Research Article

Qualitative Risk Assessment of the Introduction of *Trichinella* spp. in Wild Boar Meat from Bengkulu to Java Island Through Bakauheni Port, Lampung

Jemi Diporianto[1,4], Denny Widaya Lukman[2*], Yusuf Ridwan[3]

[1]Graduate Student of Veterinary Public Health and Epidemiology, School of Veterinary and Biomedical Science, Jl. Agatis, IPB Dramaga Campus, IPB University, Bogor, 16680; [2]Division of Veterinary Public Health and Epidemiology, School of Veterinary and Biomedical Sciences, Jl. Agatis, IPB Dramaga Campus, 16680, IPB University, Bogor, 16680; [3]Division of Parasitology and Medical Entomology, School of Veterinary and Biomedical Sciences, Jl. Agatis, IPB Dramaga Campus, 16680, IPB University, Bogor, 16680; [4]Agricultural Quarantine Agency, Ministry of Agriculture of the Republic of Indonesia, Jl. Harsono RM No. 3, 12550, Jakarta.

Abstract | The development of transportation has increased the movement of animal products, potentially leading to an increased risk of disease spread between regions. Trichinellosis is one of the diseases transmitted through animal-based food products. Currently, the utilization of wild boar meat has increased for feed and food purposes, making it challenging to control the movement of wild boar meat for trade. Wild boars are more likely to transmit *Trichinella* spp. than domestic pigs due to the lack of animal health monitoring in wildlife. This study aimed to assess the risk of introducing *Trichinella* spp. in wild boar meat transportation from Bengkulu Province to Java Island through Bakauheni Port, Lampung Province. The study was conducted from October to December 2022 in Bengkulu Province, Lampung Province, and Jakarta Province, Indonesia. The risk assessment was based on the qualitative approach outlined in the Terrestrial Animal Health Code (TAHC) for risk analysis. The entry assessment was based on the Biosecurity Import Risk Analysis Guidelines 2016 Australia, while the uncertainty level was determined based on the guidelines provided by The European Food Safety Authority (EFSA). The final assessment of the risk of *Trichinella* spp. introduction through the transportation of wild boar meat via Bakauheni Port indicated a moderate likelihood with low uncertainty level. The moderate likelihood level indicates that the event was equally likely to occur or not occur. Therefore, risk mitigation measures should be developed to reduce the risk of transmission of *Trichinella* spp.

Keywords | Bengkulu Province, Java Island, Risk Assessment, *Trichinella* spp., Wild Boar Meat

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***Correspondence** | Denny Widaya Lukman, Division of Veterinary Public Health and Epidemiology, School of Veterinary and Biomedical Sciences, Jl. Agatis, IPB Dramaga Campus, 16680, IPB University, Bogor, 16680; **Email:** dennylukman@apps.ipb.ac.id
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INTRODUCTION

The development of transportation has increased the traffic of animal products, that potentially causing the risk of disease transmission between regions. The risk increased as the volume of animal products being transported increased (WOAH, 2022b). Trichinellosis is one of the zoonosis transmitted through animal-derived products, namely through the consumption of raw or undercooked meat from infected livestock or wild animals carrying *Trichinella* spp. larvae (Diaz et al., 2020; Gómez-Morales et al., 2021; WOAH, 2022a). This disease is caused by nematodes from the genus *Trichinella* (Borhani et al., 2023). Currently, the utilization of wild boar meat for feed

and food purposes continues to increase, posing a threat to public health (Sgroi et al., 2023). Franssen et al. (2017) using quantitative microbial risk assessment (QMRA), it was found that the consumption of wild boar meat is responsible for 55% of the trichinellosis cases in humans. Bengkulu Province is one of the largest producers of wild boar meat in Indonesia. Quarantine data indicates that the traffic of wild boar meat from Bengkulu Province from 2018 to 2020 amounted to 153.79 tons (SKP Bengkulu, 2023).

