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Endoparasite and Microbial Burden in Quail Farm Systems: A Biosecurity and Water Quality Assessment in Central Java, Indonesia

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ABSTRACT

Quail farming is vital for smallholder farmers in Central Java, Indonesia; however, productivity often declines due to poor biosecurity, inadequate water quality, and parasitic infections. This study aims to examine biosecurity practices, water quality, and endoparasite loads in ten quail farms (L1-L10) located in Semarang City and nearby regencies. Data were collected through observations, interviews, water sampling, and analysis of quail droppings. Biosecurity scores (maximum 18) were categorized into three groups: Group-1 (scores 13-18), Group-2 (scores 7-12), and Group-3 (scores 1-6). Water quality was assessed based on pH, *E. coli*, and coliform counts using triplicate samples from each site. The biosecurity score showed that three farms are in Group-1 (L1, L7, L9), five are in Group-2, and two are in Group-3 (L8, L10). The water pH ranged from 4.8 to 8.0; the highest *E. coli* count was 19.33 CFU/mL (L9), and the highest Coliform count was 89.67 CFU/mL (L5). L1 had the highest parasite load, with Coccidia, Strongyloides, and *Ascaridia* sp. at 1000 oocysts/g (OPG), 100 OPG, and 33.33 OPG, respectively. Meanwhile, L7 showed no endoparasites or water contamination. Egg production ranged from 64.29% to 90.00%. Although no significant differences in endoparasite prevalence were found among biosecurity groups or water quality (p>0.05), Coliform levels differed significantly (p<0.05), with the highest levels in conventional well-water. This study revealed that only about one-third of smallholder quail farms in Semarang and its surrounding regencies adhere to proper biosecurity measures. It was also the first to document quail endoparasite burdens as well as *E. coli* and coliform contamination in drinking water.

Keywords: biosecurity; Coliform; E. coli; endoparasites; smallholder farmers

INTRODUCTION

Quail farming is a growing and dynamic part of the global poultry industry, driven by rising consumer demand for lean meat and nutrient-rich eggs (Farmers Entrance, 2025). The global quail meat market, valued at $75.85 million in 2024, is projected to reach $81.97 million in 2025 (Global Growth Insight, 2025). Domesticated quails, particularly the Japanese quail (*Coturnix japonica*), are now raised worldwide, with the Asia-Pacific region leading the market at 35% share in 2024 (Business Research Insight, 2025). In Indonesia, quail farming is vital for smallholder farmers, providing income and nutrition. The national quail population reached 24.28 million in 2024 (Badan Pusat Statistik, 2024), producing approximately 25,770 tons of eggs annually, with Central Java contributing over 8,800 tons from 4.6 million birds (Directorate General of Animal Husbandry and Animal Health, 2022). This sector is crucial for ensuring food security, generating employment opportunities, and supporting low-income rural households.

Although quail farming in Indonesia is gaining importance, it faces constant challenges that hinder its productivity and long-term sustainability. These challenges include feed quality (Gao *et al*., 2021; Ibrahim *et al*., 2020), environmental stressors (El Sabry *et al*., 2022), and suboptimal poultry management practices (Ratriyanto *et al*., 2020). Among these, biosecurity has become a key element of an effective strategy for maintaining flock health and preventing the spread of infectious diseases. Effective biosecurity encompasses a set of conceptual, structural, and operational measures that aim to minimize the risk of pathogen entry and transmission within and between flocks and farms (Tilli *et al*., 2022; Delpont *et al*., 2023). When implemented consistently, biosecurity is not only the most cost-effective way to protect flock health, cut economic losses, and reduce zoonotic risks to farm workers and nearby communities, but also a key strategy for promoting animal welfare, food safety, and environmental sustainability.

