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Epidemiology of Gastrointestinal Parasites in Beef Cattle at Baluran National Park Interface Area: Prevalence and Risk Factors

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ABSTRACT

Beef cattle are commonly infected by gastrointestinal parasites, which impact productivity and cause economic losses. Therefore, this research aimed to analyze the prevalence and risk factors of gastrointestinal parasites in beef cattle at Baluran National Park (BNP). A cross-sectional design was used from June to December 2024, with random sampling in five areas of the BNP interface, namely Air Karang, Lempuyang, Merak, Sirondo, and Simacan. In this context, 166 feces samples were collected from 25 farms and analyzed using flotation and sedimentation methods. A survey was applied to collect information about farmers, management, environment, sanitation, and biosecurity. The results showed that 51.2% (85/166) of the sample were positive for eggs or oocysts of one or more species of gastrointestinal parasites. Furthermore, this research identified nine genera, namely *Bunostomum* spp. (7.2%), *Cooperia* spp. (15.6%), *Haemonchus* spp. (4.8%), *Oesophagostomum* spp. (9%), *Ostertagia* spp. (3.6%), *Strongylus* spp. (2.4%), *Trichostrongylus* spp. (12.6%), *Fasciola* spp. (4.8%), and *Eimeria* spp. (4.2%). The samples were infected with a single infection (78,82%), while the multiple infection rate was 21,18%. Chi-square and odds ratio test suggested that pen area (p = 0.001), grazing area (p = 0.010), BCS (0.034), contact with wild ruminants (p = 0.030; OR = 2.033), infrequent pen cleaning (p = 0.004; OR = 2.581), the presence of blood in feces (p = 0.005; OR = 4.084), and pen near from house (p = 0.049; OR = 0.488) were associated with infection risk. Gastrointestinal parasites in beef cattle at the Baluran National Park interface exhibit high diversity of parasite species and are closely associated with geographic location, forest-based grazing practices, and poor body condition of the cattle.

Keywords: Baluran National Park; beef cattle; extensive; interface area

INTRODUCTION

Gastrointestinal parasites are commonly found in beef cattle and are a crucial health issue, particularly in tropical regions such as Indonesia (Nurcahyo *et al.*, 2021; Ninditya *et al.*, 2024). These parasitic infections are caused by helminths and protozoa in the digestive tract of cattle, disrupting animal physiological functions, reducing feed efficiency, and affecting production and reproductive performance. The chronic cases can cause weight loss, diarrhea, and anemia, as well as increase mortality (Strydom *et al.*, 2023; Leon-Gonzalez *et al.*, 2025).

The prevalence of gastrointestinal parasitism is influenced by sanitation, hygiene, socioeconomic status, and environmental factors, namely temperature, rain, humidity, soil, altitude, sunlight, and wind (Banda *et al.*, 2024; Abebaw *et al.*, 2025). The maintenance system, with the various management practices, affects the prevalence of parasitism. Cattle tend to defecate in grazing areas, polluting and spreading parasites through the fecal-oral route, which can increase contact between susceptible and infected livestock (Smith *et al.*, 2009; Kumar *et al.*, 2013; Bricarello *et al.*, 2023). According to Maqbool *et al.* (2017), a combination of treatment and improvement of the management system is the most appropriate step in parasite control.

The livestock system in Java is carried out intensively due to limited land availability. In Kalimantan, West Nusa Tenggara (NTB), and Bali, semi-intensive and extensive livestock management systems have been developed (Hilmiati *et al.*, 2024; Setianto *et al.*, 2024). In the northern part of Baluran National Park (BNP), East Java, Indonesia, there is a location bordering residential areas, where the livelihoods of livestock breeders intersect. This area has an arid climate due to its location on the shores of the Java Sea. Beef cattle are grazed daily into the forest to consume forage such as *Synedrella nodiflora*, *Mikania micrantha*, *Bidens bipinnata*, *Cyanthillium cinereum*, *Dichantium queenslandicum*, *Dichantium caricosum*, *Digitaria longiflora*, *Brachiaria mutica, and Themeda triandra* (Wiyono *et al.*, 2022).

