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Gastrointestinal Parasites and Relationship with Faecal IgA and Cortisol in Farmed Rabbits in Bamenda, North West, Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Authors TSD and OM conceived the study. Author TSD performed the experiments and analyzed the data. Author OM wrote the first drafts of the manuscript. Author SMA critically read and edited the manuscript. All authors read and approved the final manuscript. All authors contributed to the article and approved the submitted version. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Parasitic infections represent one of the major causes of death in rabbit's production system, which affect not only the reproductive performance but also the nutritional and dietary qualities. The objectives of the study were to determine the risk factors and prevalence of gastrointestinal parasites and its impacts in production of rabbits.
Methodology: Faecal samples were collected from 130 rabbits and were subjected to floatation and McMaster egg counting techniques for the parasitological analysis and faecal IgA and cortisol using ELISA technique. Moreover, questionnaire was used to assess some reproductive issues.

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Place and Duration of Study: The study was carried out in Bamenda, Mezam Division, Northwest region, Cameroon, between April 2022 and July 2022.
Findings: The results of this study showed an overall prevalence of gastrointestinal parasites (GIP) of 48.5% (63/130). The different gastrointestinal parasites that were obtained are *Coccidia spp* (88.89%), *Passalurus spp* (4.67%) and *Trichostrongylus spp* (6.35%). Moreover, the results showed that the production system (P=0.04) and feeding system (p = 0.04) increase the risk of GIP in rabbits production. In addition, the association of *Passalurus spp* with *Coccidia spp* decrease (P=0.049) the litter size while *Coccidia spp* increase (P=0.027) the risk of death of litters. Furthermore, co-infection of *Passalurus spp* and *Coccidia spp* lowered (p=0.06) the IgA level in animals while cortisol level is increased (p=0.001) in animals having *Coccidia* (3.065±13.05) compared to uninfected animals (1.03±1.16) as well as in animals co-infected with *Trichostrongylus spp* and *Coccidia spp* (26.72±46.14) compared to uninfected (p=0.049).
Conclusion: Gastrointestinal parasites are still major health problems resulting to death of litters in rabbit's production in which stress and decrease of immune response may play a key role.

Keywords: Gastrointestinal parasites; reproduction; cortisol; IgA; rabbits.

1. INTRODUCTION

Rabbits make important contributions to human livelihoods in developing economies, because of their high growth rate, reproductive performance, and high nutritional and dietary qualities in meat [1,2]. And it is reported that global rabbit meat production is about 1.8 million metric tonnes per year, and rabbit meat production in Cameroon is estimated to be 600 tonnes per year [3,4]. Regardless of how important rabbit production is, breeders still face a lot of challenges that arise the presence of gastrointestinal parasites. Moreover, internal parasites that attack rabbits are worms and protozoa. Worms which often invade the digestive tract of rabbits are *Passalurus ambiguus* and *Taeniapisiformis*, while protozoa commonly intruding the rabbit's digestive tract are *Eimeria sp.* and *Enchepalitozoon cuniculi* [5].

The parasites present in the digestive tract, uses host nutrients, consume host tissues or use digestive organ cells to complete the phase of their life [5]. *Encephalitozoon cuniculi* received increased attention due to its zoonotic potential, especially for immunocompromised adults and children. It is responsible for direct and indirect losses of rabbits that are attributed to acute illness and death, premature slaughter, decreased growth rate, weight loss and late maturity of slaughter stock [6]. Cryptosporidium spp. and Giardia spp. are intestinal protozoa parasites that are said to be prevalent and widespread enteropathogenes of humans and many species of mammals including rabbits. Additionally, Eimeria causes coccidiosis and can negatively affect total body mass, impair growth and food utilization, cause epithelial cell damage and inflammation, and result in diarrhoea, weight loss, economic losses, and even lead to death [5,7].

Intestinal parasites have become more difficult to manage in rabbit as parasites become resistance to several drugs. Some parasites are now recognized as emerging zoonosis by WHO (World Health Organization) and have serious impact on both public health and spread of the infection (Rautureau *et al.,* 2010). Rabbits also have many parasites species which negatively impact the animal health by reducing the productivity, weight gain and reproductive performance. Those parasites also impair the immune response which promotes the development of infection [8]. Following the parasite density and population, and the host defence mechanism, parasite infestation can provoke clinical signs and mortality. Also, they can stunt growth and partial or complete condemn the carcass.