Water quality greatly influences poultry health and productivity. Contaminated drinking water may contain microbial pathogens, such as *E. coli* and Coliform bacteria, indicating fecal contamination (Mohamed *et al*., 2025). These pathogens can spread disease, cause stress, and reduce feed efficiency. Combining water quality management and hygiene practices with biosecurity measures lowers infection risk and boosts farm resilience (Jimenez *et al*., 2023; Paramitadevi *et al*., 2023). Moreover, endoparasitic infections, often overlooked, present serious threats in quail farming. Parasites such as Eimeria, Ascaridia, Strongyloides, and *Capillaria* spp. have been found in the small intestine and feces of quail worldwide, including in India (D'souza *et al*., 2022), Nigeria (Onyeabor & Uwalaka, 2022), Egypt (Ahmed *et al*., 2017), Brazil (Neiva *et al*., 2024), and the Amazon (Monte *et al*., 2018). These parasites damage the gastrointestinal tract, impair nutrient absorption, and reduce productivity. However, studies on the prevalence of endoparasites in Indonesian quails are limited, with most research focusing on chickens (Murwani *et al*., 2022; Setyowati *et al*., 2022), highlighting a significant knowledge gap regarding the parasitic burdens of quails.

This study aims to fill the gap by assessing biosecurity implementation, water quality, and endoparasite prevalence in small-scale quail farming systems in key quail-producing areas in Semarang and its surrounding regions. Using field observations, interviews, laboratory diagnostics, and statistical analysis, the study highlights significant challenges related to biosecurity practices, water quality, and parasite burdens. The results are expected to provide data to help develop targeted interventions that improve farm management, promote animal health, and strengthen the economic resilience of smallholder farmers involved in quail production. Additionally, the findings could offer valuable insights applicable to similar poultry systems worldwide, supporting broader efforts to strengthen biosecurity and disease control in small-scale operations and helping to build resilience and sustainability in smallholder agriculture globally.

MATERIALS AND METHODS

This study was conducted in Semarang City, Semarang Regency, Demak Regency, and Kendal Regency, areas known for their quail farms and regional development potential (Figure 1). The study included ten existing quail farms (L1-L10) selected through purposive random sampling based on available quail farms. The interview data were analyzed descriptively, while quantitative data on water quality, endoparasite types, and counts were analyzed statistically. All farms housed quails in five-tier cages, with each tier holding approximately 25 to 30 birds.

Water Quality Test (pH, *E.coli*, and Coliform)

Drinking water samples were collected from ten quail farms (L1-L10) in Semarang City and the Regencies of Semarang, Demak, and Kendal (Figure 1). The sources of the quails' drinking water were recorded and tabulated. Water samples were taken in three independent replicates, each 50 ml, and placed in sterile Falcon tubes. Water quality tests were conducted for pH, *E. coli,* and Coliform (Khan & Gupta, 2020; Kristanti *et al*., 2022). The pH of the drinking water was measured with a pH meter (Merck, Germany). Total *E. coli* and Coliform counts were determined using 3M Petrifilm *E. coli*/Coliform count plates (3M Petrifilm Plates, Canada). The procedure involved placing the plate on a flat surface, aseptically opening the top layer, and evenly distributing 1 ml of the water sample onto the medium. The plates were then incubated for 24 to 48 hours. *E. coli* colonies were identified by counting blue colonies, and Coliform colonies by counting red colonies. To evaluate the effect of different water sources on water quality, water from springs, artesian wells, and conventional wells was assigned numeric values of 1, 2, and 3, respectively.

Biosecurity Implementation (ASEAN, 2021)

Farm biosecurity in poultry farming involves three main components: conceptual, structural, and operational (Table 1) (ASEAN, 2021). The conceptual part focuses on selecting the appropriate farm location, ideally at least 200 meters away from populated