An extensive farming carries a high risk of exposure to parasite eggs and larvae in the grazing area (Hashim & Yusof, 2016; Paul *et al.*, 2020; Bricarello *et al.*, 2023). Low sanitation conditions in open pens, unmeasured nutrient quality of forage, irregular deworming programs, and mixed grazing environments between beef cattle and wild ruminants from the forest can exacerbate the condition of beef cattle (Nakajima & Yayota, 2019; McIntosh *et al.*, 2023; Nosal *et al.*, 2025). Regular deworming, implementing a rotation system in livestock grazing, and implementing biosecurity are some ways to control parasitism (Kumar *et al.*, 2013; Greer *et al.*, 2020; Nosal *et al.*, 2025). However, in the extensive grazing system at the BNP interface, this is difficult to implement due to challenges in handling livestock and limited land for rotational grazing. Therefore, research must be conducted to determine the prevalence and identification of gastrointestinal parasites in beef cattle, as well as to identify risk factors for livestock maintenance. Since no investigation related to the topic has been conducted, this research helps to address the management challenges of beef cattle maintenance and supports sustainable disease control strategies in the context of conservation and public health.

MATERIALS AND METHODS

Time and Place of Research

A cross-sectional design was used from March to December 2024. The research sites were all beef cattle farms in the interface area of BNP, Indonesia. The locations for sampling beef cattle feces were at 5 farms, namely Air Karang, Lempuyang, Merak, Simacan, and Sirondo. The location of the sampling points was determined using the Global Positioning System (GPS), and a map was created through ArcGIS version 10.8. This research was conducted in the interface area of BNP, located on the north coast of BNP (114°22′30.0″ E; 7°50′0.0″ S), Situbondo, East Java, Indonesia (Figure 1).

Research Permit and Ethical Approval

This research has received permission from the Ministry of Environment and Forestry (Indonesian: Kementerian Lingkungan Hidup dan Kehutanan) through the Director General of the Directorate General of Nature Resources and Ecosystem Conservation (Indonesian: Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem, also known as Ditjen KSDAE), number: SK.28/KSDAE/SET.3/KSA.2/1/2024 on January 31, 2024. Furthermore, approval was granted by the Faculty of Veterinary Medicine, UGM, with Ethical Clearance (EC) number 33/EC-FKH/int./2024, dated May 27, 2024. This research also received a Conservation Area Entry Permit (SIMAKSI) from BNP, East Java, Indonesia, number: SI.119/T.37/TU/KSA.6/6/2024 dated June 14, 2024.

Sampling

Fecal samples were obtained using non-invasive sampling and were randomly collected at each location. The number of households and beef cattle grazing was approximately 300 and 1,500-1,600, respectively (Pudyatmoko, 2017). The sample size was determined using the Slovin formula, n = N/(1 + Ne2), with a 90% confidence level (Adam, 2020). The minimum sample size consisted of 98 cattle, with 24 respondents, leading to 166 fecal samples collected from 25 farmers. Sampling was carried out with the assistance of officers from the BNP. Furthermore, a cross-sectional research was conducted to collect social data by administering a questionnaire that included open-ended and closed-ended questions related to livestock management and risk factors for parasitic diseases. The survey respondents were residents in the interface area of BNP, and the majority were productive-aged beef cattle breeders (>18 years old). Non-invasive sampling was conducted since beef cattle were grazed in the forest from morning to evening, and were very difficult to handle. Approximately 15 grams of freshly passed feces were obtained per head using a plastic spoon and sterile disposable gloves before storing in a clean bottle. Fecal samples were given 10% formalin before examination at the Type B Animal Health Laboratory in Purwokerto, Central Java, Indonesia.

Morphological Identification of Worms and Oocysts

A stool examination was conducted using 1) the flotation method to detect the presence of nematode worm eggs, cestode eggs, and coccidia oocysts of Eimeria spp. in feces, and 2) the sedimentation method to detect the presence of trematode eggs. The floatation method was carried out by weighing 5 g of feces and adding water up to 3⁄4 of the test tube. The solution was centrifuged at 1500 rpm for 5 minutes. The sediment was saved, and the liquid was discarded. Saturated sugar was added up to 3⁄4 of the tube and homogenized before centrifuging at 1500 rpm for 5 minutes. Furthermore, saturated sugar was added to the centrifuged result until the surface of the liquid was convex, and left for 5 minutes. The object glass was attached to the convex surface of the tube and quickly inverted. The liquid was covered with a cover glass and