Rabbit's production is essentially traditional in Bamenda and farmers and breeders are still unaware of the hazards or problems caused by GIP in rabbit. Thus, it is essential to investigate the risks factors and occurrence of gastrointestinal parasites in famed rabbits to improve the productivity and health status.

2. EXPERIMENTAL DETAILS

2.1 Study Area

The study was carried out in the Northwest region of Cameroon located between latitudes 50 55' N and 60 30'N and Longitudes 100 25'E and 100 67'E [9]. Bamenda, the head quarter shows an altitudinal range of 1200 - 1700 m, and is divided into two parts that is a low lying gently

undulating part with altitude ranging from 1200 to 1400 m with many flat areas that are usually inundated for most parts of the year, and an elevated part at 1400 to 1700 m altitude that forms the crest from which creeks, streams supplying the low-lying parts take their rise. Bamenda has two rainy seasons, a long rainy season, which runs from mid-March to mid-October, and a short dry season from mid-October to mid-March with an annual rainfall ranges from 1300-3000 mm [9]. Bamenda lies between the thermic and hyper-thermic temperature regimes with mean annual temperature stands at 19.9^{o}C. January and February are the hottest months with mean monthly temperatures of 29.1◦C and 29.7◦C, respectively. Agriculture is the main human activity of the habitants of Bamenda which involves about 70% of the population (GP-DERUDEP, 2006).

2.2 Study Design

The study was carried out from April to July 2022. The list of the farms was obtained from MINEPIA. A snow ball sampling technique was then used whereby a farmer helps to locate the next farm. Faecal samples were collected randomly from the chosen farms by taking in to consideration of factors such as breed, age, gender, or housing system in a cross-sectional survey from farms and farmers who owned rabbits and wished to participate in the study.

2.3 Sampling

The sample size was determined following the formula reported by Thrustfield [10], with 95% confidence interval and 5% of absolute precision taking in consideration that expected prevalence 50% was used since there is no reported studies on prevalence in rabbit at the Bamenda municipalities or Cameroon.

$$n = \frac{1.96^2 x\, P_{exp}(1- P_{exp})}{d^2}$$

Where, *n* = required sample size P_{exp} = Expected prevalence (50%), d = desired absolute precision (0.05). Accordingly to the above calculation, the required samples size was 104 and hence, 130 animals were examined for the study.

2.4 Collection of Demography and Reproduction Parameters

Information about the rabbit's reproduction was collected through an interview with the farmer on the following:

- Number of females that give birth and number of young ones born in 3 months
- Number of females with visually confirmed foetal expulsion (abortion)
- Number of females with no gestation
- The viability of the young ones registered, differentiating between viable young's (al ive three days after birth) and non-viable kits (dead within three days of birth).

2.5 Body Condition Score Assessment

The rabbits were placed on a flat surface and their body condition score was done by palpation i.e. feeling the animals' body (the ribs, pelvis and spine), and animals were graded following the rabbit-0- meter scale as reported by Sweet *et al.* [11] (Table 1).

2.6 Collection of Faecal Samples

Briefly the rabbit pen was thoroughly swept or cleaned to get rid of the feces accumulated from the previous days. Each rabbit were then separated in different cages. Feed and water were given to them and after 10 to 15 mins, the feces were collected early in the morning from the selected rabbits in a clean disposable plate. For those that were raised on the floor, after feeding them, rabbits were caught and individually put in to a large clean bucket to defecate and faecal samples were collected. Collected faecal were placed in capped plastic sample containers. The faecal was immediately divided into 2, one part was used for the parasitological analysis and the other for IgA analysis.

2.7 Parasitological Analysis

Flotation technique using the saturated salt solution (NaCl) as flotation fluid was used to detect the parasites eggs. Quantitative evaluation of the eggs was done using the modified McMaster technique. Briefly, 2 g of fresh faeces was suspended in 60 ml saturated salt solution. The suspension was filtered through a fine filter and the Mc Master slide was filled by the filtrate using a Pasteur pipette. After some 10 minutes, the slide was examined microscopically at 100 and 400 X [12,13]. The degree of infection was categorized as: mild (50 - 799), moderate (800 - 1200) and severe (> 1200) infestation according to their egg faeces (EPG) counts [14].