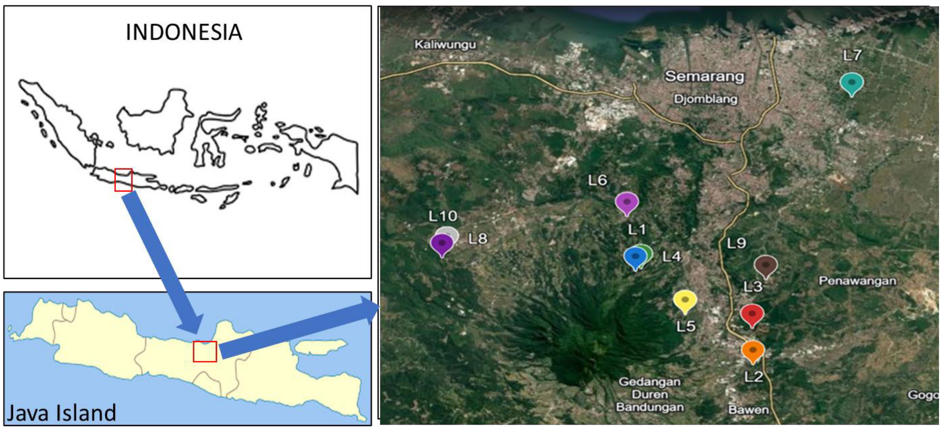

Figure 1. Sampling locations of ten quail farms in Semarang City, the Regency of Semarang, Demak, and Kendal

areas, with suitable temperature, humidity, terrain, water sources, enough land, and easy access to transportation. There should also be restrictions on keeping other livestock near the quails. The structural part involves designing the farm layout, maintaining proper distances between cages, and installing fences to prevent unauthorized access by people or animals. Other essential facilities include a protected drum area with safety doors, a feed storage area, changing rooms, bathrooms, clean water sources free of pathogens, and a designated area for disposing of quail carcasses. The operational component includes regulating limited access to the farm area, routine sanitation and disinfection of cages, disinfection before entering the cage area, controlling rats that often roam around the drums and feed warehouses, and conducting periodic laboratory tests on the drinking water used at the farm (ASEAN, 2021). Biosecurity was recorded and tabulated. Each biosecurity component implemented in each quail farm scored 1, culminating in a total score for each quail farm location (Table 1). The maximum attainable score for biosecurity is 18. To evaluate the effect of biosecurity on the fecal-endoparasite burden, the recorded scores were subsequently categorized into three distinct groups: scores ranging from 13 to 18 were classified as Group-1; scores from 7 to 12 were designated as Group-2; and scores between 1 and 6 were categorized as Group-3 (the lowest group). This systematic scoring enabled a refined analysis of biosecurity practices across the evaluated quail farms.

Endoparasite Examination from Quail Droppings

Quail droppings were sampled in three independent replicates, collected from randomly selected five-tier cages. From each cage, the droppings from each tier were pooled and mixed, then sampled and placed into bottles containing 15 mL of 10% neutral buffered formalin (NBF) (Murwani *et al*., 2022, 2024). These samples were analyzed at the Parasitology Laboratory, Faculty of Animal Health, Gadjah Mada University, Yogyakarta. Endoparasites were identified using the centrifugal fecal flotation method (Globokar *et al*., 2017): Samples in 10% NBF were centrifuged (Hittech 320R) at 5,000 rpm for 20 min. The supernatant was discarded, and the sediment was placed on a glass slide, covered with a cover slip, and examined under a microscope at 100x magnification to observe the morphology of the worm eggs and identify the type of endoparasite. Endoparasites were quantified using the McMaster method (Lozano *et al*., 2021). The number of worm eggs was counted using a McMaster counting chamber, and the following formula was applied to calculate the egg count (Imran & Alsayeqh, 2022):

Table 1. Biosecurity components and their implementation scores of ten quail farms in Semarang City, the Regency of Semarang, Demak, and Kendal

