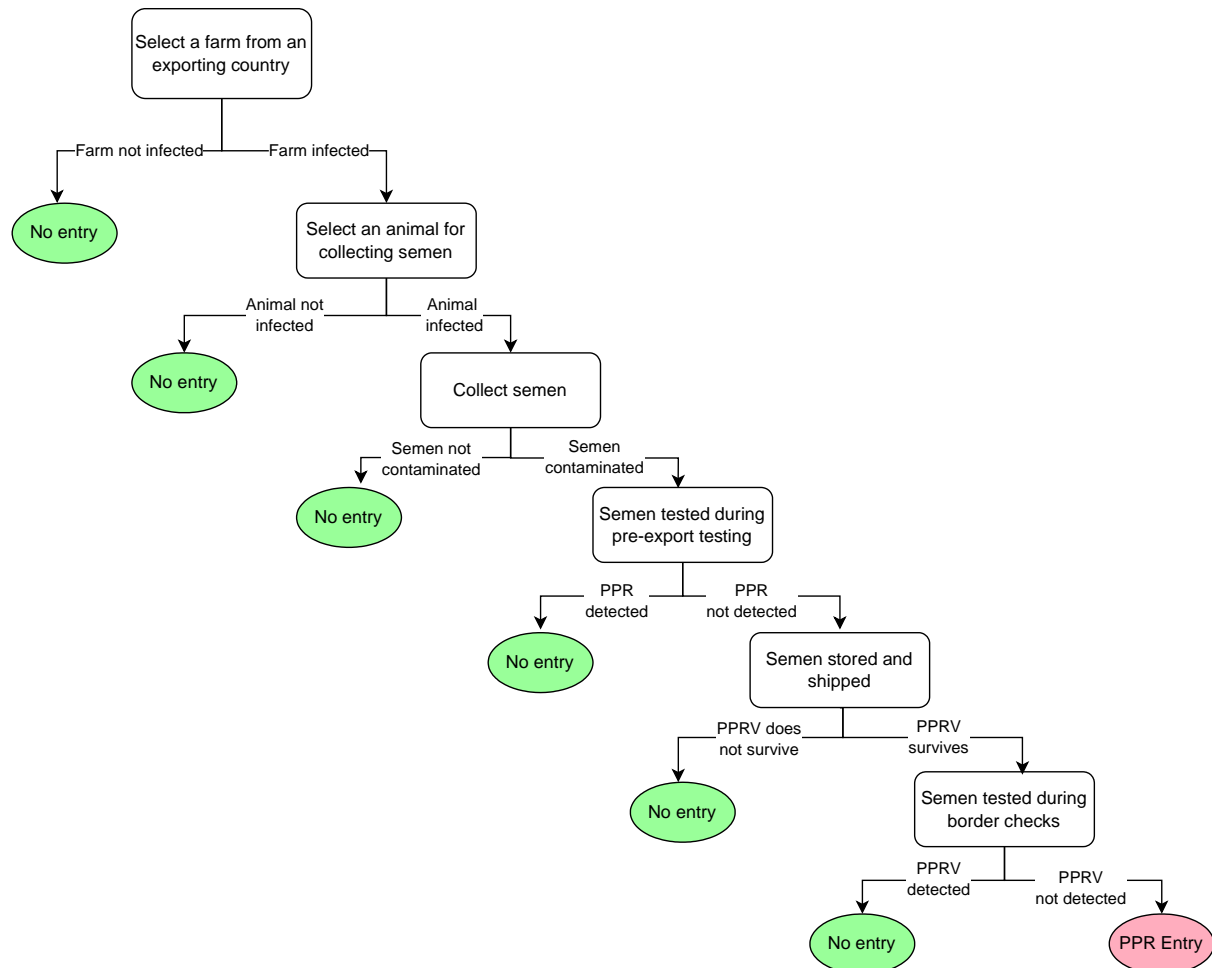


Figure 8. Risk pathways for the entry of PPRV via importation of sheep and goat semen into South-East Asian countries.