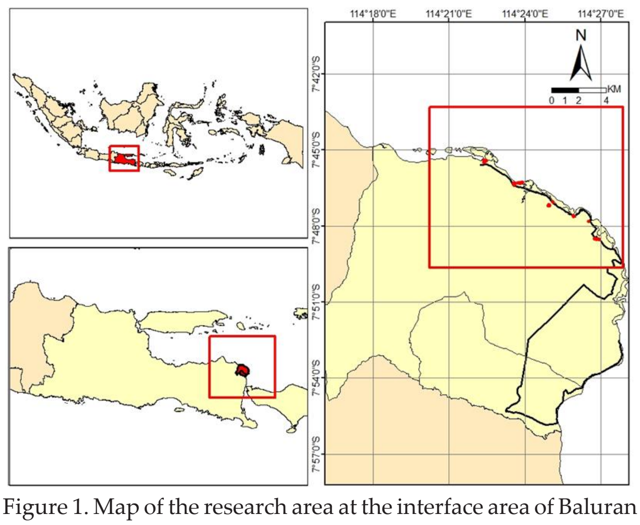

Figure 1. Map of the research area at the interface area of Baluran National Park (BNP), East Java, Indonesia. BNP is located on the northern coast of BNP(114°22'30.0"E; 7°50'0.0"S), Situbondo, East Java, Indonesia.

examined with a microscope at 400x magnification for morphological identification (Carta & Carta, 2000).

The sedimentation method was used on 3 g of the feces sample and up to 50 ml of water. The substance was stirred until homogeneous in the beaker glass and filtered through a 100-mesh sieve, then placed into a conical flask. Some water was added until the flask was full, and the flask was left for 5 minutes. The upper liquid was discarded, leaving only approximately 10 mL of filtrate. Water was added to the filtrate in the conical flask until full, and the mixture was left to stand for 5 minutes. The upper liquid was discarded again, and ± 5 mL of filtrate remained. The filtrate was poured into a petri dish or object glass, and a drop of methylene blue was added. Lastly, the solution was observed under a microscope at 100x magnification (Adam, 2020).

The total of eggs or oocysts was calculated using a Whitlock counting chamber following Storey (2015) by homogenizing 3 g of feces and 60 ml of saturated sugar solution. The filtrate was placed in a Whitlock counting chamber, and it was allowed to wait for 5 minutes. Subsequently, an examination was carried out using a microscope at 400x magnification. The number of eggs and or oocysts was calculated using the formula: number of eggs (n) = number of eggs and oocysts counted x 10.

Data Analysis

The data were analyzed using descriptive statistics to identify gastrointestinal parasites. The prevalence of gastrointestinal parasites was measured using the formula prevalence (%) = (Number of positive samples/ Total number of samples examined) x 100 (Alcaterana *et al.*, 2021; Ahmad *et al.*, 2024). Samples were notated as positive when one or more parasite eggs and/or oocysts were detected in the sample. The Chi-square test was used to evaluate the association of risk factors and infection. A p-value of less than 0.05 or a calculated Chi-square value greater than the Chi-square table value was considered statistically significant. The probability of parasitosis linked to the risk factor was analyzed by calculating the Odds Ratio. This approach ensured a comprehensive and accurate analysis of the risk factors associated with parasitic infections in cattle (Espinoza *et al.*, 2024). Data analysis was performed using SPSS software version 25.0.

RESULTS

Characteristics of Livestock Breeders in the Interface Area of Baluran National Park

A total of 25 farmers from several areas were interviewed. The sample consisted of farmers from Air Karang (2), Lempuyang (5), Merak (12), Simacan (5), and Sirondo (1). The majority of respondents had an average age above 40 years (56%), a maximum education of high school (96%), primary occupation as livestock breeders (72%), resided in the area for more than 10 years (96%), duration of livestock farming > 2 years (88%), and income < 1 million/month (40%). Beef cattle in the BNP interface area were grazed extensively in the forest from morning to evening, and the cattle were penned at night. Beef cattle feed and water were obtained daily from the forest. Table 1 shows the characteristics and ownership of livestock in the BNP interface area.

Prevalence and Intensity of Gastrointestinal Parasites in Beef Cattle

The prevalence of gastrointestinal parasitism in beef cattle was 51.2%. The results showed that the parasites infecting beef cattle in the BNP interface area were nematodes, trematodes, and coccidia of the *Eimeria* spp. Furthermore, the types of parasites found were *Bunostomum* spp., *Cooperia* spp., *Haemonchus* spp., *Oesophagostomum* spp., *Ostertagia* spp., *Strongylus* spp., *Trichostrongylus* spp., *Fasciola* spp., and *Eimeria* spp. (Table 2). The highest prevalence was observed for *Cooperia* spp., and the lowest for *Strongylus* spp.