No	Parameters	Location									
		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Conceptual biosecurity											
1	The distance of the quail farm from settlements is more than 200 meters.	-	1	-	-	1	-	-	-	1	-
2	Selecting the appropriate livestock location involves considering factors such as temperature, humidity, topography, water sources, and land area.	1	1	1	1	1	1	-	1	1	1
3	Close to transportation access	1	1	1	1	-	1	1	1	1	1
4	Restrictions on a quail farm when keeping other livestock.	1	-	-	-	-	-	1	-	1	-
Structural biosecurity											
1	Cage layout arrangement	1	1	1	1	1	1	1	-	1	-
2	Setting the distance between cage units	1	1	1	1	1	1	1	-	1	-
3	Fencing livestock areas to prevent entry by people or animals from outside.	-	-	-	-	-	1	1	-	1	-
4	Fencing off the drum area with a safety door to minimize animal entry and limit operator movement to other drums.	1	-	-	-	-	-	1	-	-	-
5	Warehouse service facilities (medicine and equipment), changing rooms, and restrooms.	1	-	-	-	-	1	1	-	1	-
6	Availability of a warehouse for feed	1	1	1	-	1	-	-	-	1	-
7	Availability of clean water free of pathogenic agents (chlorine or other peroxides)	1	-	-	-	-	1	1	1	1	1
8	A designated area for disposing of quail carcasses.	-	-	-	1	-	-	-	-	1	-
Operational biosecurity											
1	Traffic management with limited access to the farm area	1	1	1	1	1	1	1	-	1	-
2	Cage sanitation (cleaning excreta and cage floor)	1	1	1	1	1	1	1	1	1	1
3	Cage disinfection (Disinfectant spray)	1	1	1	1	1	1	1	1	1	1
4	Traffic control and disinfection before entering the cage area	-	-	-	-	-	-	1	-	-	-
5	Exterminate rats that often roam in drums and warehouses	1	1	1	1	1	1	1	1	1	1
6	Conduct regular laboratory testing of drinking water used for livestock.	-	-	-	-	-	-	-	-	-	-
TOTAL		13	10	9	9	9	11	13	6	15	6

Note: 1: Implemented, -: Not Implemented

Oocyte Per Gram (OPG) = (dropping sample volume/ counting chamber volume).

Data Analysis

Data from interviews and observations on the biosecurity implementation for quail farmers are presented in Table 1 and Figure 1, which are analyzed descriptively. To assess the effect of biosecurity on endoparasite scores in bird droppings and the effect of water sources on water quality (pH, *E. coli*, Coliform), the Kruskal-Wallis non-parametric test was used. If significant effects were found, a Mann-Whitney test was conducted to assess the differences. All statistical analyses were performed at a confidence level of greater than 95%. The statistical analyses were conducted using IBM SPSS Statistics 15.

RESULTS

There were three brands of layer feed used by the quail farmers (B, C, F). Despite using different brands, the nutritional composition of the feed during the layer phase is nearly the same (Table 2). The highest crude protein content was found in L2 (21%).

Table 3 shows that the quail population at the sampling sites ranges from 1,100 to 6,750 birds. Egg production across the 10 locations varies from 64.29% to 90.00%, depending on the age of the birds. The drinking water sources at L3, L7, and L9 are from an artesian well. L2 and L8 use a conventional well, while L1, L4, L5, L6, and L10 source their water from springs. The best biosecurity practices are observed at L1, L7, and L9, with scores ranging from 13 to 15. Biosecurity at L2, L3, L4, and L5 scored lower, between 9 and 10, while L8 and L10 scored the lowest at 6. Water quality shows an average pH of 4.8 to 8, with *E. coli* levels at 19.33 CFU/mL. Notably, L5 had the highest Coliform count at 89.67 CFU/mL. The quail droppings from L1 have the highest number of endoparasites, with Coccidia at 1.000 OPG, Strongyloides at 100 OPG, and *Ascaridia* sp. at 33.33 OPG. In contrast, no endoparasites are detected in L7 quail droppings.

The Kruskal-Wallis non-parametric analysis ($p<0.05$) showed that biosecurity did not affect the number of Coccidia (p-value= 0.16), Strongyloides (p-value= 0.40), and *Ascaridia* sp. (p-value= 0.67) (Table 4). There were no significant differences observed in water pH and *E. coli* levels across different water sources. However, Coliform levels varied significantly depending on the water source ($p<0.05$) (Table 5).