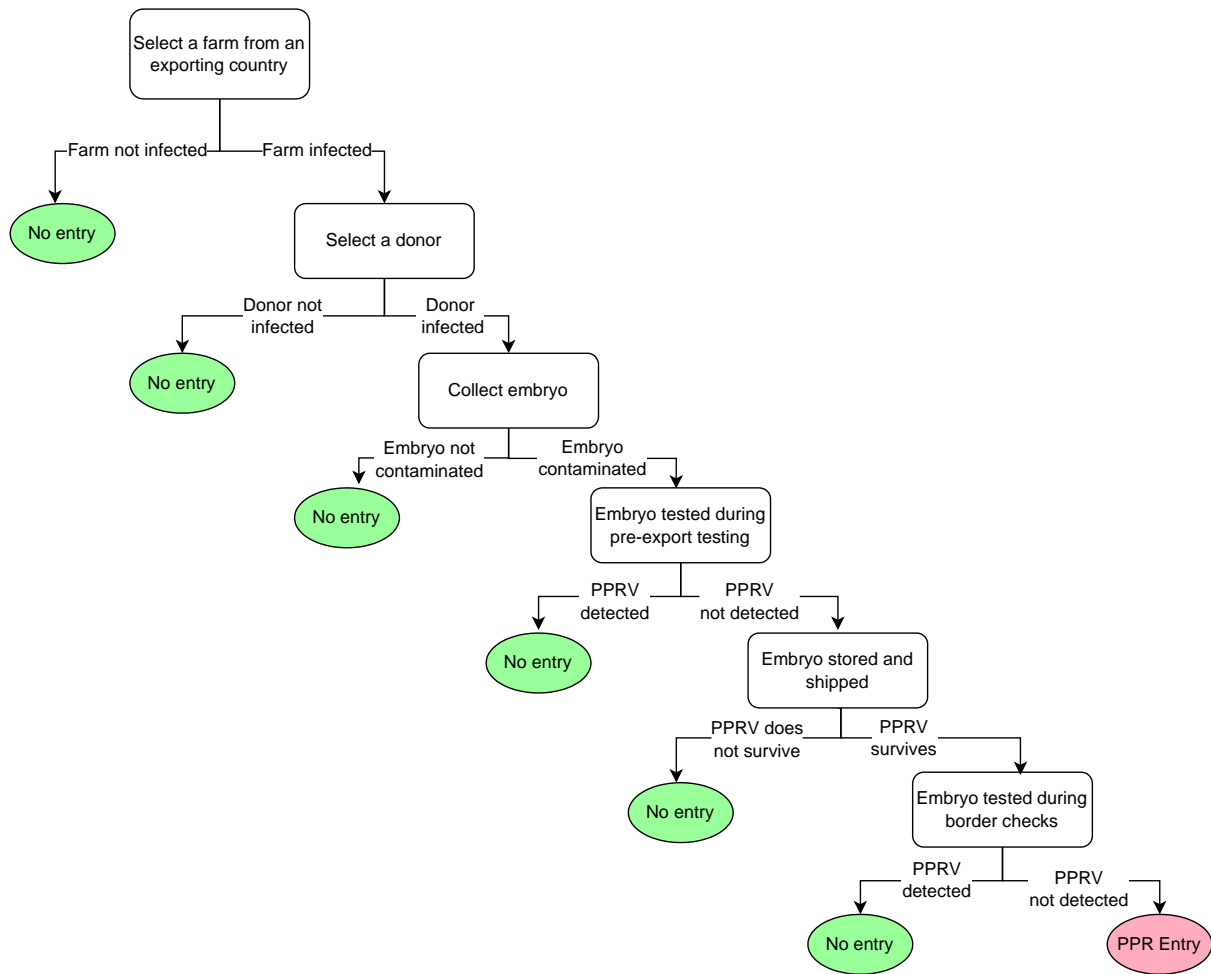


Figure 9. Risk pathways for the entry of PPRV via importation of sheep and goat embryos into South-East Asian countries.

Survey results

Only one country (Thailand) reported legally importing semen and embryos in the past five years in our survey (Tables 13 and 14). For semen import from a PPR-free country or zone, they require the presentation of an international veterinary certificate meeting the WOAHA Terrestrial Animal Health Code requirements. For embryo import from a PPR-free country or zone, they require the presentation of an international veterinary certificate ensuring that semen used to fertilise oocytes met WOAHA standards. Besides Thailand, Myanmar also reported imposing import requirements for semen (Table 13).

Table 13. Requirements imposed for the import of semen of domestic sheep and goats into the ASEAN member nations responding to the survey, based on WOAHA's Terrestrial Animal Health Code (25).

N u m	Questions	Brunei Daruss alam	Ca mb odi a	Ind on esi a	Ma lay sia	My an ma r	Phil ippi nes	Th ail an d
1	Has sheep and goat semen been legally imported in the past five years?	No	No	No	No	No	No	Ye s
2	Are any requirements imposed on the import of sheep and goat semen to your country?					Yes		Ye s
<i>Requirements imposed for import from a PPR free country or zone</i>								
3	The donor animals showed no clinical signs of PPR on the day of semen collection or during the following 21 days.					Yes		No
4	The donor animals were kept in a PPR free country or zone for at least the 21 days prior to collection.					Yes		No
5	Presentation of an international veterinary certificate meeting the requirements of the WOAHA Terrestrial Animal Health Code.					Yes		Ye s
<i>Requirements imposed for import from a country or zone considered infected with PPRV</i>								
6	The donor animals showed no clinical signs of PPR infection for at least the 21 days prior to collection and during the following 21 days.					Yes		
7	The farm had no case of PPR in the past 21 days.					Yes		
8	The animals were negative for a PPR diagnostic test conducted at least 21 days prior to semen collection.					Yes		
9	The animals were vaccinated against PPR at least 21 days prior to semen collection					Yes		
10	Presentation of an international veterinary certificate meeting the requirements of the WOAHA Terrestrial Animal Health Code					Yes		

Table 14. Requirements imposed for the import of embryos of domestic sheep and goats into the ASEAN member nations responding to the survey, based on WOA's Terrestrial Animal Health Code (25).

N u m	Questions	Brunei Daruss alam	Ca mb odi a	Ind one sia	Ma lay sia	My an ma r	Phil ippi nes	Th ail and
1	Have sheep and goat embryos been legally imported in the past years?	No	No	No	No	No	No	Yes
2	Are any requirements imposed on the establishment exporting sheep and goat embryos to your country?							Yes
<i>Requirements imposed for import from a PPR free country or zone¹</i>								
3	The donor animals were kept in a PPR free country or zone for at least the 21 days prior to collection.							No
4	The embryos were collected, processed, and stored following WOA standards.							No
5	Semen used to fertilise oocytes met WOA standards.							Yes
6	Presentation of an international veterinary certificate meeting the requirements of the WOA Terrestrial Animal Health Code.							Yes

¹No country specified any requirements imposed for import from a country or zone considered infected with PPRV.

Risk estimation

The likelihood of selection of an infected farm would depend on the country of origin, but data about semen and embryo trade were not available from the FAO STAT website.

The likelihood of selecting an infected animal for collecting semen and embryos would depend on the animal-level prevalence at the exporting farm. This risk can be reduced by requiring the presentation of an international veterinary certificate following the WOAHA guidelines, in particular, attesting that the donor animals showed no clinical sign of PPR on the day of the collection of the semen and during the following 21 days.

The likelihood of semen/embryo being contaminated and the virus remaining viable in processing and transportation would depend on the procedures implemented for semen/embryo cleaning and shipping. PPRV has been reported to enter to caprine endometrial epithelial cells experimentally (40). The virus may not be inactivated during semen processing as the collected semen is usually diluted after quality control tests and stored frozen at a very low temperature. Similarly, the embryo is washed several times with the washing media before being stored at very low temperature. If the embryo is contaminated with PPRV, it is likely that the virus may be flushed out during repetitive washing stages.

The likelihood of the virus not to be detected in pre- or post-export checks would depend on the testing procedures adopted and the diagnostic tests used.

Given that only one country reported importing semen and embryos within the past five years, and minimal information is available for the procedures used in semen cleaning, processing, transportation and testing, we were unable to objectively estimate the risk of importing PPRV via semen and embryos.

Risk mitigation measures

Several risk mitigation measures can be implemented to reduce the risk of PPRV importation via semen and embryo import. For example, countries should import from PPR-free countries to reduce the risk of selecting an infected farm, require the presentation of an international veterinary certificate following WOAHA guidelines and ensure testing of semen/embryos with a sensitive diagnostic test.

Recommendations for importation from PPR free countries of zones

Veterinary Authorities should require the presentation of an international veterinary certificate attesting that the donor animals:

1. showed no clinical sign of PPR on the day of the collection of the semen and during the following 21 days;
2. were kept in a PPR free country or zone for at least the 21 days prior to collection.

Recommendations for importation from countries of zones considered infected with PPRV

Veterinary Authorities should require the presentation of an international veterinary certificate attesting that the donor animals:

1. showed no clinical sign suggestive of PPRV infection for at least the 21 days prior to collection of the semen and during the following 21 days;
2. were kept, for at least the 21 days prior to collection, in an establishment or artificial insemination centre where no case of PPR was reported during that period, which was not situated in a PPRV infected zone and to which no animals had been added during the 21 days prior to collection;
3. were not vaccinated against PPR and were submitted to a diagnostic test for PPRV infection with negative results at least 21 days prior to collection of the semen;
OR
4. were vaccinated against PPR with live attenuated PPRV vaccines at least 21 days prior to semen collection.