Distribution of Gastrointestinal Parasites in Relation to Several Risk Factors for Beef Cattle

The incidence of gastrointestinal parasitism in beef cattle is significantly influenced by several risk factors, namely sampling location, grazing area, and body condition score (BCS) (Table 3). Air Karang (69.2%) and

Table 1. Data on respondent identity and livestock ownership in the interface area of Baluran National Park (BNP)

Variables	n	%
Gender		
Man	13	52
Woman	12	48
Age		
≤ 40 years	11	44
> 40 years	14	56
Education		
Low (≤ High school)	24	96
High (> High school)	1	4
Main job		
Breeder	18	72
Other	7	28
Settlement time		
< 10 years	1	4
> 10 years	24	96
Number of ruminant livestock		
≤ 20 cattle	13	52
> 20 cattle	12	48
Length of breeding		
≤ 2 years	1	4
> 2 years	24	96
Purpose of livestock farming		
Main livelihood	18	72
Side business	7	28
Income (in IDR)		
< 1 million	10	40
1-2 million	8	32
> 2 million	2	8
No answer	5	32

Merak (61.4%) areas had higher infection rates (>60%) compared to others. Beef cattle grazed in Bilik had the highest infection rate at 84.2%. Meanwhile, cattle with a BCS of 1 had the highest parasite infection rate at 80% compared to others.

The distribution table for each sampling site is presented in Table 4. This showed that the parasite type was not affected by the sampling site. However, Merak had the most varied types among the other farm locations.

Risk Factors for Livestock Husbandry Management Against Incidents Gastrointestinal Parasitism

The results of Chi-square analysis reported that most management factors were not significantly associated with the incidence of gastrointestinal parasite infections (Table 4). However, several variables showed a significant association, namely the presence of wild ruminants (OR=2.033; 95% CI: 1.068–3.873; p=0.030), frequency of pen cleaning (OR=2.581; p=0.004), feces color (presence of blood) (OR=4.084; 95% CI: 1.438–11.598; p=0.005), distance of the pen from the house (0–5 m) (OR=0.488; p=0.050). Other factors, such as the roof of the pen, the presence of a feeding place, vaccination, deworming treatment, and water source, did not show a significant relationship (p>0.05).

DISCUSSION

The interface area is an ecosystem at the intersection between BNP and residential areas on the north coast of Java (Namusisi *et al.*, 2021). The majority of residents work as farmers and own approximately

Table 2. Prevalence of gastrointestinal parasite infections in beef cattle in the interface area of Baluran National Park (BNP)

Parasites	Class	Number positive (%)	Range EPG or OPG	Median
Bunostomum spp	Nematodes	12 (7.2%)	20-160	20*
Cooperia spp	Nematodes	26 (15.6%)	20-300	20*
Haemonchus spp	Nematodes	8 (4.8%)	20-120	60*
Oesophagostomum spp	Nematodes	15 (9%)	20-700	100*
Ostertagia spp	Nematodes	6 (3.6%)	20-80	20*
Strongylus spp	Nematodes	4 (2.4%)	20-40	20*
Trichostrongylus spp	Nematodes	21 (12.6%)	20-100	20*
Fasciola spp	Trematodes	8 (4.8%)	1-25	1*
Eimeria spp	Coccidia	7 (4.2%)	20-320	40*

Note: E/OPG = Eeg /oocyst per gram of feces. Degree of infection in nematodes and oocysts: Mild infection: 1-499 E/OPG*; Moderate infection: 500-5000 E/OPG**; Severe infection: >5000 E/OPG*** (Thienpont *et al*., 1986). Degree of infection in trematode: Mild infection: 1-500 EPG*; Moderate infection: 501-1000 EPG**; Severe infection: >1000 EPG*** (Mpisana *et al*., 2022).