Table 1. Rabbit size-o-meter for assessing body condition score

0- meter score	Size	Characteristics
1	Very thin	• Hip bone, ribs and spine are very sharp to touch • Loss of muscle and no fat • The rump area curves in
2	Thin	• Hip bones, ribs and spine easily felt • Loss of muscle and very little fat cover • Rump areas is flat
3	Ideal	• Hip bones, ribs and spine are easily felt but are rounded, not sharp-ribs feel like pocket full of pens • Rump area is rounded
4	overweight	• Pressure is needed to feel the ribs, spine and hip • Some fat layers • The rump is rounded
5	Obese	• Very hard to feel the spine and hip bones- ribs cannot be felt • Tummy sags with obvious fat padding • Rump bulges out

2.7.1 Calculation

Number of eggs in 1 g of faeces (EPG) = $\text{Volume of floatation solution} \div \text{mass of faeces} = 60 \div 2$

From simple proportion if $1 \div 0.15 = (60 \div 2)X$, then cross multiplying will give $X = 60 \times 1 \div 2 \times 0.15 = 60 \div 0.3 = 200$

EPG = Number of eggs in one compartment of the slide × 200 [12].

2.8 Measurements of Faecal IgA ELISAs

Faecal pellets were resuspended in protein extraction buffer [10% goat serum (Fisher Scientific, Waltham, MA) in PBS] at a ratio of 10 mg per 100 µl, and vortexed for 20 min to disrupt pellets. Extracted samples were centrifuged for 10 min at 13,000 x g, and supernatants were collected for subsequent analysis. ELISA was performed to determine total IgA antibody concentrations present in rabbit faecal extracts collected. Briefly, ELISA plates were coated with goat anti-human IgA (diluted at 1: 10,000) and washed with an ELISA plate washer. Plates were then blocked and washed, and the samples for measurement of IgA from healthy controls, and standards IgA were diluted with 1% BSA in 1:1000, 1:1200, and 1:3200, respectively. Experimental samples and standards were added to the wells and incubated at room temperature for 2 h, and biotinylated anti-IgA (diluted in 1: 16,000) with HRP-conjugated streptavidin was added and incubated 1 h. Finally, the plates were developed in the dark using TMB substrate and analysed by an ELISA plate reader according to the manufacturer's instructions [15].

2.9 Measurement of Faecal Cortisol

Measurement of cortisol concentration in faecal samples was conducted using a commercial cortisol ELISA kit.50 µL of standard and samples were filled into the microplate well. Moreover, 75 µL of assay buffer was filled into the non-specific binding (NSB) wells and 50 µL of assay buffer into the maximum binding well. Afterward, 25 µL of the DetectX cortisol conjugate was added to each well using a repeater pipet. 25 µL of the DetectX cortisol antibody was then added to each well, except the NSB wells. The microplate was then covered with the plate sealer, homogenized for 10 seconds and then incubated at room temperature for 1 hour. After that, the microplate was washed with 300 µL of washing solution four times. Afterward, 100 µL of TMB substrate solution was added to each well and covered with the sealer plate and then re-incubate for 30 minutes at room temperature. Finally, 50 µL stop solution (0.5 M H_2SO_4) was added to each well to stop the enzymatic reaction. The absorbance was determined by using an ELISA reader at 450 nm. The concentration of cortisol was then calculated using the Microplate Manager 6 Software [16,17].

2.10 Data Analysis

Data obtained from laboratory results and questionnaires assessing some reproductive

parameters as well as risk factor was entered into micro-soft excel 2013 for descriptive statistic and later transferred to SPSS version 23 for further statistical analysis. Different parameters were compared using the chi-square test. In all analysis, confidence level was held at 95% and P-values less than 0.05 was considered as significant.

3. RESULTS AND DISCUSSION

3.1 Distribution of Rabbits and Risk Factors of Gastrointestinal Parasites

The results revealed that 56.9% of the rabbits were adults and the young are the fewer (20%). Farmers have mostly females (76.2%). According to breeds, most of the animals were New Zealand white (44.6%). Most of the rabbits are ideal condition (36.2%) and very few are obese (0.8%). Farmed rabbits are mostly intensive (40.8%) with most of the animals were kept on wired cage (50%) and 40.8% of the farmers are mostly used supplemented feed (Table 2).