Recommendations for importation from PPR free countries of zones

Veterinary Authorities should require the presentation of an international veterinary certificate attesting that:

1. the donor animals were kept in an establishment located in a PPR free country or zone at least 21 days prior to embryo collection;
2. the embryos were collected, processed and stored in accordance with Chapters 4.8., 4.9. and 4.10., as relevant;
3. semen of domestic sheep and goats used to fertilise the oocytes complies at least with the requirements in Article 14.7.12. or Article 14.7.13.

Recommendations for importation from countries of zones considered infected with PPRV

Veterinary Authorities should require the presentation of an international veterinary certificate attesting that:

1. the donor animals
 - a. and all other animals in the establishment showed no clinical sign suggestive of PPRV infection at the time of collection and during the following 21 days;
 - b. were kept, for at least the 21 days prior to collection, in an establishment where no case of PPR was reported during that period, and to which no susceptible animals had been added during the 21 days prior to collection;
 - c. were not vaccinated against PPR and were subjected to a diagnostic test for PPRV infection with negative results at least 21 days prior to collection; OR
 - d. were vaccinated against PPR with live attenuated PPRV vaccines at least 21 days prior to embryo collection.
2. the embryos were collected, processed and stored in accordance with Chapters 4.8., 4.9. and 4.10., as relevant;
3. semen of domestic sheep and goats used to fertilise the oocytes complies at least with the requirements in Article 14.7.12. or Article 14.7.13.

Supplementary data

Besides the data presented above, we also collected data about importing some other products that were not part of the risk assessment and about small ruminant production in the ASEAN countries. These data are summarised in Appendices 4 and 5 and could be used by future investigators to conduct additional import or exposure risk assessments or other purposes.

Discussion

The ASEAN region is home to a large population of small ruminants (Tables 44 and 45, Appendix 5) producing large quantities of meat, hides, wool, skin, milk and their products (Tables 46 – 51, Appendix 5). Small ruminants contribute significantly to the regional economy and farmer livelihoods, particularly the smallholders. They also function as ‘family banks’, providing a readily available source of credit to meet the social and financial needs of the family (41) and have a role to play in women’s empowerment as small ruminants are raised and managed by women in many communities.

Transboundary infectious diseases causing morbidity and mortality in small ruminants can devastate rural economies and significantly impact farmer income and livelihoods, particularly in the most impoverished communities. PPR is one of the most important small ruminant diseases known to cause significant morbidity and mortalities in small ruminants, particularly in naïve regions, thus affecting food security, farmer livelihoods and rural economy. The international organisations, including the FAO and WOA, are determined to eradicate PPR to support farmer income and food security and have made an ambitious target of eradicating PPR by 2030.

The ASEAN region is in an enviable position for being essentially free from PPR, excluding sporadic outbreaks and some reports of seropositivity (15-17; 20; 21). However, the region is a hotspot for emerging infectious and transboundary diseases, as seen with frequent outbreaks of avian influenza, African swine fever, foot-and-mouth disease and lumpy skin disease. Further, the region is surrounded by Bangladesh, China and India, three countries where PPR is endemic and conducts trade in live sheep and goats and their products with a large number of countries, including several countries that are positive for PPR. Therefore, there is a risk of a potential incursion and establishment of PPR into the region, which can spread quickly unless contained and cause significant morbidity and mortality in the naïve small ruminant populations and devastate rural economies of vulnerable communities.

This project was conducted to assess the risk of introducing PPR via the importation of live sheep and goats and their products, to enable veterinary authorities to make informed risk management decisions. We based our inferences on the official trade data available from the FAOSTAT database, PPR status information available from WAHIS and a survey of the ASEAN Member states. The results presented in this report indicate that the ASEAN region has a non-negligible risk of PPR introduction both through the trade of small ruminants and their products and because of the potential incursion of the disease from the neighbouring countries. However, most of the risks are manageable by changing the source of small ruminants and their products, requiring the presentation of an international veterinary certificate along with the imported products adhering to the WOA recommendation and strengthening border quarantine, veterinary and laboratory facilities and services by participating in PVS evaluations and implementing the recommendations. The risk management strategies from this risk assessment are summarised in Table 15 below. Following these recommendations will reduce the risk of PPR incursion and strengthen the capacity of Member States to tackle other transboundary diseases while continuing the desired trade in small ruminants and their products.

This work had several strengths. We were able to source objective data from the FAOSTAT database about trade activities of the ASEAN countries with their trading partners in the past 20 years, painting a clear picture of the volume, frequency and riskiness of the trade. Further, we also used data from WOA’s WAHIS system about the PPR status exporting countries, enabling us to make objective decisions regarding the risk of importation of small ruminants and their products from various countries. We were also able to get feedback from Member States about the risk pathways and obtain additional information about the gaps in data from a survey conducted specifically for this risk assessment with the Member States. The advice of experts in the core and advisory groups was valuable in refining the questionnaire and the risk pathways.

Table 15. Summary of risk management strategies that could be used to reduce the risk of importation of PPR with the legal or illegal importation of live animals, meat and meat products and semen/embryos Requirements into the ASEAN member nations based on the risk assessment and WOAHA's Terrestrial Animal Health Code (25).

Activities	Risk management strategies
Selection of a farm in an exporting country or zone	<ul style="list-style-type: none"> • Purchase small ruminants and their products from a country/zone certified free of PPR or at least where PPR has been historically absent. • Select a farm that has not observed/reported any case of PPR in the past or at least in the past 21 days.
Selection of an animal	<ul style="list-style-type: none"> • Require the exporting country to provide an international veterinary certificate confirming that the selected animals showed no clinical signs of PPR in the past 21 days. • Require the presentation of an international veterinary certificate that donor animals for semen/embryo were kept in a PPR-free country or zone for at least 21 days prior to collection. • Evaluate the exporting country's PVS reports to determine the quality of their veterinary services.
Detection of PPR in an abattoir	<ul style="list-style-type: none"> • Ask the exporting country to present an international veterinary certificate that the consignment of meat comes from animals that showed no clinical sign of PPR within 24 hours before slaughter. • Require that animals are slaughtered in an approved abattoir and are subjected to ante- and post-mortem inspections with favourable results. • Evaluate the exporting country's PVS reports to determine the quality of their veterinary workforce.
Prevention of contamination in semen/embryo	<ul style="list-style-type: none"> • Ensure the embryos are collected, processed, and stored following WOAHA standards. • Ensure that semen used to fertilise oocytes meets WOAHA standards.
Detection of PPR in pre-export facilities	<ul style="list-style-type: none"> • Require the exporting country to keep animals in pre-export facilities for at least 21 days prior to shipment and discard the entire consignment if any animal shows clinical signs during this period. • Ensure the veterinarians operating the pre-export facilities are qualified and trained in diagnosing PPR. • Ensure the pre-export facilities have SOPs that are duly followed by animal attendants and veterinarians. • Ask for mandatory testing of animals pre-export with a test with high diagnostic sensitivity. • Evaluate the exporting country's PVS reports to determine the quality of their laboratory facilities and personnel. • Ensure that the laboratory personnel are qualified and trained in testing for PPR.
Detection of PPR in quarantine facilities	<ul style="list-style-type: none"> • Keep animals in the quarantine station for at least 21 days, particularly if they were not kept in pre-export facilities for this duration.