Trichinella spp. can infect approximately 150 species of carnivorous and omnivorous animals (Cybulska et al., 2016). The genus *Trichinella* currently consists of nine species and four additional genotypes (T-6, T-8, T-9, and T-13) whose taxonomic status has not been determined yet (Marucci et al., 2021; Pozio, 2021; Zarlenga et al., 2020). There are three classes of vertebrates that serve as hosts for *Trichinella* spp., namely mammals, birds, and reptiles (WOAH, 2022a). Wild carnivores serve as the main reservoir hosts, although the majority of infections in humans are caused by the consumption of pork (Pozio, 2021) Therefore, historically, it has been considered a "pig parasite." (Zarlenga et al., 2020). The life cycle of *Trichinella* spp. consists of two types: the domestic cycle that occurs in synanthropic and domestic animals, and the sylvatic cycle that occurs in wild animals (Foreyt, 2013). This disease also affects humans with varying degrees of severity, ranging from mild symptoms to death (WOAH, 2022a). The Centers for Disease Control and Prevention (CDC) estimated 10,000 cases of trichinellosis every year (CDC, 2019).

The transportation of wild boar meat from endemic areas to disease-free areas can be facilitated by conducting a risk analysis to determine the necessary mitigation measures. Risk analysis provides likelihood results regarding the transmission of disease agents from the source area, also known as the entry assessment. The entry assessment is conducted by developing a biological pathway for the likelihood of pathogen transmission through wild boar meat from the source area to the entry area. The trafficking of wild boar meat requires attention as it poses a risk of spreading zoonotic diseases, including *Trichinella* spp., between regions (Bezerra-Santos et al., 2021; Pozio et al., 2019; Pozio & Zarlenga, 2013). Unlike most nematodes, the biomass of *Trichinella* spp. in the wild is larger compared to domesticated animals (Pozio, 2022). Several case studies on trichinellosis conducted through laboratory examination in domestic pig meat have been reported in Indonesia. Angi et al. (2015) reported the prevalence of trichinellosis in pigs in Kupang in 2014 was 0.9%. Pramono et al. (2016) found no *Trichinella* spp. infected pigs in Manado in 2015. Furthermore, Setyani et al. (2018) reported that the seroprevalence of trichinellosis in pig farms in the Tangerang Regency in 2018 was 1.25%. The seroprevalences of trichinellosis reported in wild boar meat testing are higher than in domestic pig meat. The Agricultural Quarantine Station in Palembang reported seroprevalence of trichinellosis in wild boar meat samples from Prabumulih and Palembang City in 2021-2022 was 22% (BKP Palembang, 2023). Therefore. this study is necessary to assess the likelihood of the introduction of *Trichinella* spp. in wild boar meat that will be transported from the Province of Bengkulu to Jawa Island through Bakauheni Port, Lampung, and develop the mitigation measures.

MATERIALS AND METHODS

The study was conducted from October to December 2022. The study activities included field observations, expert interviews, and literature collection. Data collection took place at authorized agencies and wild boar slaughterhouses in Bengkulu Province, Lampung Province, and Jakarta Province, Indonesia. The risk analysis referred to the Terrestrial Animal Health Code *(TAHC)* Chapter 2.1 (WOAH, 2022b). The entry assessment referred to the biosecurity import risk analysis guidelines 2016 by the Australian Government (DAWR, 2016) using a qualitative approach as presented in Table 1. While the level of uncertainty referred to The European Food Safety Authority (EFSA) guidelines (Benford et al., 2018) as presented in Table 2.

Table 1: Category of likelihood and its interpretation

Likelihood	Interpretation
High	The event would be very likely to occur
Moderate	The event is equally likely to occur or not occur
Low	The event would be unlikely to occur
Very low	The event would be very unlikely to occur
Extremely low	The event would be extremely unlikely to occur
Negligible	The event would almost certainly not occur

Source : DAWE (2020); DAWR (2016)

Table 2: Qualitative uncertainty categories

Categories of Uncertainty	Interpretation
Low	Complete data, strong evidence presented by various references, various authors have the same conclusion, structured observation conducted
Medium	There were several incomplete data, evidence presented in limited references, and the authors conclusions varied.
High	Data are very scarce or unavailable. Evidence is not available in references but can be found in unpublished reports or based on observations or communication.