3.2 Prevalence of Gastrointestinal Parasites in Farmed Rabbits in Bamenda

Out of the 130 rabbits examined, 63 (48.5%) were found positive with one or more parasites. The results showed that sex, age, breeds, body condition and the production system did not significantly (P > 0.05) influenced the prevalence of GIP in rabbits. In contrast, the housing system significantly (P = 0.002, x^2 = 12.47) influenced with high prevalence when the plank was used (60.0%) and 0.00% for floor. The prevalence based on the feeding system was statistically significant (P = 0.043) with high prevalence (57.9%) when animals are fed with feed and grass (Table 3).

3.3 Prevalence of Single and Co-Infection of Parasites

As shown in Table 4, the results revealed that among the infected animals, 43.1% and 5.4% of the animals were infected by single and co-infection of parasite species respectively. Amongst the 63 GIP infections detected, 56 (43.1%) were infected only by *Coccidia*, 3 (2.3%) were co-infected by *Passalurus* and *Coccidia* and 4(3.1%) were co-infected by *Trichostrongylus* and *Coccidia*.

3.4 Influence of Different Risk Factors on Gastrointestinal Parasites Density

Of the 63 positive cases, 14(22.2%) had mild infestation, 7(11.1%) had moderate infestation and 42(66.7%) were found severe infestation (Table 5). Comparing the prevalence of the severe infestation with regards to different factors, the results showed that sex, age, breed, body condition score and housing system of animals have no significant effect (P> 0.05). But, the results showed a significant effect of the production system (χ^2 = 7.98; P = 0.04) and feeding system ($\chi 2$ = 9.60; p = 0.04). Animals fed with feed and grass had more severe cases (88.9%) as well as animals kept in wired cage (70.0%).

3.5 Influence of Gastrointestinal Parasite on Litter Size and Viability of Young in Infected and Uninfected Rabbits

Results revealed that *Coccidia* as well as the co-infection with *Trichostrongylus* and *Coccidia* have no significant (P>0.05) effect on the litter size. In contrast, the association *Passalurus* and *Coccidia* have a significant difference (P = 0.049), with a decrease in the litter size of co-infected animals (Table 6). As shown in table 6, it was noted that animals infested with *Coccidia* had significantly (P = 0.027) less number of viable litters (5.87 ± 1.76) compared to uninfected (6.08 ± 2.44). However, they were no significant difference in number of litters in animals co-infected with *Passalurus* and *Coccidia* (P = 0.15) as well as those co-infected with *Trichostrongylus* and *Coccidia* (P = 0.45).

3.6 Influence of Gastrointestinal Parasite Species on IgA and Cortisol Level for Infected and Uninfected Rabbits

As shown in Table 7, the results revealed that the mean of IgA in infected animals with *Coccidia* (116.21±96.81) was high than that of uninfected animals (95.94±70.79), but there no was significant difference (p=0.64). Similarly, there was no difference (p=0.12) in co-infected with *Trichostrongylus* and *Coccidia* (1.31±1.58) and uninfected (0.32±1.12), while animals with co-infection of *Passalurus* and *Coccidia* (9.82±17.49) was significantly low (p = 0.06) than that of uninfected (30.45±38.66). The results also showed that cortisol level was significantly (p = 0.001) high in animals having *Coccidia* (3.065±13.05) compared to uninfected animals

(1.03±1.16) as well as in animals co-infected with *Trichostrongylus* and *Coccidia* (26.72±46.14) compared to uninfected (6.01±1.20) (p = 0.049). There was no difference in cortisol level in animals co-infected with Passalurus and Coccidia and those uninfected (p = 0.24).