Activities	Risk management strategies
	<ul style="list-style-type: none"> • Train veterinarians operating the quarantine station in diagnosing PPR, collecting and submitting samples. • Prepare SOPs for the quarantine station. • Ensure that animals in the quarantine station are carefully examined following the SOPs. • Test animals with a test with high diagnostic sensitivity. • Arrange quality assurance of the laboratory facilities testing for PPR. • Train laboratory personnel in testing for PPR • Participate in external PVS evaluations including PVS Laboratory Mission to advance laboratory quality.
Illegal importation	<ul style="list-style-type: none"> • Ensure adequate border surveillance. • Train border and quarantine workforce. • Confiscate and euthanase illegally smuggled animals. • Seize and destroy illegally smuggled raw animal products.

Similar to other studies, this risk assessment had some limitations. We aimed to conduct a regional risk assessment, but the processes may differ in a particular country or the importation of a specific consignment. We tried to achieve as much national granularity in our estimates as possible while maintaining the regional perspective, but further tweaking of the risk pathways would be essential for implementing the pathways in a particular country or a specific context.

While we were able to get objective data for several nodes in risk pathways, we were not able to validate the data with the country records to check the integrity of data. Therefore, our results will be impacted by any inaccuracies in the FAOSTAT data. Further, we could not obtain objective information about several nodes and had to rely on our subjective opinions. For example, we did not have access to PPR prevalence estimates of various exporting countries or zones, the quality of their veterinary and meat inspection services or the sensitivity and specificity of the diagnostic tests they use to test for PPR. Although we did find data in the literature about some estimates, they could vary widely under different conditions. Therefore, the results of the risk assessment should be interpreted with caution. For example, the likelihood of an animal showing clinical signs was considered to be high in this risk assessment, but it could vary depending on the viral strains (42; 43), the host characteristics such as age and condition score of the animal and whether the animals are naïve or have been previously immunised/exposed or received maternal antibodies. Similarly, the case fatality rate could vary depending on all of these factors, besides the stocking density and the managemental conditions. Similarly, while survey responses enabled us to make several estimates, some countries did not complete the surveys, and there was missing (or conflicting) data for many of the questions from some others. This made it difficult for us to estimate the risk and increased uncertainty about some estimates. The importing countries would have better data about these nodes and could replace our estimates with their own to correct the risk estimate.

Further, we only conducted a qualitative risk assessment, but a quantitative risk assessment can be conducted in the future with the availability of additional data, at least for some of the pathways. It will allow the inclusion of variability and uncertainty in estimates and enable the investigator to conduct sensitivity analyses to evaluate the impact of changing some estimates. Finally, it was beyond the scope of the project to conduct exposure and consequence assessments. The current assessment can be extended in the future by conducting these additional assessments to have a more comprehensive estimate of risk by integrating the results from the entry, exposure, and consequence assessments to produce overall measures of risks.

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Appendix 1: Risk analysis participants

Technical team

- Dr Navneet Dhand, Veterinary Epidemiologist, Sydney, Australia.
- Dr Balbir B Singh, Veterinary Epidemiologist, Ludhiana, India.
- Dr Madhuchhanda Mahapatra, Veterinary Virologist, Hampshire, UK.

Advisory committee

- Dr Karma Rinzin, WOAHA Sub-Regional Representation for South-East Asia, Bangkok, Thailand.
- Dr Kinley Choden, WOAHA Sub-Regional Representation for South-East Asia, Bangkok, Thailand.
- Dr Solomon Benigno, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.
- Dr Sith Premashthira, Department of Livestock Development, Thailand.
- Dr Pebi Purwo Suseno, Directorate General of Livestock and Animal Health Services, Indonesia.
- Dr Barbara Alessandrini, Capacity-Building Department, WOAHA, Paris, France.
- Dr Nadège Leboucq, Capacity-Building Department, WOAHA, Paris, France.
- Dr Viola Chemis, Regional Activities Department, WOAHA, France
- Dr Simon Kihu, WOAHA Sub-Regional Representation for Eastern Africa and the Horn of Africa, Nairobi, Kenya.

Workshop participants

Appendix 2: Questionnaire

Appendix 3: Trade of sheep and goats and their products in the past 20 years

Table 16. Number of six-monthly PPR-positive reports submitted to WOAAH between 2005 and 2020 by countries exporting domestic sheep and goat or their products to ASEAN countries based on analysis of data from WOAAH's WAHIS information system (33). A value of four means that the trading partner has submitted four positive reports in a year (two each for domestic and wild animals).

Exporting country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Argentina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Bangladesh			4	4	2	2	2	2	2	2	2	2	2	2	2	1
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Benin	2	2	2	3	2	2	2	2	3	4	2	2	2	4	2	
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brunei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
Canada	0	0	0	0	0	0	0	0	0	0	0	0	0			0
Chile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China	0	0	1	2	0	1	0	0	1	2	2	2	2	2	1	2
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethiopia	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ghana	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Exporting country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hong Kong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
India	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	
Indonesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Iran	2	2	2	2	2	2	2	2	2	2	3	4	4	4	4	4
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Israel	2	1	0	0	0	0	1	1	1	1	1	1	4	4	4	3
Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kenya	0	1	2	2	1	2	2	2	1	2	1	1	0	1	2	2
Laos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Lebanon	0	0	0	4 ^s	2 ^s	2 ^s	2 ^s	0	0	0	0	0	0	0	0	
Madagascar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Malaysia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mauritania	2	3	2	4	2	1	2	2	2	3	2	2	2	2	2	
Mongolia	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	
Mozambique	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myanmar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Namibia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pakistan	2	2	3	4	2	4	4	4	4	4	4	4	4	4	4	4
Peru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philippines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Exporting country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saudi Arabia	2	3	4	4	2	2	2	2	2	1	2	2	2	2	2	2
Senegal	2	1	2	2	2	2	2	2	1	1	2	2	2	2	4	
Serbia			0	0	0	0	0	0	0	0	0	0	0	0	0	
Singapore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Korea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Switzerland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taiwan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanzania	0	0	0	1	3	4	4	4	4	3	4	4	4	4	4	
Thailand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Togo	2	2	2	2	2	2	2	2	3	4	3	4	4	4	4	
Turkey	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	
Turkmenistan		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uganda	0	0	2	3	2+2 ^s	2+2 ^s	4	4	4	4	4	4	4	4	4	2
UK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ukraine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Arab Emirates	2	2	2	2	2	1	0	0	0	0	0	4	3	2	2	3
Uruguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exporting country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Vietnam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

S: Suspected.