Source : Benford et al., 2018

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Table 3: Categories of experts, criteria of experts, number of experts, and data collection method in the study

No.	Experts	Criteria of experts	Number of experts	Data Collection Method
1	Parasitology experts	Someone who knew about *Trichinella* spp. and had publications in national or international journals.	2	In-depth interview
2	Agricultural quarantine officers	The animal quarantine officers have experience inspecting wild boar meat at the Agriculture Quarantine Station in Bengkulu and the Agriculture Quarantine Station in Bakauheni, Lampung.	18	In-depth interview
3	Laboratory supervisors	The laboratory supervisors at the Lampung Veterinary Office, the veterinary public health laboratory of the Provincial Office, the Agriculture Quarantine Station in Bengkulu, the Agriculture Quarantine Station in Bakauheni, Lampung, and the Agricultural Quarantine Standard Testing Center (BBUSKP).	6	In-depth interview
4	Veterinary authorities at provincial and district offices	Authorised veterinarians at Provincial and District Offices conducting wild boar meat inspection.	6	In-depth interview
5	Bakauheni Port Authority	Officers from relevant agencies, such as the port authority and the port police at the Bakauheni Port in Lampung.	5	In-depth interview
6	Wild boar collectors / hunters	The person who hunted wild boars.	7	In-depth interview
7	Colectors member	The owner and members of the wild boar slaughterhouses.	12	In-depth interview
8	Drivers and assistants	Drivers and assitant of vehicles transporting wild boar meat	2	In-depth interview

Table 4: Matrix of combination rules for combining likelihood levels

		Likelihood 2					
		High (H)	Moderate (M)	Low (L)	Very low (VL)	Extremely low (EL)	Negligible (N)
Likelihood 1	High (H)	H	M	L	VL	EL	N
	Moderate (M)	M	L	L	VL	EL	N
	Low (L)	L	L	VL	VL	EL	N
	Very low (VR)	VL	VL	VL	EL	EL	N
	Extremely low (EL)	EL	EL	EL	EL	N	N
	Negligible (N)	N	N	N	N	N	N

Source : DAWE (2020); DAWR (2016)

Table 5: Rules for combining the likelihood levels of more than one partial risk

Description	Overall Assessment
One of the partial risks is "high"	High
More than one partial risk is "moderate"	High
One of the partial risks is "moderate," and every other partial risk is "low."	High
There is one partial risk that is "moderate," and not all other partial risks are "moderate."	Moderate
All partial risks are "low."	Moderate
One or more partial risks are "low."	Low
All partial risks are "very low"	Low
One or more partial risks are "very low"	Very low
All partial risks are "extremely low"	Very low
One or more partial risks are "extremely low"	Extremely low
All partial risks are "negligible"	Negligible

Source : DAWE (2020); DAWR (2016)

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Data Collection

The data used in this study consist of primary and secondary data. Primary data were obtained through expert opinions and direct field observations. Experts were individuals who were knowledgeable in specific fields and could provide opinions and information related to their expertise. The categories of experts, criteria of experts, number of experts, and data collection method in the study were presented in Table 3. Secondary data were obtained through the exploration of scientific publications, literature, laboratory test results, and reports or documents from authorized agencies, whether published or unpublished.

Entry Assessment

The risk assessment for entry consists of three stages: the development of *biological pathways*, the assessment of likelihood and uncertainty, and the final entry assessment. The biological pathways were constructed based on the process flow of wild boar meat from hunting, collection, cutting, laboratory testing, permits procedures, and transportation of wild boar meat from Bengkulu Province to Java Island through Bakauheni Port.

The likelihood assessment was conducted by considering scenarios and posing questions at each stage or *node* formed in the biological pathway. Primary and secondary data were used as information to answer each question. The likelihood level would estimate the probability of wild boar meat infected with *Trichinella* spp. being transmitted when passing through a node, taking into account biological factors, area factors, and commodity factors based on the established biological pathway. Primary and secondary data were used as information to answer each question. The level of uncertainty was assessed based on the availability of primary and secondary data required for the likelihood assessment. The level of uncertainty serves to assess the validity of the obtained data qualitatively and was categorized into three categories based on EFSA (European Food Safety Authority) guidelines (Benford et al., 2018).

The final assessment was conducted once the qualitative likelihood level had been determined for each node and pathway in the biological pathway. A form of combination rules was required to calculate the probability of all scenarios, referring to the combination rule matrix based on the likelihood levels as presented in Table 4, and the combination rule for multiple partial risks as described in Table 5.

RESULTS AND DISCUSSION

Based on the in-depth interview results from experts, as well as direct field observations, a diagram of the biological pathway was developed as presented in Figure 1. Eight nodes were formed in the biological pathways, from the province node (L1) to large collectors (L4), representing hunting activities. Meanwhile, from the District office node (L5) to the Bakauheni quarantine node (L8), it represented the surveillance activities carried out by the local veterinary authorities.