3.7 Discussion

Parasitic diseases constitute a major impediment to livestock production in sub-Saharan Africa owing to the direct and indirect losses they cause. Gastrointestinal parasite infestations are widespread in livestock and are major constraint to livestock production in many countries including Cameroon. Rabbits harbour a variety of gastrointestinal parasites. The results of this study revealed a high prevalence of gastrointestinal parasites in rabbits to be 48.5%, which could be attributed to the poor management and husbandry practices. It was in contrast with those of Ilić *et al*. [18] who reported a prevalence rate 82.68% on the external and internal parasites of rabbits. The high prevalence in this study could also be attributed to illiteracy on the side of the rabbit's keepers and their ignorance or avoidance tendency of preventive measures. The differences in prevalence of gastrointestinal parasites in this study may also be associated with differences in environmental conditions, stocking rate, nature of their diet immunity status of the animal.

The study revealed that *Coccidia* was the highest parasite that affects farm rabbits in Bamenda with prevalence of 88.89% this high prevalence could be attributed to the poor feed management and the fact that most farmers use little or no anti-coccidia drugs in rabbit health management. Similar results were obtained by Ilić *et al* [18] who reported high prevalence of *Coccidia* among other internal parasites. In rabbits the most frequent are mixed infections of intestinal *Coccidia*, which cause clinical coccidiosis in offspring, with anaemia, diarrhea, dehydration, lagging in growth and development [19,20]. Coccidiosis is controlled with prophylactic application of anti-coccidia. But, these variations

Table 2. Distribution of animals according to the risk factors

Parameter	Variable	Proportion (%)
Sex	Female	99(76.2)
	Male	31(23.8)
Age	Young (0 - 5 Months)	26(20)
	Adult (5 months – 1 year)	74(56.9)
	Old (Above 1 Year)	30(23.1)
Breed	Angora	5(3.8)
	Chinchilla	37(28.5)
	Flemish G	6(4.6)
	French C	7(5.4)
	Mixed Breed	16(12.3)
	New zealand white	58(44.6)
Body condition score	Ideal	47(36.2)
	Obese	1(0.8)
	Over weight	2(1.5)
	Thin	38(29.2)
	Very thin	42(32.3)
Production System	Extensive	38(29.2)
	Intensive	53(40.8)
	Semi intensive	39(30)
Housing System	Floor	10(7.7)
	Plank Cage	55(42.3)
	Wired Cage	65(50)
Feeding system	Feed and grass	39(30)
	Feed supplementation	53(40.8)
	Forage only	38(29.2)
Reproduction characteristics	Number of females with litter	68 (70.10)
	Number of females with abortion	4 (4.12)
	Number of females with no gestation	4(4.12)

Table 3. Proportion prevalence of farm rabbit's in bamenda following the different demographic factors

Parameter	Variable	No of animal examined	No positive	Prevalence	X^2(P Value)
Sex	Female	99	46	46.5	0.66(0.416)
	Male	31	17	54.8	
Age	Young (0 - 5 moths)	26	11	42.3	0.49(0.782)
	Adult (5 months - 1year)	74	37	50.0	
	Old (above 1 year)	30	15	50.0	
Breed	Angora	5	1	20.0	9.02(0.172)
	Chinchilla	37	18	48.7	
	Flemish g	6	5	83.3	
	French c	7	1	14.3	
	Mixed breed	16	8	50.0	
	New zealand white	59	30	50.9	
BSC	Ideal	47	24	51.2	1.94(0.746)
	Obese	1	0	0.00	
	Over weight	2	1	50.0	
	Thin	38	16	42.1	
	Very thin	42	22	52.4	
Production system	Extensive	38	22	57.9	1.981(0.371)
	Intensive	53	23	43.4	
	Semi intensive	39	18	46.2	
Housing system	Floor	10	0	0.00	12.47(0.002)
	Plank cage	55	33	60.0	
	Wired cage	65	30	46.2	
Feed type	Feed and grass	38	22	57.9	9.603(0.043)
	Feed supplementation	53	23	43.4	
	Forage only	39	18	46.2	
Total		130	63	48.5	

Table 4. Prevalence of single and co- infections in rabbits in bamenda

Type of parasite	Number positive	Prevalence (%)
Single infections		
Coccidia spp	56	43.1
Co- infections		
Passalurus spp + Coccidia	3	2.3
Trichostrongylus spp + Coccidia ssp	4	3.1
Total Co-infections	7	5.4
Overall prevalence	63	48.5

were likely due to wide usage of grass, silage and grain as rabbit diet, making the administration of anticoccidials in feed impracticable in small farms, although practice other than anticoccidials was also employed in rabbit farming, poor hygienic conditions and suboptimal temperatures were observed on some small individual rabbit farms in most farms in Bamenda, which can favour the occurrence of *Eimeria* spp. Infections. The present finding was lower than that reported in some previous studies. This may be attributed to various factors, including the difference in environmental conditions prevailing in each region, meteorology and agro-ecology.