Table 3. Distribution of gastrointestinal parasites by location, maintenance pattern, grazing area, body condition score, and forage origin in the interface area of Baluran National Park (BNP)

Different risk factor	Variables	Number of examined	Number of positives	Prevalence	Chi-square	p-value
Study area	Air Karang	13	9	69.2%	19.205	0.001
	Lempuyang	39	12	30.8%		
	Merak	88	54	61.4%		
	Simacan	19	10	52.6%		
	Sirondo	7	0	0.0%		
Maintenance pattern	Intensive	6	3	50.0%	0.105356	0.94869
	Semi-Intensive	7	4	57.1%		
	Extensive (night shelter)	153	78	51.0%		
Grazing ground of cattle	Bilik	19	16	84.2%	14.949117	0.01058
	Mount Patik	13	9	69.2%		
	Mount Malang	42	23	54.8%		
	Twin Mountains	27	18	66.7%		
	Simacan Hill	26	10	38.5%		
	Mount Cabe	39	12	30.8%		
Body condition scoring of cattle	1=very thin	5	4	80.0%	8.648486	0.03435
	2=thin	10	5	50.0%		
	3=moderate/ good	95	40	42.1%		
	4=fat	56	36	64.3%		
Origin of greens	Forest	142	78	54.9%	5.731669	0.05694
	Fields/ rice Fields	15	5	33.3%		
	Buy	9	2	22.2%		
Feeding frequency	Shepherded	97	55	56.7%	3.558873	0.16873
	1 time a day	34	13	38.2%		
	2 times a day	35	17	48.6%		

Table 4. Prevalence of parasite types (Egg/gram) from beef cattle farm locations in the interface area of Baluran National Park (BNP)

Farm location	Number examined (%)	Number positive (%)								
		Bunostomum spp	*Cooperia* spp	*Haemonchus* spp	*Oesophagostomum* spp	*Ostertagia* spp	*Strongylus* spp	*Trichostrongylus* spp	*Fasciola* spp	*Eimeria* spp
Air karang	13 (7.8)	1 (7.6)	4 (30.7)	-	-	-	-	2 (15.3)	1 (7.6)	2 (15.3)
Lempuyang	39 (23.4)	3 (23)	3 (23)	1 (7.6)	2 (15.3)	-	1 (7.6)	5 (38.4)	-	1 (7.6)
Merak	88 (53)	5 (38.4)	18 (138.4)	7 (53.8)	10 (76.9)	6 (46.1)	1 (7.6)	12 (92.3)	7 (53.8)	4 (30.7)
Simacan	19 (11.4)	3 (23)	1 (7.6)	-	3 (23)	-	2 (15.3)	2 (15.3)	-	-
Sirondo	7 (4.2)	-	-	-	-	-	-	-	-	-
Chi-square		2,952	8,507	4,293	4,346	5,518	6,427	1,258	5,411	5,446
p-value		0.566	0.075	0.368	0.361	0.238	0.169	0.869	0.248	0.245

Table 5. Table of predictors of beef cattle management practices related to gastrointestinal parasite infections in the Baluran National Park (BNP) interface area

