Original Article

Trichinellosis Prevalence and Distribution Flow of Wild Boar Meat in West Pasaman Regency, West Sumatera Province, Indonesia

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ABSTRACT

Background: Trichinellosis is a zoonotic disease transmitted by the consumption of undercooked meat infected with Trichinella larvae. Wild boars are significant reservoirs of this pathogen, posing health risks to humans, particularly in regions where hunting is prevalent. Wild boar meat infected with larvae *Trichinella* spp. has an increased risk of human infection with trichinellosis.

Objectives: This study aimed to measure the prevalence of trichinellosis in wild boars and analyze the wild boar meat distribution flow in West Pasaman Regency, West Sumatera Province, Indonesia.

Methods: Muscle samples were collected from 106 wild boars that were captured during a traditional hunting event. The samples were obtained from four anatomical sites (masseter, forelimb, diaphragm, and intercostal muscles), pooled, and tested for antibodies against Trichinella excretory/secretory antigens using indirect enzyme-linked immunosorbent assay (ELISA). Data on meat distribution were gathered through interviews with hunters, collectors, traders, and authorized officers, using a structured questionnaire.

Results: ELISA results showed that 48(45.28%) of the 106 wild boar samples tested positive for *Trichinella* spp. There was no significant correlation between seropositivity against sex (P=0.503) and body weight (P=0.485) of wild boars. The interview results showed that the captured wild boars were collected by local small-scale collectors and sold the meat either to local consumers or large-scale collectors. Local large-scale collectors sold meat both inside and outside the West Pasaman Regency. Large-scale collectors outside West Pasaman Regency sold meat to traders or directly to consumers. The Plantation and Livestock Services

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of West Pasaman Regency did not know about the distribution of the resulting wild boar meat or inspect this product. Distribution flow analysis showed that wild boar meat is consumed locally and sold outside the region and province.

Conclusion: This study revealed a relatively high prevalence of trichinellosis in wild boars in the West Pasaman Regency, West Sumatra Province, Indonesia. Hunted wild boars were distributed to consumers through various actors in the West Pasaman Regency and beyond. Such conditions raise concerns about the health implications for consumers. Therefore, it is important to increase public awareness regarding safe food practices and conduct surveillance of wildlife and livestock health in the region.

Keywords: Antibodies, Hunting, Trichinella, Wild boar, Zoonotic Disease

Introduction

Trichinellosis is a parasitic disease caused by infection with nematodes of the genus *Trichinella* (Borhani et al., 2023). These nematodes are foodborne parasites that are globally present in wild carnivores and omnivores. Their spillover into domestic livestock and humans has significant trade and health implications (Malone et al., 2024). Human trichinellosis transmission mostly occurs through the consumption of undercooked pork or other infected meat containing *Trichinella* spp. larvae (Pozio 2022; Zhang et al., 2022). Additionally, the transmission of *Trichinella* spp. parasites through predation, necrophagy, or cannibalism of raw meat is vital for ensuring their survival in a variety of hosts (Romashov et al., 2021).

Trichinella infection in wild boars has been reported worldwide. Studies in Brazil, China, India, South Korea, Vietnam, and the Philippines have shown varying prevalence of *Trichinella* infection in wild boars, from 0.54% to 42.11% (Lee et al., 2015; Unger et al., 2016; Lagrimas et al., 2021; Silva et al., 2022; Zhang et al., 2022; Kalambhe et al., 2024). Trichinellosis in Indonesia was first reported in the Tapanuli Residency (now part of North Sumatera Province) in 1930 by Visser and Manap. Subsequent monitoring and control efforts from 1930 to 1939 showed an overall prevalence of approximately 3.06% in pigs (Holz, 1962). Angi et al. (2014) reported that 0.9% of pork samples from the Kupang City abattoir were infected with *Trichinella* spp., whereas Lestari et al. (2018) reported a 68.2% seroprevalence of trichinellosis in wild boars in Central Bengkulu Regency. Trichinellosis in humans has also been reported by Chomel et al. (1993) on Bali Island, with a seroprevalence of 19.5%. However, the occurrence of trichinellosis in Indonesia remains underreported.