In this research, *Trichostrongylus* spp was diagnosed to be 6.35% and the parasites were prevalent in old, adults and young animals. It is reported that sometimes wild rabbits *Trichostrongylus* spp of ruminants parasitize [21], demonstrating that these wild animals' species can be vectors of domestic rabbits [21,22]. *Passalurus* was diagnosed with prevalence of 4.76%. The prevalence of this parasite varies depending on age and season [23,24]. In Egypt,

Table 5. Degrees of gastrointestinal parasitic infestation based on risk factors

Parameter	Variable	No positive	Mild (50-799)	Moderate (800-1200)	Severe (>1200)	X^2(P value)
Sex	Female	46	12(26.1)	6(13.0)	28(60.9)	2.578(0.27)
	Male	17	2(11.8)	1(5.9)	14(82.4)	
Age	Young (0 - 5 months)	11	0(0.00)	1(9.1)	10(90.9)	4.784(0.31)
	Adult (5 months - 1year)	37	11(29.7)	4(10.8)	22(59.5)	
	Old (above 1 year)	15	3(20.00)	2(13.3)	10(66.7)	
Breed	Angora	1	0(0)	0(0.0)	1(100.0)	12.233(0.27)
	Chinchilla	18	5(27.9)	3(16.7)	10(55.6)	
	Flemish g	5	0(0.0)	0(0.0)	5(100.0)	
	French c	1	1(100.0)	0(0.0)	0(0.0)	
	Mixed breed	8	3(37.5)	2(25.0)	3(37.5)	
	Newzealand white	30	5(16.7)	2(6.7)	23(76.7)	
Body condition score	Ideal	24	3(12.5)	2(8.3)	19(79.2)	7.989(0.4)
	Over weight	1	0(0.0)	0(0.0)	1(100.0)	
	Thin	16	5(31.6)	4(25.0)	7(43.8)	
	Very thin	22	6(27.3)	1(4.6)	15(68.2)	
Production system	Extensive	22	9(40.9)	2(9.4)	11(50.0)	9.603(0.05)
	Intensive	23	4(17.4)	4(17.4)	15(65.2)	
	Simi intensive	18	1(5.6)	1(5.6)	16(88.9)	
Feeding system	Feed and grass	18	1(5.6)	1(5.6)	16(88.9)	9.603(0.04)
	Feed supplementation	23	4(17.3)	4(17.4)	15(65.2)	
	Forage only	22	9(40.9)	2(9.2)	11(50.0)	
Housing	Plank cage	33	10(30.3)	2(6.1)	21(63.6)	3.723(0.15)
	Wired cage	30	4(13.3)	5(16.7)	21(70.0)	
Total		63	14(22.2)	7(11.1)	42(66.7)	9.44(0.036)

P. ambiguus is one the most prevalent helminthes found in domestic rabbits, up to 40 % of samples are infected with it and younger animals are more commonly infected than adults [24]. However, the prevalence rates were relatively lower than that recorded previously in eastern Scotland (14.2%) and in Egypt (26.7%) by Ashmawy *et al*. [24]. These variations were likely to be due to difference in environmental condition, management care, nature of pasture and the level of humidity from one to another place.

Results revealed no significant difference among different risk factors of gastrointestinal parasites of rabbits such as the age, sex, breed, and production system. This result contradicts the findings of Ilić *et al* [18] who reported a significant higher prevalence of gastrointestinal parasites in rabbits of different sex and age. Moreover, influences of age, sex and breeds were also taken into consideration by Pakandl *et al.* [25] who reported that there was a lower resistance or less immunity to coccidian infection in young rabbits than older animals which is responsible for the high prevalence of coccidiosis in young rabbits (47.1%). Additionally, host sex exercises a great significant influence on parasitism, as females harboured more infection compared to males, agreeing with various studies. Similar risk of infection could be due to the fact that both young and adult rabbit were exposed to the same risk of infection by the infective stage of *P.* ambiguus due to the lack of knowledge about the hygienic measures as kids remain in contact with their dams, as well as might be attributed to the nature of the study area as reported by Abdel-Baki & Al-Quraishy [26]. The differences in prevalence of gastrointestinal parasites in this study may also be associated with differences in environmental conditions, stocking rate, nature of their diet immunity status of the animal.