Table 17. Number of live sheep and goat heads imported in Indonesia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	2003	2004	2005	2006	2007	2009	2010	2012	2013	2015	2018	2019	2020	PPR status
China		1498													Present
Hong Kong			7												Absent
Japan				0											Absent
Malaysia							1	0							Absent
Thailand		35713		3											Absent*
Australia	3		10	14	151	6093			219	83	467	1400	714	645	Free
Czechia								10							Free
Netherlands		821						13							Free
Singapore													0		Free
South Korea						5								0	Free
UK		2													Free
USA			1												Free
Grand Total	3	38034	18	17	151	6098	1	23	219	83	467	1400	714	645	

Table 18. Number of live sheep and goat heads imported in Malaysia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status
Bangladesh						12															Present
China						24000				26											Present
India				532		70															Present
Brunei Darussalam					100												107	15			Absent
Indonesia	348	70	644	6512	5963	25348	32104	26762	8962	3091	5064	1047	872		235		210	3250	800	4295	Absent
Malaysia	1799								2												Absent
Myanmar								1500		2739	250		990								Absent
Namibia	1300			53			395														Absent
Thailand		535																	2220		Absent*
Cyprus									496												Free
France											204										Free

Germany										900											Free
Australia	42	57	60	53	61	833	935	879	932	976	75	84	112	124	131	118	48	54	51	33	Free
	75	55	50	39	51	37	79	50	07	87	65	45	662	702	907	264	41	35	16	06	
	5	3	8	8	6						3	5					8	2	9	6	
Netherlands				8			39											40			Free
New Zealand	86					268	289		164	40	38										Free
	0										6										
Singapore	15																				Free
	5																				
South Africa								225	179				31					42			Free
								6										6			
South Korea																	46				Free
																	0				
USA				12		300		871													Free
Grand Total	47	58	61	60	67	133	126	119	103	104	81	85	114	124	132	118	49	60	51	37	
	21	15	15	51	57	335	406	339	010	457	58	50	555	702	142	264	19	30	96	36	
	7	8	2	5	9						3	2					5	3	9	1	

Table 19. Number of live sheep and goat heads imported in Thailand from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	2003	2004	2005	2006	2007	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	PPR status
Bangladesh				2	10										16				28	Present
Benin																		21	21	Present
China			936	463	701	260													2360	Present
Ethiopia																		16	16	Present
Ghana																		65	65	Present
Saudi Arabia										132									132	Present
Togo																17	64	91	172	Present
Tanzania				54															54	Present
Japan									1										1	Absent
Laos										20									20	Absent
Malaysia								60				2	7						69	Absent
Myanmar		2826	9550	2715					1	400	59	4200	3100	65001	66338	58766	22620	86324	321900	Absent
Australia			783	41	82	420	162	341			72	51				192	5881	90	8115	Free
Brazil										105									105	Free
Canada			6																6	Free
Cyprus																1140			1140	Free

France																	121 14	8	1212 2	Free	
Germany																17			17	Free	
Netherlands	0										12	40	18						70	Free	
New Zealand		160	105 6								15								1231	Free	
Philippines								1											1	Free	
South Africa								24 7		423	62 0	50					35	674 6	375 7	1187 8	Free
Spain																			107	107	Free
Sweden						520 0														5200	Free
USA	2											8	68	49				80	132	339	Free
Grand Total	2	298 6	123 31	327 5	79 3	588 0	16 2	64 9	2	108 0	77 8	435 1	319 3	650 50	663 54	601 67	475 05	906 11	3651 69		

Table 20. Number of live sheep and goat heads imported in Brunei Darussalam from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	2003	2013	2014	2015	2016	2017	2018	2019	2020	Total	PPR status
Indonesia						2	210			1305	1517	Absent
Malaysia	74	3	145	331	263	567	250	73	48	180	1934	Absent
Australia	3370	2947	1776	154	2991	639		1			11878	Free
Cyprus								3			3	Free
Netherlands							2				2	Free
Singapore							4				4	Free
Taiwan					1						1	Free
USA							1				1	Free
Grand Total											15340	

Table 21. Number of live sheep and goat heads imported in Cambodia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2010	2018	2019	2020	Total	PPR status
Myanmar		2			2	Absent
Thailand		22	313	548	883	Absent*
South Korea	1				1	Free
USA		318			318	Free
Grand Total					1204	

Table 22. Number of live sheep and goat heads imported in Philippines from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2019	2020	Total	PPR status
Australia	70	2	286		625	1397		575	2800		632		1125	1881	9393	Free
USA	123	454	51	5	21	243	84	4	494	4100	308	61			5948	Free
Grand Total															15341	

Table 23. Number of live sheep and goat heads imported in Singapore from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2019	2020	Total	PPR status
Australia	2788	827	1078	2802	3130	4919	3389	4306	3705	3525	2966	568	1870	41	35882	Free
	7	1	1	4	1	9	5	7	0	3	9	8	0		6	
New Zealand					45		930		135						1110	Free
South Africa							223	1165						426	1814	Free

Table 25. Sheep and goat meat imported in Malaysia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status	
Lebanon												3										Suspect
China	18	25		15		432	228	91	307	430	26	23	101	17					153		3	Present
India	69	350	235	133	165	450	645	489	70	24	70	141	166	591	269	247	235	245	76	220		Present
Mongolia																		87				Present
Saudi Arabia											298		149	149						360		Present
United Arab Emirates	15	25			18																	Present
Brunei Darussalam						2																Absent
Hong Kong			26		1														56	27		Absent
Japan		13																	1			Absent
Mozambique			7																			Absent
Thailand			24									3			1							Absent*
Ukraine															25							Absent
Viet Nam																			87			Absent
Argentina						2	4	1											25	24		Free