Predictor variable	Response (Frequency)	Percentage positives (%)	OR (95% CI)	Chi-square	p-value
Age uniformity in 1 cage	Yes (9)	4 (44.4%)	1	0.174	0.677
	No (157)	81 (51.5%)	1.332 (0.345-5.147)		
Roof of the cage	Yes (10)	7 (70%)	1	1.504	0.220
	No (156)	78 (50%)	0.429 (0.107-1.718)		
Quarantine cage	Yes (60)	35 (58.3%)	1	1.911	0.167
	No (106)	30 (28.3%)	0.638 (0.336-1.209)		
The distance of the cage is 0-5 m from the cattle farmer's house	Yes (124)	58 (46.7%)	0.488 (0.237-1.006)	3.851	0.049
	No (42)	27 (64.2%)	1		
There is a feeding place	Yes (38)	22 (57.8%)	1	0.883	0.347
	No (128)	63 (49.2%)	0.705 (0.339-1.465)		
There is a waste place	Yes (15)	9 (60%)	1	0.511	0.475
	No (151)	76 (50.3%)	0.676 (0.229-1.992)		
Mating Artificial Insemination (AI)	Yes (15)	7 (46.6%)	1	0.136	0.712
	No (151)	78 (51.6%)	1.221 (0.422-3.537)		
Mating recording	Yes (21)	12 (57.1%)	1	0.339	0.560
	No (145)	73 (50.3%)	0.760 (0.302-1.915)		
There are wild ungulates (such as deer, banteng (*Bos javanicus*), and water buffalo (*Bubalus bubalis*)) in the study area.	Yes (106)	61 (57.5%)	2.033 (1.068-3.873)	4.721	0.030
	No (60)	24 (40%)	1		
Grazing into the forest (Baluran National Park)	Yes (164)	85 (51.8%)	2.076 (1.771-2.433)	2.124	0.145
	No (2)	0 (0%)	1		
Heard about zoonoses	Yes (9)	2 (22.2%)	1	3.199	0.074
	No (157)	83 (52.8%)	3.926 (0.791-19.491)		
Forest clearing for agriculture	Yes (3)	3 (100%)	0.503 (0.432-0.586)	2.911	0.088
	No (163)	82 (50.3%)	1		
Vaccination	Yes (25)	17 (68.0%)	1	3.323	0.680
	No (141)	68 (48.2%)	0.438 (0.178-1.081)		
The beef cattle sheds were cleaned at least once daily	Yes (39)	12 (30.7%)	1	8.52	0.004
	No (137)	73 (53.2%)	3.042 (1.415-6.541)		
Farmers often leave the village	Yes (148)	79 (53.3%)	1	2.581	0.108
	No (18)	6 (33.3%)	2.290 (0.816-6.426)		
Preferences for drug use	Chemical drugs (29)	18 (62%)	1	1.66	0.198
	Herbal medicine (137)	67 (48.9%)	0.585 (0.257-1.330)		
Worm treatment	Yes (34)	19 (55.8%)	1	0.374	0.541
	No (132)	66 (50%)	0.789 (0.370-1.685)		
Livestock feed is the same as wild ruminants	Yes (150)	77 (51.3%)	1.055 (0.376-2.957)	0.01	0.919
	No (16)	8 (50%)	1		
Water source when grazing	In the cage (105)	50 (47.6%)	1	1.47	0.225
	In the forest (61)	35 (57.3%)	1.481 (0.784-2.796)		
Feces consistency	Normal (163)	84 (51.5%)	1	0.391	0.532
	Soft (3)	1 (33.3%)	0.470 (0.042-5.288)		
The presence of blood in cattle feces was observed	No (143)	67 (46.8%)	1	7.822	0.005
	Yes (23)	18 (78.2%)	4.084 (1.438-11.598)		

20 cattle per household. Most of the people are approaching 40 years old after living in the area for more than 10 years. Furthermore, the farmers have a low education level (elementary school) and an income of less than 2 million a month.

Livestock rearing patterns in this area are extensive (88%), and use communal pens (100%). The pen area is relatively loose and roomy, but several requirements are minimal, such as 29.4% of cattle are semi-grazing feeding, 15% of samples have waste disposal in the pen, and none possess drainage. The pens have a dirt floor (95.8%), and only 37.5% possess a quarantine pen. Farmers mostly clean the pen once a day (75%) in the morning while the cattle are grazing. The forage is given 1-2 times a day for semi-grazing cattle. The water source comes from the forest, and the area tends to be hot, with temperatures above 25 °C. In reproduction, 96% of the samples comprised natural service with a male-female ratio <1:15–20 (68.4%). The natural service prevents the farmers from recording livestock.

In practice, livestock are grazed in the forest daily (96%–100%), engage in frequent interactions with wildlife (68%), and are occasionally subjected to predator attacks (66.7%). However, farmers' knowledge of zoonotic diseases is very low (4.3%). In terms of veterinary care, 91.3% desire to treat sick livestock, but the willingness to vaccinate is low, with only 17.4% of the samples having received a vaccination. Most of the farmers use herbal drugs (81%), and 31.6% deworm the cattle. Generally, biosecurity implementation remains low, as shown by the proximity of pens to residential buildings, improper deworming practices, the frequent presence of wild animals such as deer and long-tailed monkeys, and the occurrence of vectors.

The incidence of gastrointestinal parasitism in beef cattle is 51.2% (85/166). This is classified as high (>50%), approaching endemicity. The number is consistent with the endemic pattern observed by Ngowi (2020) and Ninditya *et al.* (2024) regarding parasite prevalence in tropical areas, compared to parasitism incidence in non-tropical countries (Rizwan *et al.*, 2024; Su *et al.*, 2024). Single gastrointestinal parasite infections accounted for 78.82%. Meanwhile, mixed infections, including the presence of two or more GIT parasites, comprised 21.18%. This infection can suppress the immune system and make the cattle more vulnerable to other parasites or diseases (Tiele *et al.*, 2023).