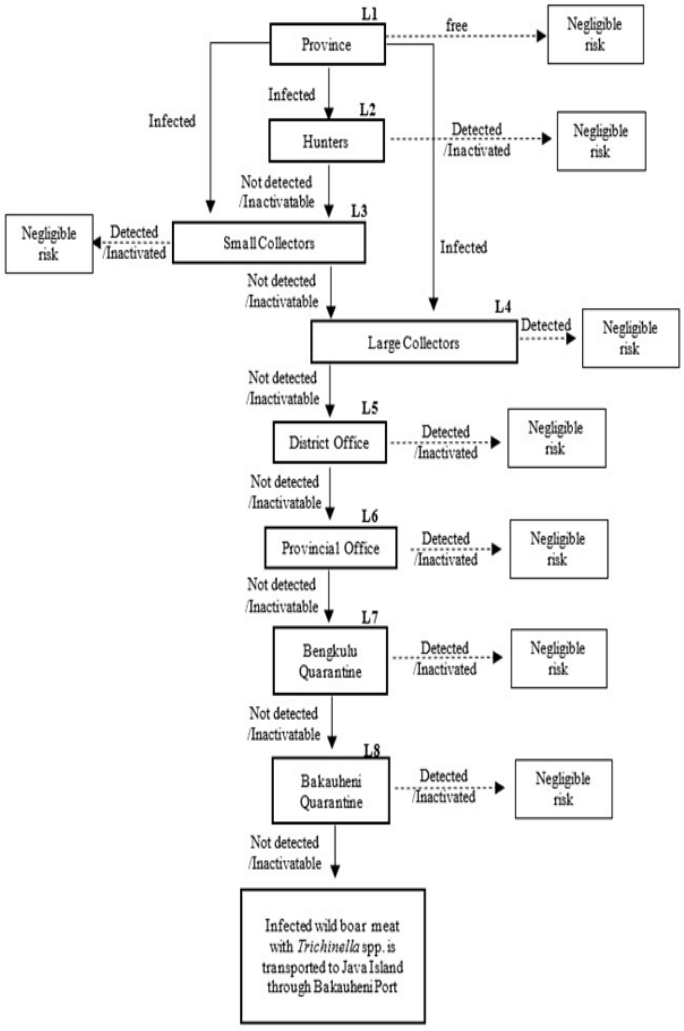

Figure 1: Biological pathway for introducing *Trichinella* spp. in wild boar meat transported through Bakauheni Port.

The forest and plantation areas in Bengkulu Province (L1) were locations for wild boar hunting. There were three parties involved in the hunting activities in Bengkulu Province, namely hunters (L2), small collectors (L3), and large collectors (L4). The hunters sold their hunted wild boars to the small collectors, who then sold them to the larger collectors. The small and large collectors also obtained wild boars from their hunting activities. Inspection and supervision were conducted in stages, starting from the District Office (L5), Provincial Office (L6), Bengkulu Quarantine (L7), and finally by Bakauheni Quarantine (L8). Each stage, starting from the District Office, issued a veterinary certificate that would be required for the next stages permits. If Bengkulu Province were a *Trichinella* spp. free area, wild boar meat would not pose a potential hazard of

Table 6: Likelihood assessment results at each of the nodes based on the biological pathways

No.	Nodes		Key Question	Answer	Likelihood Assessment Results	Uncertainty	Data Source
1	Bengkulu Province (L1)	1	Is Bengkulu Province a free area of *Trichinella* spp.?	Bengkulu Province is an endemic area of *Trichinella* spp. The test results showed high seropositive results (seroprevalence range 7.14%-68.2%).	High	Low	BBUSKP, 2020; Lestari et al., 2018; In depth interview
		2	Is there a potential transmission of *Trichinella* spp. in nature?	There are hunter activities that can potentially increase the prevalence of *Trichinella* spp. in nature, such as disposing of slaughtering waste in nature, feeding pets with hunted pork, and the presence of sensitized wild animals in nature.	High	Low	In-depth interview
		3	Has monitoring and surveillance of *Trichinella* spp. been conducted?	No monitoring and surveillance activities have been conducted.	High	Low	In-depth interview
Results of likelihood assessment at Bengkulu Province node (L1)					High[a]	Low	
2	Hunters (L2)	1	Do hunters know information about *Trichinella* spp. or trichinellosis?	Hunters do not know any information about *Trichinella* spp. or trichinellosis.	High	Low	In-depth interview
		2	Do veterinary authorities conduct antemortem and postmortem examinations on wild boars obtained by hunters?	The veterinary authorities do neither antemortem nor postmortem examinations in hunted wild boars.	High	Low	In-depth interview
Results of likelihood assessment at Hunters node (L2)					High[a]	Low	
3	Small collectors (L3)	1	Are owners and members of small collectors aware of information on trichinellosis?	Owners and members at small collecting nodes know nothing about *Trichinella* spp. or trichinellosis.	High	Low	In-depth interview
		2	Do veterinary authorities conduct inspections and supervision of wild boar meat?	The veterinary authority at small collectors does not conducts inspection and supervision	High	Low	In-depth interview
		3	How do small collectors store wild boar meat?	The meat will be cut into 3-5 kg pieces, then packed in 20 kg plastic packages with a 15-30 cm thickness. They are then stored in a freezer. The maximum shelf-life is two weeks. In high-cutting activities, the storage period is only a few hours before being sold. There is no recording and organization of the layout of wild boar meat in the freezer.	Moderate	Low	In-depth interview