Wild boar hunting is a culture known as 'Baburu Kandiak' for controlling agricultural pests and community plantations in West Pasaman Regency, West Sumatra Province. In this activity, wild boars are chased and killed by hunting dogs (Hidayati, 2017; Andrian et al., 2023). Wild boars serve as potential reservoirs of Trichinella, and the incidence of zoonotic trichinellosis is linked to the human consumption of wild meat (Foreyt, 2013). This study aimed to measure the prevalence of trichinellosis in wild boars and analyze the distribution flow of wild boar meat in West Pasaman Regency, West Sumatera Province, Indonesia.

Materials and Methods

Study area

Sample collection was conducted in West Pasaman Regency, West Sumatra Province, Indonesia, from January to July 2024 (Figure 1). The West Pasaman Regency covers an area of 3887.77 km². Geographically, it is located between 0°03' north latitude and 0°11' south latitude, as well as between 99°10' and 100°04' E, lying on the equatorial line at 0° latitude. The West Pasaman Regency is bordered by North Sumatra Province to the north, Pasaman Regency to the east, Agam Regency and Pasaman Regency to the south, and the Indonesian Ocean to the west (BPS-Statistics West Pasaman Regency, 2024). Sample analysis and data processing were performed at the Helminthology Laboratory, Division of Parasitology and Medical Entomology, and Integrated Research Laboratory, Division of Medical Microbiology, School of Veterinary Medicine and Biomedical Sciences, IPB University, Bogor, Indonesia.

Sample animals

Wild boar samples were collected during hunting activities (Figure 2). The number of wild boars required

Figure 1. Location of West Pasaman Regency within West Sumatera Province, Indonesia

for this study was calculated based on the formula given by Thrusfield & Christley (2018). The sample size was determined based on the expected prevalence of 50%, a 95% confidence interval, and a desired precision level of 10%, resulting in a minimum sample number of 97 wild boars.

Sampling methods

The morphometric (sex, body length, and chest circumference) data and source location of the wild boars obtained by the hunters were recorded once they arrived at the assigned collection points. These morphometric data were then used to estimate the body weight of wild boars using the formula of Baruzzi et al. (2023). The muscle samples were then collected from four anatomical sites within the body of the wild boar: The masseter, forelimb, diaphragm, and intercostal muscles. At each site, approximately 50 g of muscle sections were carefully collected using a sharp knife and then placed in a 12×20 cm plastic sample bag. These individual bags were then combined into larger bags measuring 25×35 cm. Subsequently, the samples were stored in a -20 ˚C freezer for preservation and transportation.

Figure 2. Wild boar hunting activities in West Pasaman Regency using hunting dogs

Table 1. Prevalence of *Trichinella* spp. infection according to sex and body weight

Risk Factors	Variables	Prevalence		95% CI	X^2 (P)	r (P)
		No.	No. (%)			
		Examined Sample	Positive Results			
Sex	Male	72	31(43.06)			
	Female	34	17(50.00)			
	Total	106	48(45.28)			
Body weight (kg)	<20	29	12(41.37)	[40.28, 50.28]	0.449 (0.503)	0.068 (0.485)
	20-39.9	46	20(43.47)			
	40-59.9	30	16(53.33)			
	>60	1	0(0)			

Muscle juice collection

The frozen samples were placed in conical containers and thawed at 4 ˚C for 24-48 hours. The resulting liquid (muscle juice) that was concentrated at the end of the container was then collected and transferred into a 1.5 mL plastic sample tube. This muscle juice was then centrifuged at 10000 rpm for 10 min to obtain a cleaner sample before being stored in a -20 ˚C freezer until the immunoassay was performed.

Enzyme-linked immunosorbent assay (ELISA)

The immunoassay was conducted using the indirect ELISA method with the ID Screen® Trichinella Indirect multi-species ELISA kit (ID-VET, France) to detect antibodies against *Trichinella* spp. This diagnostic kit detects the reaction between excretory/secretory (E/S) antigens within the kit and specific antibodies against *Trichinella spiralis*, as well as several other species, including *T. pseudospiralis*, *T. britovi*, and *T. nativa* in the sample. The assay was conducted according to the manufacturer's protocol, and optical density (OD) values were measured using a BIOTEK® 800TS microplate reader (BioTek Instruments Inc., USA) at a wavelength of 450 nm. Antibody titers were calculated from the measured OD values using the following S/P ratio (S/P %) formula (Equation 1):

$$1.\ S/P\% = \frac{(OD_{Sample} - OD_{NC})}{(OD_{PC} - OD_{NC})}$$

The resulting S/P% values were compared against a set threshold to determine the antibody titers of the samples. A sample was considered seropositive when S/P% ≥ 30%, negative when S/P% ≤25%, and doubtful/dubious when 25% < S/P% < 30%.