DISCUSSION

Biosecurity implementation across farms revealed varying degrees of compliance. Conceptual biosecurity was well implemented in L2, L5, and L9, which were located over 200 meters from settlements. However, L7 lacked proper site selection based on environmental parameters. Structurally, most farms (L1–L7, L9) maintained cage layout and spacing, but several (L4, L6, L7, L8, L10) lacked dedicated feed storage, potentially compromising feed quality over time. Operational biosecurity practices were consistently implemented, with all farms conducting sanitation and disinfection procedures. However, only L7 implemented traffic control measures, such as hand disinfection and the use of protective clothing. This farm also had the lowest bird population, suggesting that smaller-scale operations may facilitate more rigorous biosecurity enforcement.

The quail farms surveyed in Semarang and its surrounding areas showed bird populations ranging from 1,100 to 6,750 individuals. Egg production varied with age, reaching 79.17% at 10 weeks (L7), 80% at 12 weeks (L6), and peaking between 82.50% and 90% at 16–17 weeks (L1, L9, L10). A decline was seen between 32 and 40 weeks (L3–L5, L8), with the lowest rate of 64.29% at 40 weeks (L2). These patterns align with previous studies reporting egg production rates between 55.78% and 91% for quails aged 10 to 32 weeks (Gül *et al*., 2022; Hossain *et al*., 2024; Lokapirnasari *et al*., 2017; Murwani *et al*., 2024; Silva *et al*., 2020), confirming that the observed performance remains within expected physiological norms.

Water quality assessments showed pH values ranging from 4.8 to 8.0. The ideal pH range for drinking water suitable for broilers is 5.5-6.5 (Hubbard, 2025). However, since quail are smaller than chickens, they may be more sensitive to water pH, with a target of 6.0-6.8 (Poultry Trends, 2023). Ideal water pH supports

Table 2. Quail feed nutritional content used by ten quail farms in Semarang City, the Regency of Semarang, Demak, and Kendal

	Location										Average
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	
Water (%)	12	14	12	13	13	13	13	13	12	13	12.8
Crude protein (%)	19.5	21	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.8
Crude fiber (%)	7	7	7	7	7	7	7	7	7	7	7
Crude fat (%)	7	7	7	7	7	7	7	7	7	7	7
Ash (%)	14	14	14	14	14	14	14	14	14	14	14
Calcium (%)	3	3	3	3	3	3	3	3	3	3	3
Phosphor (%)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Metabolizable energy (Kcal/kg)	2800	2818.4	2800	2853.5	2853.5	2853.5	2853.5	2853.5	2800	2853.5	2833.9

Note: Metabolizable energy (ME) is calculated using the Bolton formula (Sutrisno *et al*., 2013). ME = 40.81 (0.87 (crude protein + 2.25 crude fat + nitrogen-free extract)) + 4.9. Nitrogen-free extract = 100% - (ash + crude protein + crude fat + crude fibre). Layer quail feed brands: L1, L3, L9 = Brand C; L2 = Brand B; L4 – L8, L10 = Brand F. Brand C and brand F are different brands but have similar nutritional content except for water content.

Table 3. The characteristics of ten quail farms in Semarang City, the Regency of Semarang, Demak, and Kendal

Parameters	Quail farm location									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Temperature (°C)	22-28	22-28	23	22-28	22-27	23	25-26	21-22	23-29	21-22
Humidity (%)	64-95	64-95	88-91	64-95	64-95	88-92	83-84	94-97	61-91	94-97
Elevation (msl)	587	414	469	537	398	290	13	323	343	327
Population (birds)	2,500	3,500	4,250	3,500	2,500	2,000	1,200	1,100	6,750	2,500
Age (weeks)	16	40	35	32	37	12	10	33	16	17
Egg production (%)	88.00	64.29	70.59	74.29	68.00	80.00	79.17	75.00	82.50	90.00
Water sources	1	3	2	1	1	1	2	3	2	1
Drinking water- additive*	herbs/ two weeks	herbs/ day	herbs/ 3 days	-	herbs/ 3 days	herbs/ two weeks	herbs/ day	vita stress/ 3 days	-	vita stress/ 3 days
Biosecurity	1	2	2	2	2	2	1	3	1	3
	Water quality									
pH	7.00	7.00	7.00	7.00	6.00	7.00	8.00	4.80	5.53	5.37
Escherichia coli (CFU/mL)	19.00	5.67	2.00	0.00	1.67	0.00	0.00	5.33	19.33	3.33
Coliforms (CFU/mL)	21.33	43.67	3.33	5.33	89.67	2.67	0.00	44.33	23.33	34.33