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Results of likelihood assessment at small collectors node (L3)					High[a]	Low	
4	Large collectors (L4)	1	Are owners and members at large collectors aware of information on trichinellosis?	Owners and members at small collecting do not know about *Trichinella* spp. or trichinellosis.	High	Low	In-depth interview
		2	Do veterinary authorities inspect wild boar meat?	Inspection and supervision of wild boar meat are carried out by the veterinary authority at the location of large collectors.	Low	Low	In-depth interview
		3	How do large collectors store wild boar meat?	The meat will be cut into 3-5 kg pieces, then packed in 20 kg plastic packages with a 15-30 cm thickness. They are then stored in a freezer. The maximum shelf life is two months. In high-cutting activities, the storage period is only a few hours before being sold. There is no recording and organization of the layout of wild boar meat in the freezer.	Moderate	Low	In-depth interview
Results of likelihood assessment at large collectors node (L4)					High[a]	Low	
5	District office (L5)	1	Does the district office conduct regular inspections and supervise wild boar slaughterhouses and wild boar meat?	The district office routinely inspects and supervises wild boar slaughterhouses and meat.	Low	Low	In-depth interview
		2	Is laboratory examination for *Trichinella* spp. conducted by the district office?	The district office does not conduct laboratory examinations for *Trichinella* spp. testing, but if there is a request, the district office can collect and send samples to the laboratory for testing.	Moderate	Low	In-depth interview
Results of likelihood assessment at District office node (L5)					Moderate[a]	Low	
6	Provincial offices (L6)	1	Does the provincial office conduct regular inspections and supervision of wild boar slaughterhouses and wild boar meat?	The Provincial Office does not conduct routine inspection and supervision and laboratory testing. This is because the district office has carried out the inspection. The provincial office only issues veterinary certificates based on the examination conducted by the district offices.	High	Low	In-depth interview
Results of likelihood assessment at provincial offices node (L6)					High[a]	Low	

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7	Bengkulu quarantine (L7)	1	Does Bengkulu Quarantine conduct routine inspection and supervision of wild boar slaughterhouses and wild boar meat?	Bengkulu Quarantine routinely monitors and inspects wild boar slaughterhouses and wild boar meat.	Low	Low	In-depth interview
		2	Does quarantine in Bengkulu conduct laboratory tests?	Bengkulu quarantine does not routinely carry out laboratory examinations. In certain activities, Bengkulu quarantine conducts sampling for *Trichinella* spp. testing at the animal quarantine laboratory at the Agricultural Quarantine Standard Test Center.	Moderate	Low	In-depth interview
Results of likelihood assessment at Bengkulu Quarantine node (L7)					Moderate[a]	Low	
8	Bakauheni quarantine (L8)	1	Does the Bakauheni Quarantine conduct routine inspections and surveillance of wild boar slaughterhouses and meat?	Since 2019, the Bakauheni Quarantine has only checked the completeness of documents and the integrity of the seals of vehicles transporting wild boar meat. Physical inspection had been no longer carried out because all activities have been carried out by authorized agencies in the area of origin of the wild boar meat.	High	Low	In-depth interview
Results of likelihood assessment at Bakauheni Quarantine node (L8)					High[a]	Low	

Note : [a]The final entry assessment is obtained using combining the likelihood of more than one partial risk (Table 5).