Australia	86 10	81 74	53 71	99 32	79 67	88 93	90 96	92 94	108 76	119 47	90 18	114 00	179 19	236 19	254 19	243 57	238 84	258 00	243 41	271 75	Free
Austria																			49		Free
Belgium	20 09								1												Free
Brazil							13								40						Free
Canada		18 7							9						3			33			Free
Denmark	68 8		20							15											Free
France						28							1	6	1						Free
Germany	43										4			26	1						Free
Iceland																	3				Free
Italy													1					26			Free
Netherlands	15	15		27		3								2		18					Free
New Zealand	64 55	53 66	59 87	59 99	71 18	62 22	77 30	80 41	723 9	965 6	86 70	894 5	721 7	681 3	837 2	878 1	144 79	975 9	646 8	103 81	Free
Norway								18													Free
Singapore								3	17												Free
Taiwan				21	29																Free
UK												1		1	19	1	1			25	Free
USA	34					30	22	15	34	28	5	26	3		7	13	27	14		2	Free
Uruguay		11				25	2	16													Free

Table 26. Sheep and goat meat imported in the Philippines from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status	
China							4						19	20								Present
India	159			52		75	1															Present
Hong Kong	2	5																				Absent
Indonesia							13															Absent
Thailand		27																				Absent*
Viet Nam												25										Absent
Australia	364	398		199	369	401	341	326	352	352	403	412	422	658	431	593	614	608	709	362		Free
Belgium															29							Free
Brazil						13																Free
Canada							49			20	24											Free
Germany													24									Free
Ireland																				1		Free
Netherlands						1									2							Free
New Zealand	30	16		30	5	40	56	67	86	119	85	98	111	581	94	73	111	671	61	30		Free
South Korea				16																		Free
USA		1			24	55	1	46	29	30	0	27	11	63	16	32	6	17	10	2		Free

Table 27. Sheep and goat meat imported in Thailand from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status	
China											23										Present	
Iran														28								Present
Malaysia											2	7										Absent
Namibia	9																					Absent
Australia	12 9	40	12 1	31 5	38 7	39 4	41 9	42 8	34 4	43 0	53 7	63 3	67 0	68 7	71 8	73 3	87 5	90 0	87 3	57 4	Free	
France								1														Free
Netherlands				11																		Free
New Zealand	16 1	25 2	23 4	26 3	27 3	24 7	24 6	30 6	26 7	30 4	48 5	37 0	49 0	63 7	72 1	92 8	56 0	79 6	43 4	30 0	Free	
Sweden	3																					Free
UK															1	46	1					Free
USA										17	1											Free

Table 28. Sheep and goat meat imported in Indonesia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status	
China	77																				Present	
Hong Kong SAR			1																			Never reported

Japan		1																			Never reported
Australia	55 4	43 3	43 0	48 1	67 1	66 4	51 3	63 4	82 6	77 3	97 9	11 57	13 34	19 15	26 85	20 95	41 38	20 32	22 70	13 27	Free
Austria	10																				Free
Czechia			1																		Free
France		11													20						Free
New Zealand	45	36	38	38	59	34	58	65	18	14	16	19	26	15	28		79				Free
Norway		1																			Free
Singapore	5	0			10 0	13	0												1	1	Free
South Korea						2															Free
Taiwan			5																		Free
USA																		2			Free

Table 29. Sheep and goat meat imported in Cambodia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status
China									13	84	23	3	Present
Malaysia									3	12		7	Absent
Thailand								2					Absent*
Viet Nam										6			Absent
Australia	0	2	7	2	3	25	65	48	29	50	49	112	Free
France				0	1	0		0	1	0	0	0	Free
New Zealand			2	10	17	35	38	81	46	56	11	21	Free
Singapore	0	2	3	3		1	1		8	18		23	Free
USA				0		2	16	40					Free
Niue		8											N/A

Table 30. Sheep and goat meat imported in Singapore from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status
Hong Kong																				6	Absent
Malaysia																		17	18		Absent
Argentina																26			25	119	Free
Australia	84 55	73 29	70 82	72 55	68 23	73 81	78 71	82 89	90 89	70 22	71 32	73 70	88 02	112 28	111 71	121 92	122 03	117 57	124 65	130 99	Free
Brazil			13		17					20	25					10					Free
Chile																				24	Free
Denmark																	42	41			Free
France					1		1										2	0	3	69	Free
Germany						1	1								6		1				Free
Ireland												9							5	107	Free
Italy															1	1		221	837	473	Free
Netherlands																		1		111	Free
New Zealand	12 96	11 28	14 53	13 45	11 81	12 66	16 05	15 57	14 09	19 65	18 42	17 03	18 51	121 7	135 2	115 9	155 6	106 8	752	156 2	Free
Norway																		186	17		Free
Peru																		14			Free
Romania																		70	71	27	Free
South Korea		21																			Free
Spain											3	1	0				99	21	24	86	Free

UK								3	6	10	14	17	13	9	9	7	9	31	44	53	Free
USA	9	2	7	2	0	0	0	1	0	1	8	7	13	8	7	8	8	36	15	16	Free
Uruguay							10										35				Free

Table 31. Sheep and goat meat imported in Vietnam from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2014	2015	2016	2017	2018	2019	2020	Total	PPR status
Argentina						57	40	97	Free
Australia	1072	1002	1162	600	568	621	333	5358	Free
Austria	7							7	Free
New Zealand	95	115	161	162	152	144	120	949	Free

Table 32. Sheep and goat meat imported in Brunei Darussalam from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	2003	2013	2014	2015	2016	2017	2018	2019	2020	PPR status
Thailand	24	11									Present
Malaysia						24					Absent
Australia	204	255	889	841	948	974	1003	1145	861	264	Free
Singapore		42								1	Free
UK						1			1		Free

Appendix 4: Importation of other products into the ASEAN countries

We were able to source data from the FAO STAT website and our survey about the importation of some other products, which were not part of the risk assessment in this project. In this section, we provide a summary of the results to enable veterinary authorities in the ASEAN countries to conduct complete risk assessments in the future. Data about the importation of these products into the ASEAN region from our survey are presented in Table 33 below. None of the countries completing the survey reported illegal/informal importation of products of wool, hair, raw hides and skins from sheep and goats been reported in the past five years.

Table 33. Some other products imported by the ASEAN countries from their trading partners based on the survey conducted with the ASEAN Member States in 2022.