Result of this study revealed that the body conditions of the animal were not affected by the prevalence of the parasites and degree of EPG which is in agreement with study of Keyyu *et al*. [27], but this is in contrast with the results of fikru *et al*. (2006). This could be explained by the fact that loss of body condition in the study animals could be due to other factors, such as seasonal change of forage feed stuff and the presence of other concurrent disease conditions [27]. However, statistically significant effects of housing and feed type have been observed in this study. This is in line with the findings of Yab *et al.* [28] who reported that nutrition influences the incidence rate and severity of infection with GI nematodes in animal. This finding also showed an existence of difference in degree of parasitic infestation with the variation of species, age and sex of the animals. However, there was no significant difference in EPG among different age groups, sex and species.

It was observed that the co-infection *Passalurus and Coccidia* cause a decrease in the litter size of co-infected animals and also animals having *Coccidia* had few viable litters. This suggest that gastrointestinal parasites affect directly or indirectly the reproduction in females, which concur with facts started by Mavrogianni *et al.* [29] that parasites also affect reproduction by affecting litter size, delaying onset of puberty, reduced mating activity of rabbits, increases the inability of the animals to conceive, abortion or abnormal delivery of young one. The fact that *Coccidia* spp affects the viability of young is in line with the findings of Kusiluka & Kambarage [30]. This may be that younger rabbits are immunological naive and are susceptible to infection from adult carriers especially after weaning [25]. Moreover, weaning stress has been reported to lower the immunity of rabbits to infections and the ingestion of coccidian parasites couple with contaminated solid feed may raise the intensity of infection in young there by increasing mortality in the young [31].

Table 6. Size and number of viable litters in infected and uninfected farmed rabbits

Parasite species	Infected	Uninfected	*P value*
Size of litters			
Coccidia spp	6.03±2.54	6.08±2.44	0.87
Passalurus spp + Coccidia spp	4.28±1.74	6.08±2.44	0.049
Trichostrongylus spp + Coccidia spp	6.12±2.60	6.08±2.44	0.45
Number of litters viable			
Coccidia spp	5.87±1.76	6.0875±2.44	0.027
Passalurus spp + Coccidia spp	6.10±0.55	6.0875±2.44	0.154
Trichostrongylus spp + Coccidia spp	6.12±2.62	6.0875±2.44	0.45

Table 7. IgA and cortisol level following the parasites species in rabbits

Parasite	IgA (µg/ml)		P	COR (ng/dl)		P
	Infected animal	Uninfected animal	value	Infected animal	Uninfected animal	value
Coccidia spp	116.21±296.81	95.94±270.79	0.64	3.065±13.05	1.03±1.16	0.00
Trichostrongylus spp+Coccidia spp	1.31±1.58	0.32±1.12	0.12	26.72±46.14	6.01±1.20	0.04
Passalurus spp + Coccidia spp	9.82±17.49	30.45±38.66	0.06	0.57±0.99	0.55±1.32	0.24

4. CONCLUSION

Gastrointestinal parasites are still major health problems in rabbit production. The major groups of parasites present are *Trichostrongylus, Coccidia* and *Passalurus*. These parasites may leads to death of litters in rabbit's production in which stress and decrease of immune response play a keys role.