Note: Primary data were obtained from interviews and observations. The numerical water quality values are the average of three independent replicates with no SD. For statistical analysis, the biosecurity scores obtained in Table 1 were categorized into three groups: scores 13–18 were assigned to Group-1, 7–12 to Group-2, and 1–6 to Group-3. Drinking water from a spring, an artesian well, and a conventional well was assigned values of 1, 2, and 3, respectively, for statistical analysis. *Herbs: L1= *Tinospora crispa L. Miers, Curcuma longa Linn, Piper betle L., Curcuma xanthorrhiza Roxb.*; L2= *Curcuma longa* L., *Curcuma xanthorrhiza* Roxb., *Moringa oleifera*, *Carica papaya* L. leaves, *Annona muricata* L. leaves, *Andrographis paniculata* (Burm.f.) *Nees* leaves, *Morinda citrifolia L., Tinospora crispa (L.) Miers., Kaempferia galanga, Curcuma aeruginosa Roxb., Zingiber officinale, Allium sativum, Allium cepa L. var. aggregatum, Curcuma heyneana, Cymbopogon citratus, Panax*; L3= *Curcuma longa L., Zingiber officinale, Curcuma xanthorrhiza Roxb., Andrographis paniculata*; L5= *Curcuma xanthorrhiza Roxb*, palm sugar; L6= *Curcuma longa Linn, Curcuma xanthorrhiza Roxb, Kaempferia galanga, Carica papaya L.* leaves, *Moringa oleifera*; L7= *Curcuma xanthorrhiza Roxb*.

Table 4. Biosecurity effect on endoparasites of ten quail farms in Semarang City, The Regency of Semarang, Demak, and Kendal

Biosecurity	Coccidia		*p-value*	Strongyloides		*p-value*	*Ascaridia* sp.		*p-value*
	Min-max	x̄(SD)		Min-max	x̄(SD)		Min-max	x̄(SD)	
Biosecurity (Group-1)	0-2,800	372.22(918.94)		0-350	33.33(82.92)		0-100	11.11(33.33)	
Biosecurity (Group-2)	0-1,450	143.33(364.92)	0.16	0-150	23.33(45.77)	0.40	0-50	6.67(17.59)	0.67
Biosecurity (Group-3)	0-850	333.33(310.91)		0	0.00(0.00)		0	0.00(0.00)	

Note: Data were tested using Kruskal-Wallis non-parametric statistics. To evaluate the effect of biosecurity on the fecal-endoparasite burden, the biosecurity scores were categorized into three groups: 13 to 18 as Group-1, 7 to 12 as Group-2, and 1 to 6 as Group-3 (the lowest group).

Table 5. Water source effect on water quality (pH, *Escherichia coli*, and coliform) of ten quail farms in Semarang City, the Regency of Semarang, Demak, and Kendal

Water source	pH		*p-value*	*E. coli*		*p-value*	Coliform		*p-value*
	Min-max	x̄(SD)		Min-max	x̄(SD)		Min-max	x̄(SD)	
Spring	5.20-7.00	6.49(0.67)		0-32	4.80(8.81)		0-96 [a]	30.67(33.40)	
Artesian well	5.30-8.00	6.84(1.08)	0.21	0-22	7.11(9.49)	0.30	0-27 [b]	8.89(11.44)	0.01*
Conventional well	4.50-7.00	5.90(1.22)		3-9	5.50(2.17)		18-63 [a]	44.00(14.87)	

Note: The sample from each farm consisted of three independent replicates. *Coliform: Different subscripts with different letters indicate significant differences. Statistical significance at p<0.05. To evaluate the effect of different water sources on water quality, water from springs, artesian wells, and conventional wells was assigned numeric values of 1, 2, and 3, respectively.