N u m	Questions	Brunei Darussala m	Camb odia	Indon esia	Mala ysia	Myan mar	Philip pines	Thail and
1	Has the legal/formal importation of wool, hair, raw hides and skins from sheep and goats been reported in the past five years?	No	No	No	Yes	No	No	No
2	Has the illegal/informal importation of products of wool, hair, raw hides and skins from sheep and goats been reported in the past five years?	No	No	No	No	No	No	No
3	Has the legal/formal importation of live wild small ruminants been reported in the past five years?	No	No	No	Yes	No	Yes	Yes
4	Has the illegal/informal importation of live wild small ruminants been reported in the past five years?	No	No	No	No	No	No	No
5	Has the legal/formal importation of milk and milk products from sheep and goats been reported in the past five years?	No	No	Yes	Yes	Yes	No	No
6	Has the illegal/informal importation of milk and milk products from sheep and goats been reported in the past five years?	No	No	No	Yes	No	No	No

Edible offals

The analysis of FAO STAT data indicated that 1 555 tonnes of edible offals of sheep were imported in Brunei, Cambodia and Vietnam in the past 20 years (Table 34). Brunei was the biggest importer importing 1 483 tonnes of edible offals, followed by Cambodia (46 tonnes) and Brunei (26 tonnes). Most of the quantity of edible offals was imported from less risky countries. Brunei is the only country importing edible offals from countries that are not certified PPR free. The first import was from a country that had an incursion of PPR in 2021 (Thailand), but that import was done 2003. The second import was from Malaysia in 2013. Other than these two imports, all other imports in Brunei, Cambodia and Vietnam were from PPR free countries (Tables 35, 36 and 37).

Based on this information, the risk of PPR introduction via the importation of edible offals into the ASEAN countries appears to be negligible, assuming that the volume of trade will continue to be low and the countries will continue to import edible offals from PPR free countries, although complete risk assessments can be conducted in the future.

Table 34. Edible offals of sheep, fresh, chilled or frozen (tonnes) imported by South-East Asian countries in 20 years between 2001 and 2020 based on analysis of FAO STATS data (32). The PPR status was determined based on the data sourced from WOA's WAHIS information system (33; 34).

Exporting country	Importing country			PPR status
	Brunei Darussalam	Cambodia	Viet Nam	
Malaysia	2			Absent
Thailand	19			Absent*
Australia	5	32	483	Free
Austria			14	Free
Canada			10	Free
Germany			146	Free
Italy			136	Free
Netherlands			20	Free
New Zealand		3	489	Free
Poland			84	Free
Spain			39	Free

USA		11	62	Free
Grand Total	26	46	1483	

Table 35. Edible offal of sheep, fresh, chilled or frozen imported in Brunei Darussalam from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2003	2013	2015	2018	2020	PPR status
Malaysia		2				Absent
Thailand	19					Absent*
Australia		0	2	3		Free

Table 36. Edible offal of sheep, fresh, chilled or frozen imported in Cambodia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2014	2016	2018	Total	PPR status
Australia	15	4	13	32	Free
New Zealand		3		3	Free
USA		11		11	Free

Table 37. Edible offal of sheep, fresh, chilled or frozen imported in Vietnam from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2014	2015	2016	2017	2018	2019	2020	Total	PPR status
Australia	7		145	151	41	0	139	483	Free
Austria		14						14	Free
Canada					10			10	Free
Germany		45	88			13		146	Free
Italy			116		20			136	Free
Netherlands							20	20	Free
New Zealand			11	51	427			489	Free
Poland		84						84	Free
Spain			22	17				39	Free
USA				25	37			62	Free

Raw hides and skins

The FAO STAT data indicated that more than 10 kilotonnes of raw hides and skins of sheep or lamb were imported in several ASEAN countries in the past 20 years (Table 38). Indonesia was by far the largest importer importing 7.3 kilotonnes of raw hides and skins of sheep or lambs, with wool followed by Thailand (2.5 kilotonnes). Indonesia also imported these products quite frequently from several PPR positive countries, including China, Ethiopia, India, Iran and Pakistan (Table 39). Similarly, Thailand imported these products from several PPR positive countries, including most recently in 2019 and 2020 from Soudi Arabia (Table 40). Singapore only imported raw hides and skins of sheep or lamb from a PPR positive country in 2002.

Malaysia and the Philippines also imported raw hides and skins of sheep or lamb from PPR positive countries but in smaller quantities (80 and 26 tonnes, respectively). Moreover, they appear to have reduced/stopped import from risky countries over time (Tables 41 and 42). However, in our survey, we asked if the legal/formal importation of wool, hair, raw hides and skins from sheep and goats been reported in the past five years. Malaysia reported importing 10,345 kg of Australian wool in November 2021 from China and and 18,607 kg of Australian wool from China and Japan in December 2021, suggesting that there is an ongoing trade in these commodities.

Table 38. Raw hides and skins of sheep or lambs, with wool (tonnes) imported by South-East Asian countries in 20 years between 2001 and 2020 based on analysis of FAO STATS data (32). The PPR status was determined based on the data sourced from WOA's WAHIS information system (33; 34).

Exporting country	Importing country						PPR status
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam	
China	52	46			12		Present
Ethiopia	18				935		Present
India	19						Present
Iran	6						Present
Israel					9		Present
Pakistan	3						Present
Saudi Arabia			21		963		Present
Thailand							Present
Turkey							Present
United Arab Emirates				12			Present
Hong Kong	2						Absent
Indonesia		31					Absent
Japan		2	5		2		Absent
Malaysia	11					89	Absent
Myanmar							Absent
Viet Nam	0				1		Absent
Australia	6962				501		Free

Belgium							Free
Brazil		1					Free
Canada							Free
France							Free
Greece							Free
Italy	21				24		Free
New Zealand					27		Free
Norway					25		Free
Peru						6	Free
Portugal							Free
Singapore	4						Free
South Africa				180			Free
South Korea	207					49	Free
Spain	1						Free
Taiwan	9						Free
USA	1			0	5	1	Free
Uruguay					45		Free
Grand Total	7316	80	26	192	2549	145	

Table 39. Raw hides and skins of sheep or lambs, with wool imported in Indonesia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2001	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	PPR status
China						7	16	4	20	3	1	0		1	0					Present
Ethiopia		18																		Present
India													1	7	7	4				Present
Iran							6													Present
Pakistan															2	1				Present
Hong Kong							2													Absent
Malaysia								11												Absent
Australia	58	51	396	493	454	453	450	389	265	356	284	314	425	331	472	234	442	714	381	Free
Italy		18						3												Free
South Korea									206					1						Free
Singapore							1	3												Free
Spain														1						Free
Taiwan								1	2							6				Free
USA														1						Free

Table 40. Raw hides and skins of sheep or lambs, with wool imported in Thailand from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015	2016	2017	2018	2019	2020	PPR status
China					12											Present
Ethiopia		627	250	53	5											Present
Israel	9															Present
Saudi Arabia														541	422	Present
Japan			2													Absent
Viet Nam					1											Absent
Australia				243	169		89									Free
Italy													24			Free
New Zealand				10	17											Free
Norway												25				Free
USA					5											Free
Uruguay													45			Free

Table 41. Raw hides and skins of sheep or lambs, with wool imported in Malaysia from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	2003	2004	2005	2006	2008	2012	2014	2015	2016	2017	2018	2019	PPR status
China	2	15	12	3	13				1					Present
Indonesia				25				1	1	1	1	1	1	Absent
Japan						2								Absent
Brazil		1												Free

Table 42. Raw hides and skins of sheep or lambs, with wool imported in the Philippines from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2016	2017	2018	2019	PPR status
Saudi Arabia	21				Present
Japan	0	4	1	0	Absent

Table 43. Raw hides and skins of sheep or lambs, with wool imported in Singapore from its trading partners in the past 20 years between 2001 and 2020.