Trichinella spp. transmission. However, Bengkulu Province is an endemic area, thus, there is a potential hazard from the traffic of wild boar meat. If *Trichinella* spp. were successfully detected or inactivated at a node, then the risk of transmission would be negligible. However, if it were not successfully detected or inactivated, it would become a risk for the next node. Furthermore, if *Trichinella* spp. were not detected or inactivated until the final node, wild boar meat would become a hazard for transmission to the destination area.

The likelihood assessment results for each node were presented in Table 6. There were six nodes with high likelihood assessment results and two nodes with moderate likelihood assessment results. The high likelihood assessment results in multiple nodes were due to the lack of any activities implemented to prevent *Trichinella* spp. infection in those nodes with the risk of transmission. The veterinary authorities should conduct the preventive measures of *Trichinella* spp. transmission through, among others, education about *Trichinella* spp. to hunters and collectors so that they have knowledge and awareness in prevention of *Trichinella* spp. in nature, animals, and humans. Furthermore, the preventive measures also include surveillance, e.g., antemortem, postmortem and laboratory examinations, and application of specific treatments to wild boar meat due to inactivation of *Trichinella* spp. larvae in wild boar meat.

On the other hand, the District Office node (L5) and Bengkulu Quarantine node (L7) have a moderate likelihood assessment. This value is one level lower due to the supervision and inspections conducted by the local veterinary authorities (veterinarians at the District Office and Agricultural Quarantine) to maintain the quality of wild boar meat through monitoring the handling and storage processes. The veterinary authority's supervision is carried out by ensuring that the wild boar meat remains frozen throughout the storage period of up to two months. This activity indirectly reduces the risk of *Trichinella* spp. in wild boar meat. The overall uncertainty assessment is low due to the availability of complete primary and secondary data required for the assessment.

In the biological pathway shown in Figure 1, it can be observed that wild boar meat from Bengkulu Province is obtained through hunting activities carried out by hunters,

Table 7: Evaluation of each risk pathway formed within biological pathways and the final results of the entry assessment.

Risk Pathways	Node	Likelihood Combining	Likelihood Value	Uncertainty
Risk Pathways 1	L1 → L2 → L3 → L4 → L5 → L6 → L7 → L8 → Infected wild boar meat was transported to Java Island through Bakauheni Port, Lampung.	H x H x H x H x M x H x M x H	Low[a]	Low
Risk Pathways 2	L1 → L3 → L4 → L5 → L6 → L7 → L8 → Infected wild boar meat was transported to Java Island through Bakauheni Port, Lampung.	H x H x H x M x H x M x H	Low[a]	Low
Risk Pathways 3	L1 → L4 → L5 → L6 → L7 → L8 → Infected wild boar meat was transported to Java Island through Bakauheni Port, Lampung.	H x H x M x H x M x H	Low[a]	Low
Final Entry Assessment			Moderate[b]	Low

Note : [a] The likelihood is obtained using a combination rule matrix combining the likelihood levels (Table 4)
[b] The final entry assessment is obtained using combining the likelihood of more than one partial risk (Table 5). H : High , M : Moderate.

small collectors, and large collectors. This forms three risk pathways, namely Risk Pathway 1, 2, and 3 (Table 7). The assessment of these three risk pathways indicate similar results due to the nearly identical handling processes of wild boar meat and the absence of significant treatments that can significantly reduce the risk of *Trichinella* spp. transmission in each pathway.

Based on the obtained likelihood assessment results for each node and the assessment of the three existing risk pathways, the risk of *Trichinella* spp. entry in wild boar meat transported through Bakauheni Port, Lampung can be evaluated. The final result of the entry risk assessment is moderate with low uncertainty level. A moderate risk value indicates that the likelihood of *Trichinella* spp. entry through wild boar meat is the event is equally likely to occur or not occur.

All wild boar meat produced in Bengkulu Province originates from hunting activities conducted in areas endemic for trichinellosis. The Agricultural Quarantine Standard Testing Center (BBUSKP) reported in 2019, using the Enzyme-linked immunosorbent assay (ELISA) testing method, that 7.14% of the 26 samples of wild boar meat from Bengkulu were seropositive for *Trichinella* spp. (BBUSKP, 2020). Lestari et al. (2018) was also reported that 68.2% of the total 44 serum samples from wild boar meat obtained through hunting in Central Bengkulu District were seropositive for *Trichinella* spp. Specifically, 12 out of 18 serum samples from wild boars (66.7%) in Pondok Kubang Sub-district and 18 out of 26 serum samples from wild boars (69.2%) in Pondok Kelapa Sub-district were seropositive for *Trichinella* spp.