Questionnaire interview

Questionnaire interviews were conducted with wild boar hunters, collectors, traders, and representatives of the Veterinary Public Health section of the Plantation and Livestock Services of West Pasaman Regency, West Sumatra Province, Indonesia. Each respondent was interviewed using a questionnaire with closed-ended questions to obtain information on wild boar meat trading and the distribution flow of wild boar meat after the wild boar hunting activity.

Data analysis

The morphometric measurements, immunoassay, and interview results were arranged in a digital database using Microsoft Excel. This database was then statistically analyzed using descriptive and inferential statistics in Microsoft Excel and Epitools. The inferential statistics used were the chi-square test (for ELISA results vs sex) and Pearson's correlation analysis (for ELISA results vs body weight).

Result

A total of 106 wild boar samples (72 male and 34 female) were collected during the study period. Of the collected samples, 48(45.28%) tested positive for ELISA; 31(43.06%) were male and 17(50.00%) were female.

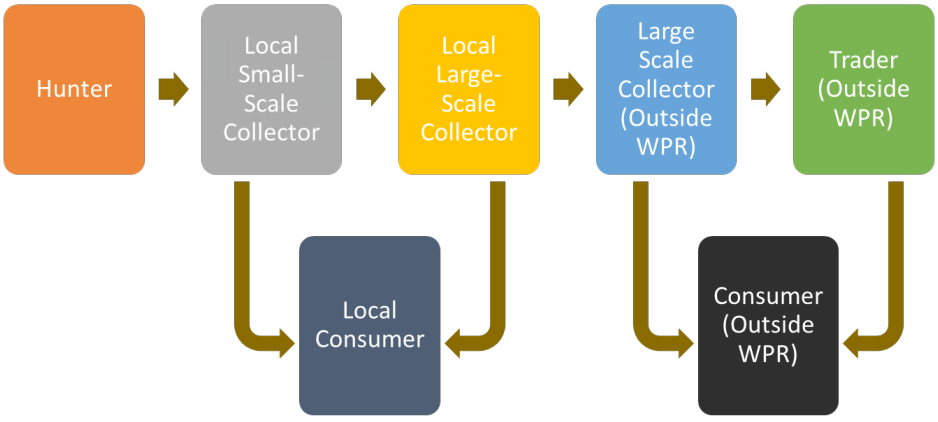

Figure 3. Distribution flow of wild boar hunted in West Pasaman Regency, West Sumatera Province, Indonesia.

The chi-square test showed no correlation between the positive results of *Trichinella* spp. antibodies and wild boar sex at a 95% confidence interval (CI), as indicated by a P of 0.503 (P>0.05). The average body weight of wild boar samples was 30.35±1.51 kg, with nine animals weighing <10 kg and one weighing >60 kg (96.54 kg). The Pearson correlation results showed no correlation between the positive results for *Trichinella* spp. antibodies and wild boar body weight at a 95% CI, as indicated by the P of 0.485 (P>0.05) (Table 1).

Questionnaire interviews were conducted with ten hunter respondents, two collector respondents, two wild boar trader respondents, and four respondents from the Plantation and Livestock Services of West Pasaman Regency, West Sumatra Province. The wild boar hunting frequency varied from region to region. In some areas, hunting was conducted three times a week, whereas in other areas, it was conducted up to six times a week. The authors' observations and interviews showed that six types of actors were involved in the wild boar meat distribution flow: Hunters, local small-scale collectors, local large-scale collectors, large-scale collectors outside West Pasaman Regency, traders, and consumers (Figure 3). The Plantation and Livestock Services of West Pasaman Regency, as the authorized agency, were well aware of traditional wild boar hunting activity. However, this agency was not informed about the distribution of the resulting wild boar meat or inspecting this product.

Wild boars were hunted by the hunting dogs. Once the dogs had eaten enough, the remaining meat was prepared for personal consumption by small-scale local collectors. These collectors then sold the meat to local consumers or large-scale collectors. The local large-scale collectors sold meat within the West Pasaman Regency and beyond, particularly in the South and Central Tapanuli Regencies of North Sumatera Province. Large-scale collectors outside West Pasaman Regency sell meat to traders or directly to consumers in their respective areas. Along the distribution flow, wild boar meat is usually stored in actors' freezers before sale.