optimal digestion, nutrient absorption, gut microbial balance, palatability, and water intake. A pH below 5 could irritate the digestive lining, while a pH above 6.8 could reduce mineral solubility and promote the growth of harmful bacteria. *E. coli* levels varied from 0 to 19.33 CFU/mL, and Coliform counts ranged from 0 to 89.67 CFU/mL. Acceptable limits for *E. coli* and Coliform are 0 CFU/100 mL. The presence of these bacteria indicates fecal contamination, likely from human, animal, or environmental sources (WHO, 2017; Reitter *et al*., 2021). While *E. coli* is often non-pathogenic, certain strains, such as APEC, can cause *colibacillosis* and *colisepticemia* (Samanta *et al*., 2018; Ananda *et al*., 2023).

Endoparasites identified in this study included *Coccidia*, *Strongyloides*, and *Ascaridia* sp., marking a novel contribution to the Indonesian poultry health literature. To our knowledge, this is the first report documenting endoparasitic infections in quail farms in Indonesia. Among the sampled locations, farm L1 exhibited the highest parasite burden, while farm L7 showed no detectable endoparasites. This contrast underscores the crucial role of traffic control and sanitation in mitigating parasite transmission (Talazadeh *et al*., 2024). Additionally, the smaller flock size at L7 may have facilitated more effective management and biosecurity practices. Coccidia oocysts are transmitted via contaminated equipment, footwear, feed, water, and personnel. The pathogenicity of Coccidia, specifically *Eimeria* spp., is well-documented, with lesions in the intestinal mucosa leading to hemorrhage, dehydration, and impaired nutrient absorption (Belete *et al*., 2016; Blake *et al*., 2021; Das, 2021). In contrast, *Strongyloides* and *Ascaridia* sp. are associated with metabolic disorders, reduced growth, and poor feed conversion (Ombugadu *et al*., 2021; Afia *et al*., 2019; Zulmi *et al*., 2020).

The Kruskal–Wallis test revealed no significant differences in endoparasite prevalence across biosecurity groups (p>0.05), indicating that infections may originate from breeder-level sources. Quails are typically introduced to farms at approximately one month of age, just before the onset of egg laying, and may already harbor endoparasites at the time of arrival. Similarly, no significant differences were observed in water pH and *E. coli* levels across different water sources. However, Coliform levels varied significantly depending on the water source (p<0.05). Notably, artesian wells exhibited significantly lower Coliform contamination (p<0.05), likely attributable to natural soil filtration and deeper construction (100–200 m), which limits exposure to surface pollutants (Santos *et al*., 2023; Somaratne & Hallas, 2015). In contrast, conventional wells and springs are more susceptible to contamination due to their shallow depth (10–20 m) and frequent absence of protective casings. This increases vulnerability to runoff, flooding, and proximity to waste sources (Putri *et al*., 2024; Somaratne & Hallas, 2015). Properly constructed artesian systems also reduce direct contact with contaminants compared to open springs or inadequately sealed conventional wells. Elevated Coliform levels observed in this study may be further exacerbated by contamination from animal and human waste, as well as increased rainfall, which can intensify surface water infiltration (Bagordo *et al*., 2024; Mondal & Mishra, 2024).

These findings highlight the importance of integrated biosecurity and water management strategies. Regular sanitation, controlled access, and clean water sources are essential for reducing microbial and parasitic threats. Future interventions should also focus on breeder-level health screening and promoting farmer education to improve disease prevention and farm sustainability.

CONCLUSION

Coliform levels are affected by the quality of the water source. Although no statistically significant difference exists between biosecurity and endoparasite prevalence, farms practicing better traffic control and sanitation (such as L7) had lower endoparasite loads. These results underscore the importance of targeted actions, including improved water source management, regular testing for bird droppings and drinking water, and enhanced biosecurity measures. Improving these practices can significantly enhance quail health, productivity, and farm sustainability.

CONFLICT OF INTEREST

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author(s) utilized the "Premium Grammarly" program to improve the readability and clarity of the English language, including correcting spelling errors and refining sentence structure. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the publication's content.

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