Wild boars obtained from hunting are often cut and handled in unsuitable locations such as forest areas, plantations, private homes, or makeshift buildings, without proper waste management. The wild boar heads and offal left from the butchering process are typically buried haphazardly using soil, wild grass, or oil palm fronds. *Trichinella* spp. larvae can survive in decaying animal carcasses, even when the carcasses have completely decomposed (Pozio, 2016, 2022). This condition renders the transmission of *Trichinella* spp., which should only occur through predation processes and risk-prone carnivores, less significant. This is because infected decomposing carcasses will contaminate plants or wild grass, which serve as food for herbivorous animals, thereby potentially infecting them with *Trichinella* spp. (Pozio, 2016). Additionally, these carcasses will also serve as food for wild rats in the natural environment (Foreyt, 2013). This activity represents a significant biomass of parasites re-entering the life cycle of wildlife (Pozio, 2022) and can dramatically increase the prevalence of *Trichinella* spp. in reservoir animals (Foreyt, 2013). Unfortunately, so far, there has been no monitoring and surveillance conducted on trichinellosis cases in Bengkulu Province by the local veterinary authorities. Based on interviews with the district and provincial offices, they have never conducted monitoring and surveillance for cases of trichinellosis in Bengkulu Province because this activity has not been a priority program. The latest decree of the minister of agriculture of the Republic of Indonesia, number 121 of 2023, concerning the determination of the type of strategic infectious animal disease, also does not include trichinellosis as a disease in this group, resulting in the required funds for such activities never being allocated.

Based on the interviews, neither hunters nor collectors have any knowledge about *Trichinella* spp. Lack of understanding among hunters and collectors contributes to the potential transmission of the parasite (Pozio, 2014). This information is also consistent with the interview results

conducted with the District and Provincial Offices responsible for veterinary public health functions, indicating that *Trichinella* spp. has not yet become a priority program. Consequently, programs such as prevention, monitoring, surveillance, and education for hunters and collectors have not been implemented. Education and communication with hunters and collectors are crucial for reducing or eliminating potential sources of *Trichinella* spp. exposure (Borhani et al., 2023; Pozio, 2019; Vu Thi et al., 2013). Antemortem and postmortem examinations by veterinary authorities are never conducted at the hunting nodes and small collectors, but at the large collector nodes, postmortem examinations have been carried out. Antemortem and postmortem examinations should be conducted for the prevention of *Trichinella* spp. Infections (Noeckler et al., 2019; Pozio, 2019; WOAH, 2022a).

All individuals involved in both small and large collectors, from members to owners, do not have sufficient information about *Trichinella* spp. At small collectors, wild boar meat is typically cut into average sizes of 3-5 kg, then packaged in plastic packaging weighing approximately 20 kg and with a thickness of 15-30 cm. It is then stored in a *freezer.* The maximum storage period for wild boar meat is two weeks. The cutting locations are often private homes or makeshift buildings with inadequate waste management, and wild animals still have easy access to the meat handling area. The production sites should ideally serve as epidemiological units that enable the implementation of effective measures to prevent exposure to *Trichinella* spp. infections (Gamble et al., 2019).

The wild boar meat will also be packed in plastic packaging the same size as the small collector at the large collector level. The maximum storage period for meat at large collectors is two months, but on average, storage does not exceed two weeks. In high cutting activities, the storage period at both small and large collectors is only a few hours before being sold. Storing meat under frozen conditions can be used by large collectors to inactivate *Trichinella* spp. larvae in wild boar meat. Yera et al. (2022) stated Southeast Asia has no *Trichinella* spp. infections tolerant to cold temperatures, such as *Trichinella britovi*, *Trichinella nativa*, and *Trichinella* Genotype T-6. Therefore, freezing methods with specific combinations of temperature and duration are recommended as one of the larval inactivation methods for *Trichinella* spp., following International Commission on Trichinellosis (ICT) recommendations (Noeckler et al., 2019). In this study, no record is kept from the hunter nodes to the large collectors regarding the source of wild boar, date of slaughter, storage temperature records, and other relevant information. Codex Alimentarius Commission and European Commission state that recording is necessary at the cutting locations as a form of traceability (CAC, 2015; EC, 2015).