Discussion

The prevalence of *Trichinella* spp. in wild boars observed in this study was significantly higher than that reported previously. Studies by Pinilla et al. and Akibekov et al. found no seropositive antibodies against *Trichinella* spp. in wild boar samples in Colombia and Kazakhstan, respectively (Pinilla et al., 2023; Akibekov et al., 2023). Previous studies on pigs in other regions of Indonesia reported seroprevalences of 0.8% and 1.25% in Kupang and Tangerang, respectively (Angi et al., 2015; Setyani et al., 2018). Cleveland et al. (Cleveland et al., 2024) reported that 927 of 7467 wild boar samples collected from 2014 to 2020 (12.4%) tested positive for *Trichinella* spp. A study in Ghana by Addo et al. (2021) reported a 4.5% (11/245) seroprevalence of *Trichinella* spp. in domesticated pigs. Other studies have reported that the prevalence of *Trichinella* spp. varies between 2.5% and 13.6% in South Korea, Cambodia, Vietnam, and Russia (Kim et al., 2015; Söderberg et al., 2021; Le et al., 2022; Glazunov & Vinogradova 2023;). A higher seroprevalence (64.2%) was observed in wild boars in the Bihor District, Romania (Boros et al., 2020). The prevalence of *Trichinella* spp. in this study was also lower than that reported by Lestari et al. (2018) in the Central Bengkulu Regency, Bengkulu Province, reporting a seroprevalence of 68.2%.

The wide variation in the prevalence in these studies is closely related to the variation in environmental background and the number of collected samples. Pozio (2013) reported that environmental conditions also affect

the geographical distribution of enzootic parasites. The different adaptation strategies developed by *Trichinella* spp. and the influence of differences in the humidity and temperature of the habitat environment where the host lives are the reasons why some species and genotypes appear more restricted in their distribution (Pozio & Zarlenga 2013). West Sumatera Province in Indonesia features a tropical climate with an average temperature of 27.3 ˚C and an average humidity of 81.3%. The maximum recorded temperatures can reach 35.1 ˚C and humidity levels can hit 100.0% (BPS-Statistics West Sumatera Province 2022). Regions with a tropical wet climate, higher humidity, higher average temperature, and higher annual rainfall had a higher prevalence, while the regression indicated that temperature influenced prevalence. These environmental factors can influence *Trichinella* transmission (Eslahi et al., 2022). Owen and Reid (Owen & Reid, 2007) indicated that temperature, humidity, and fauna were involved in the decomposition of wild boar carcasses. This significantly affects the longevity of larvae in the muscle, which plays a role in spreading the infection.

The findings of this study also reveal the existence of the sylvatic cycle of *Trichinella* spp. in wildlife in the forest area of West Pasaman Regency, West Sumatra Province. Wild boar collectors in West Pasaman Regency sold only the meat parts of wild boar carcasses to consumers or to larger-scale collectors. As a result, they have a habit of disposing of boar heads and offals in streams, puddles, or bushes at hunting locations. This practice leads to an ongoing cycle in nature through the transmission of *Trichinella* spp. from infected wild boars to hunting dogs or other wildlife in the forest, such as wild boars, forest cats, forest rats, bears, and tigers that consume the organs. Pozio (2019) reported that offal and wild boar carcasses abandoned by hunters could also play a role in perpetuating the cycle of the nematode, as *Trichinella* larvae can survive for a long period of time in decaying carcasses or carrion and be a source of infection for scavenging hosts. The survival of larvae in decomposing flesh is significantly influenced by the environmental conditions. Specifically, elevated humidity and reduced temperatures promote survival, even when the muscle tissue has undergone complete liquefaction. This adaptive survival mechanism is a biological characteristic of all taxa within the genus *Trichinella*. Moreover, encapsulated species exhibit a longer duration of survival in host carcasses than their non-encapsulated counterparts (Pozio, 2019). In the natural cycle of the parasite, the importance of larval survivability in animal carcasses is further proven by the resistance of muscle larvae in frozen muscles for one or more years (Pozio, 2016).