Exporting country	2002	PPR status
United Arab Emirates	12	Present
South Africa	180	Free

Appendix 5. Small ruminant production in Southeast Asia

Available data about sheep and goat populations and products sourced from the FAO STAT website are summarised in this section. The results indicate that Indonesia, Myanmar and the Philippines lead in small ruminant production. Some other countries also have substantial numbers of domestic goats and sheep, contributing to the domestic economy and to farmer livelihoods. The results suggest that PPR entering and establishing in the region could have a devastating effect on the economy of ASEAN countries and impact farmer livelihoods.

Table 44. Goat populations in Southeast Asia (heads) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	6101	6850	6950	6769	7283	8770	7589	6162	5851	6110	68435
Indonesia	16946186	17905862	18500322	18639533	19012794	17847197	18208017	18306476	18463115	18689711	182519213
Lao PDR	430900	443799	470000	481000	533000	560000	588000	616325	647000	682000	5452024
Malaysia	476431	462510	435000	429439	431651	416529	385304	359200	312571	324355	4032990
Myanmar	3851919	4486000	4964542	5615439	6324762	7289158	8447700	1973820	2059989	2145200	47158529
Philippines	3881500	3715228	3694025	3695627	3674186	3663060	3710348	3724808	3755879	3813454	37328115
Singapore	670	670	670	670	696	686	687	702	716	727	6894
Thailand	427567	461814	420354	447546	447869	450276	457843	458250	466822	477170	4515511
Viet Nam	1267800	1343642	1394608	1600275	1992656	2021003	2556268	2683942	2609198	2654573	20123965
Total	27289074	28826375	29886471	30916298	32424897	32256679	34361756	28129685	28321141	28793300	301205676

Table 45. Sheep populations in Southeast Asia (heads) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	4000	4000	4000	4000	4135	4080	4155	4172	4281	4378	41201
Indonesia	11790612	13420439	14925898	16091838	17024685	15716667	17142498	17611392	17833732	17523689	159081450
Malaysia	126412	131923	141918	143138	147033	138479	130658	128298	121677	124674	1334210
Myanmar	854383	884000	1016461	1162318	1321424	1496476	1314300	404300	421900	439400	9314962
Philippines	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	300000
Thailand	51735	54221	42040	43901	43153	41972	42461	42472	42132	41914	446001
Total	12857142	14524583	16160317	17475195	18570430	17427674	18664072	18220634	18453722	18164055	170517824

Table 46. Goat meat (fresh or chilled) produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	32	37	36	33	28	24	11	16	18	30	264
Indonesia	66345	65216	65169	65142	64948	67845	70354	70155	72852	61711	669737
Lao PDR	1666	1708	1806	1897	2141	2186	2298	2419	2550	2699	21369
Malaysia	2269	3649	3259	2995	2930	3192	2368	2554	2171	1823	27210
Myanmar	46766	52199	58472	66445	77000	79418	81410	9200	9500	9900	490310
Philippines	55619	54257	54569	55323	56705	49047	41324	33859	33598	31556	465856
Singapore	11	12	12	12	11	10	9	10	10	10	106
Thailand	1575	1815	1845	1833	1745	1766	1792	1905	1911	1942	18128
Viet Nam	8055	8070	8070	10089	12820	13155	16431	18850	20990	21318	137848
Total	182338	186963	193238	203769	218328	216643	215997	138967	143598	130988	1830828

Table 47. Sheep meat (fresh or chilled) produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	26	19	18	22	24	25	25	27	28	29	242
Indonesia	46793	44357	41487	43612	44525	45912	55112	82274	70073	54188	528333
Malaysia	823	1157	1430	1551	1477	1799	2032	1880	2029	2094	16271
Myanmar	7515	7662	7967	9670	11589	12360	11874	1880	1950	2000	74467
Philippines	117	117	117	117	117	117	117	117	117	117	1168
Singapore	27	27	27	27	23	19	15	23	23	23	233
Thailand	70	161	317	136	163	170	191	160	159	157	1684
Grand Total	55371	53499	51363	55135	57918	60401	69366	86360	74378	58607	622398

Table 48. Raw hides and skins of goats or kids produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	19	22	22	20	17	15	7	10	11	18	159
Indonesia	14116	13876	13866	13860	13819	14435	14969	14927	15500	13130	142497
Lao PDR	363	373	394	414	467	477	501	528	556	589	4662
Malaysia	740	1190	1063	977	955	1041	772	833	708	594	8873
Myanmar	9353	10440	11694	13289	15400	15884	16282	1840	1900	1980	98062
Philippines	12029	11735	11802	11965	12264	10608	8937	7323	7266	6825	100755
Singapore	1	1	1	1	1	0	0	0	0	0	5
Thailand	214	246	250	248	236	239	243	258	259	263	2457
Viet Nam	1360	1363	1363	1704	2165	2222	2775	3183	3545	3600	23281
Total	38195	39244	40454	42478	45324	44920	44487	28902	29746	27000	380752

Table 49. Raw hides and skins of sheep or lambs produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Brunei Darussalam	5	4	4	4	5	5	5	5	5	6	48
Indonesia	9956	9438	8827	9279	9473	9769	11726	17505	14909	11529	112411
Malaysia	206	289	358	388	369	450	508	470	507	523	4068
Myanmar	1503	1532	1593	1934	2318	2472	2375	376	390	400	14893
Philippines	26	26	26	26	26	26	26	26	26	26	257
Singapore	3	3	3	3	3	2	2	3	3	3	28
Thailand	12	27	54	23	28	29	32	27	27	27	284
Total	11711	11319	10864	11657	12221	12752	14673	18412	15867	12513	131990

Table 50. Raw milk of goats produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Indonesia	353270	353916	354761	363310	368589	352791	357585	359140	361482	364766	3589610
Myanmar	13049	14222	15063	16151	17276	18719	20091	9000	9220	9434	142224
Total	366319	368138	369824	379461	385865	371510	377676	368140	370702	374200	3731834

Table 51. Raw milk of sheep produced in Southeast Asia (tonnes) in the last decade based on the analysis of FAO STAT data (32).

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Indonesia	120329	120677	121245	155155	161101	152920	161222	164167	165606	163827	1486251
Myanmar	3300	3361	3618	3884	4157	4439	4111	2241	2292	2341	33743
Total	123628	124038	124863	159039	165258	157359	165334	166408	167898	166169	1519994