The veterinary public health department regularly conducts visits to the cutting locations to perform organoleptic inspections and assess the storage conditions of wild boar meat. In addition to inspections, the department also provides guidance on meeting the minimum requirements for proper cutting facilities. However, specific education on diseases in wild boar meat, particularly *Trichinella* spp., has not been provided. Routine laboratory examination for *Trichinella* spp. is also not conducted by the District Office. The Provincial Office (Livestock and Animal Health Department) does not conduct physical inspections or laboratory examination for *Trichinella* spp. on wild boar meat. The Provincial Office only issues veterinary certificates and issuance recommendations based on the inspections conducted by the District Office. According to Gamble (2022), pigs that are not kept in controlled cage systems must undergo physical inspections and laboratory examination to ensure the absence of *Trichinella* spp. infection. The laboratory examination should refer to the method recommended by ICT (Bruschi et al., 2019; Gajadhar et al., 2019).

The Agriculture Quarantine Station in Bengkulu routinely conducts inspections of the meat quality and *freezer* conditions at large collection and cutting locations. Wild boar meat must always be in a frozen state in the freezer to ensure its quality. However, *Trichinella* spp. examination has not been prioritized. The Agriculture Quarantine Station in Bengkulu will issue animal product sanitation certificates and install seals and GPS (*Global Positioning System*) on transport vehicles once the inspections are deemed complete. Inspections carried out by the District Officer and Quarantine Officer regarding the quality of wild boar meat through proper freezing storage can reduce the risk of transmission of *Trichinella* spp.

The Agriculture Quarantine Station in Bakauheni, Lampung, conducts inspections to verify the completeness and authenticity of documents, as well as the integrity of seals on vehicles transporting wild boar meat. Physical inspections are no longer conducted by Bakauheni Quarantine officer since 2019. Bakauheni Quarantine officer serves as the final supervisory authority for veterinary regulations before the wild boar meat is transported. The absence of physical inspections and laboratory examination increases the risk of undetected *Trichinella* spp. in wild boar meat. Pozio (2015) and Rostami et al. (2017) reported that the traffic of wild boar meat had been proven to spread *Trichinella* spp. and cause outbreaks in several European countries.

Based on the obtained entry assessment results, several

risk mitigation measures can be taken to reduce the risk of *Trichinella* spp. transmission through wild boar meat to meet the acceptable risk level for a region. These measures include: 1) The veterinary authorities conduct regular supervision and monitoring at slaughterhouses by systematically taking samples and testing for *Trichinella* spp. using recommended methods at accredited laboratories (Bruschi et al., 2019; EC, 2015; WOAH, 2022a). 2) Implement a policy of meeting technical requirements that stipulate that wild boar meat has undergone treatment to inactivate larvae in the issuance of veterinary certificates, and the wild boar meat being transported must be frozen. 3) Applying treatments to inactivate *Trichinella* spp. larvae. For wild boar meat, the recommended methods by ICT include heating the meat to reach an internal temperature of 62.2 ˚C for two seconds, or reaching an internal temperature of 54.5 ˚C for 30 minutes, or using other specific internal temperatures and times. Another treatment is freezing at specific temperatures and durations, such as freezing at -15 ˚C for 20 or 30 days depending on the thickness of the wild boar meat. Another method is the application of irradiation at a dose of 0.3 kGy to packaged wild boar meat (CAC, 2015; FSIS, 2018; Noeckler et al., 2019; WOAH, 2022a). Freezing is the most recommended method for wild boar meat originating from Bengkulu Province. 4) Provide education about *Trichinella* spp. to hunters, collectors, and the community.

CONCLUSION

The final result of the entry assessment for wild boar meat originating from Bengkulu Province, which is being transported to Java Island through Bakauheni Port, is moderate with low uncertainty level. This result is not sufficient to meet the acceptable risk level for a region, which is generally at a very low or extremely low level. Therefore, risk mitigation measures are needed to reduce the risk to an acceptable level.

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CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

NOVELTY STATEMENT

This study represents the first risk assessment conducted on the legal transportation of animal products from wild animals in Indonesia. The findings of this study can serve as a valuable reference for the government in the establishment of policies related to animal product transportation. Additionally, it can provide useful information for future risk assessment studies on different diseases and animal products.

AUTHOR'S CONTRIBUTION

Jemi Diporianto contributed to collecting data, data analysis, and preparing the original manuscript. Denny Widaya Lukman and Yusuf Ridwan contributed to the study design, revised the manuscript, and supervised. All authors read and approved the final version of the manuscript in the present journal.

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