The most varied parasite incidences were in the Merak area, with the largest number of cattle on the BNP interface. The higher density and larger population of cattle increase gastrointestinal parasites (Sun *et al.*, 2018; Ninditya *et al.*, 2024). The transmission of parasites in beef cattle at the BNP interface is influenced by wildlife-livestock interactions. In this context, the interactions between community-owned beef cattle and wildlife such as Timor deer (*Cervus timorensis*) provide a route for parasite transmission through shared resources and environmental contamination. The shared use of resources increases the risk of parasite transmission from wildlife to livestock (Babayani *et al.*, 2022; Titcomb *et al.*, 2023). Another risk factor is poor hygiene, where cattle housed in dirty pens face a 2.6-times higher risk of infection. An infrequently cleaned pen accumulates large feces and facilitates parasitic transmission (Ramadhani *et al.*, 2022). Another factor is the presence of blood in the cattle's faeces. This can be linked to lesions caused by gastrointestinal worm infestations, such as *Haemonchus* spp., which cause bleeding in the abomasal mucosa. The final factor, the proximity of the pen to the house (0–5 m), was considered a protective factor (OR = 0.488; p = 0.050). Farmers who have a pen near a residential area tend to pay more attention to hygiene, reducing exposure to eggs/oocysts. Several variables showed high odds ratios but were not statistically significant, including grazing in forests (OR = 2.076; p = 0.145). The small sample size influences the condition in the "not grazed" category. However, grazing in forest areas is still considered an important risk factor because the concept increases contact with wildlife and contaminated environments.

The free grazing allows cattle to enter conservation areas, opening up opportunities for direct and indirect contact between cattle and wildlife. Intensive interactions between humans, livestock, and wildlife pose significant ecological and health risks, one of which is the potential for zoonotic disease transmission through two-way disease transfer (Banda *et al.*, 2024; Huaman *et al.*, 2023; Nguyen *et al.*, 2025). Moreover, there are several negative impacts, especially increasing prevalence, decreased productivity, mortality, disease resistance, and the risk of zoonoses (*Bunostomum* spp., *Oesophagostomum* spp., *Trichostrongylus* spp., and *Fasciola* spp.).

Several control measures that can be applied to livestock in the BNP interface area include limiting beef cattle grazing (ensuring that livestock do not enter the BNP area), providing several areas equipped with sufficient and nutritious feed. Therefore, grazing rotation can be carried out, providing adequate beef cattle pens, clean water sources, and routine deworming, as well as implementing biosecurity on beef cattle farms (Sakti *et al.*, 2024) and monitoring the health of beef cattle (Herrik *et al.*, 2023; Ngoshe *et al.*, 2023; Vougat Ngom *et al.*, 2024). The statements complement previous research (*Alamanda et al.*, 2022), presenting opportunities for further analysis on the potential for disease transmission between beef cattle and wild ruminants in the BNP interface area, specifically Timor deer (*Cervus timorensis*).

CONCLUSION

In conclusion, the prevalence of gastrointestinal parasitism in beef cattle in the BNP interface area was 51.2% (85/166). This research identified nine genera, namely *Bunostomum* spp. (7.2%), *Cooperia* spp. (15.6%), *Haemonchus* spp. (4.8%), *Oesophagostomum* spp. (9%), *Ostertagia* spp. (3.6%), *Strongylus* spp. (2.4%), *Trichostrongylus* spp. (12.6%), *Fasciola* spp. (4.8%), and *Eimeria* spp. (4.2%). A combination of specific risk factors and overarching livestock management practices increased the infection rate. Key risk factors significantly associated with infection included the geographic location (Air Karang and Merak), grazing in the Bilik forest area, and a low BCS. The root causes of endemic parasitism were deeply embedded in the prevailing extensive grazing system, which facilitated constant contact with wildlife and a contaminated forest environment, possessing low biosecurity and anthelmintic practices.

CONFLICT OF INTEREST

There is no conflict of interest concerning financial, personal, or other relationships with people or organizations related to the material discussed in the manuscript.

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

Google Translate was used to translate the manuscript from Indonesian to English during the preparation of this research. The content was reviewed and edited before taking full responsibility for the content of the publication after using the tool/service.

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