This study showed no significant correlation between trichinellosis and the wild boar sex. These results are in line with a study by Silva et al. (Silva et al., 2022), which found no significant correlation between *Trichinella* spp. infection and sex. Boros et al. found no significant association between positive results and sex, although more positive results were observed in females (Boros et al., 2020). This implies that male and female boars are at an equal risk of contracting or transmitting *Trichinella* spp. In another study, Buffoni et al. (2024) found a significant correlation between *Trichinella* spp. seropositivity and gender, revealing that females had a significantly higher seroprevalence than males. This discrepancy could be attributed to the number of samples collected, which differed considerably (male=603; female=734) compared to (male=72; female=34). The distribution of positive results across all weight ranges demonstrated that there was no weight-based difference in *Trichinella* spp. infection. This finding indicates that both small and large boars are equally at high risk of infection. Diaz et al. (Diaz et al., 2021) explained that body weight is one of the most variable parameters in wild boars from population to population and is largely determined by environmental factors. In the same study, the authors reported that piglets can be infected by *Trichinella* spp. at an early age, representing a risk of infection in humans.

The results of the questionnaire interviews indicated that wild boar meat was consumed by local small-scale collectors or non-Muslim minority communities living in West Pasaman Regency, West Sumatera Province. This was supported by data from Rambey et al. (2020), who stated that the people in Bahai Gajah Village, Simalungun Regency, North Sumatera Province, use wild boars as food for daily consumption or during rituals by consuming all parts of the wild boar. The majority of wild boar meat from the hunt in West Pasaman Regency, West Sumatera Province, was sold by local large-scale collectors or directly by wild boar local small-scale collectors outside the region. The exact amount of wild boar meat sold out of West Pasaman Regency each year is unknown. In Jambi, wild boars are often the only wild meat that is routinely sold in local rural and urban markets. Each wild meat dealer sold 400–1100 kg of wild boar meat per week (10–30 wild boars) or more than 7500 wild boars and 250 tons of wild boar meat. The largest customers were local Batak or Chinese restaurant owners who frequently purchased wild boars. Wild meat dealers outside urban areas also exported their meat, primarily via refrigerated trucks that regularly travel to Medan, a city in North Sumatera home to a large Batak population (Luskin et al., 2013).

Trichinella infection in wild boars remains a public health problem in West Pasaman Regency, West Sumatera Province. The high prevalence rate and interaction rate between wild boars, hunting dogs, and humans pose a high transmission risk for all involved hosts. Educating wild boar hunters and collectors to avoid risky practices, such as leaving wild boar carcasses or offal in the environment, could contribute significantly to reducing the spread of this zoonosis. Local authorities must closely monitor the distribution of wild boar meat and conduct regular inspections to prevent the rapid spread of trichinellosis to other animals and humans. This proactive approach is essential for safeguarding the health and well-being of both wildlife and people.

Conclusion

This study revealed a relatively high prevalence of *Trichinella* spp. at 45.28% in wild boars in West Pasaman Regency, West Sumatra Province. There was no correlation between the distribution of trichinellosis and the sex or weight of wild boars, indicating an equally high risk of *Trichinella* spp. infection in both sexes and ages of wild boars. Hunted wild boars were consumed by hunting dogs and distributed to consumers through various actors in West Pasaman Regency and beyond. Risky practices carried out by some actors perpetuate the presence of *Trichinella* spp. in the environment. The significant prevalence of trichinellosis indicates the presence of a sylvatic lifecycle among wild boars in the West Pasaman Regency. Such conditions raise concerns about the health implications for consumers, who may be unaware of the risks associated with undercooked or contaminated wild meat. Therefore, it is important to increase public awareness regarding safe food practices and to conduct surveillance of wildlife and livestock health in the region.

Ethical Considerations

Compliance with ethical guidelines

All procedures were performed in accordance with the standards outlined in the guidelines of the Animal Welfare, Ethics, and Experimentation Committee (No: 213/KEH/SKE/IV/2024) of The Animal Ethics Committee at the School of Veterinary Medicine and Biomedical Sciences, IPB University, Bogor, Indonesia.

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Authors' contributions

Conceptualization and supervision: Fadjar Satrija, and Yusuf Ridwan; Methodology, project administration and formal analysis: Fadjar Satrija, Yusuf Ridwan, Sri Murtini, and Yasir Hamdani Dalimunthe; Software, data curation and data analysis: Etih Sudarnika, and Yasir Hamdani Dalimunthe; Data collection and investigation: Yasir Hamdani Dalimunthe; Validation, visualization, and writing: All Authors.

Conflict of interest

All authors declared no conflict of interest

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