ETHICAL APPROVAL

The studies were reviewed and approved by Departmental Scientific Board of the department of Animal production, College of Technology, The University of Bamenda, Cameroon.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Zvinorova PI, Halimani TE, Muchadeyi FC, Matika O, Riggio V, Dzama K. Prevalence and risk factors of gastrointestinal parasitic infections in goats in low-input low-output farming systems in Zimbabwe. Small Ruminant Research. 2016;143:75-83.
2. Tchoffo H, Malloum F, Ngoumtsop HV, Lontio FA, Deutcheu SN, Kana D. Comparative study of growth and hematologic characteristics in dwarf rabbit doe (*Oryctolagus cuniculus*) fed with cowpea and peanut offal in the North Region of Cameroon. Journal of Veterinary Medicine and Animal Sciences, 2020;3(1):1021.
3. Lebas F, Colin M. Production et consommation de viande de lapin dans le Monde Estimation en l'an 2000. Jornadas Internacionas du Cunicultura. 2000:24-25.
4. Mohamad-Radzi NN, et al. Preliminary detection of mites and coccidia with their zoonotic potential in meat-farmed rabbits in three districts in Selangor, Malaysia. Journal of Parasitic Diseases. 2021;45(1):169-175.
5. Tanjung M, Rangkuti P. Species and prevalence of rabbit gastrointestinal parasites in Berastagi Farm Karo District, North Sumatra, Indonesia. proceedings of the International Conference on Natural Resources and Technology (ICONART 2019); 2019.
6. Morsy EA, Salem HM, Khattab MS, Hamza DA, Abuowarda MM. Encephalitozoon cuniculi infection in farmed rabbits in Egypt. Acta Veterinaria Scandinavica. 2020;62(1):1-11.
7. Cizauskas CA, Turner WC, Pitts N, Getz WM. Seasonal patterns of hormones, macroparasites, and microparasites in wild African ungulates: The interplay among stress, reproduction, and disease. Plos One. 2015;10(4):e0120800.
8. Kornas S, Kowal J, Wierzbowska I, Basiaga M, Nosal P, Niedbala P. The Alice-" Follow the White Rabbit"-parasites of farm rabbits based on coproscopy. Annals of Parasitology. 2015;61(4).
9. Thrusfield MV. Veterinary Epidemiology. 2nd ed,London, UK:Black well science. 2005;233.
10. Ndenecho E. Biological resource exploitation in Cameroon: From crisis to sustainable management: Bamenda. Unique Printers. 2005:181.
11. Sweet H, Pearson A, Watson P, German A. A novel zoometric index for assessing body composition in adult rabbits. Veterinary Record. 2013;173(15):369-369.
12. Thienpont D, Rochette F, Vanparijs OFJ. Diagnosing helminthiasis by coprological examination (Vol. 1986). Janssen

Research Foundation Beerse, Belgium; 1986.
13. Verocai GG, Chaudhry UN, Lejeune M. Diagnostic methods for detecting internal parasites of livestock. Veterinary Clinics: Food Animal Practice. 2020;36(1):125-143.
14. Paul BT, et al. Risk factors and severity of gastrointestinal parasites in selected small ruminants from Malaysia. Veterinary Sciences. 2020;7(4):208.
15. Peters I, Calvert E, Hall E, Day M. Measurement of immunoglobulin concentrations in the feces of healthy dogs. Clinical Vaccine Immunology. 2004;11(5):841-848.
16. Gholib G, Wahyuni S, Wahyudi A, Silalahi KS, Akmal M, Sabri M, Nugraha TP. Validation of commercial ELISA kit for non-invasive measurement of cortisol concentrations and the evaluation of the sampling time of blood and fecal sample in Aceh cattle. E3S Web of Conferences; 2020.
17. Blasco X, Manteca X, López-Béjar M, Carbajal A, Castellà J, Ortuño A. Intestinal parasites and fecal cortisol metabolites in multi-unowned-cat environments: The impact of housing conditions. Animals. 2021;11(5):1300.
18. Ilić T, Stepanović P, Nenadović K, Dimitrijević S. Improving agricultural production of domestic rabbits in Serbia by follow-up study of their parasitic infections. Iran J Vet Res. Autumn. 2018;19(4):290–297.
19. Sadzikowski AB, Szkucik K, Szczepaniak KO, Paszkiewicz WJMW. Prevalence of protozoan genus Eimeria in slaughter rabbits. Med Weter. 2008;64:1426-1429.
20. Pakandl M. Coccidia of rabbit: a review. Folia Parasitologica. 2009;56(3):153-166.
21. Ilić T, Stojanov I, Dimitrijević S. Parasitic infections in wild ruminants and wild boar. Veterinarski Glasnik. 2011;65(5-6):419-431.
22. Ilić T, Petrović T, Dimitrijević S. Parasitic infections of wild rabbits and hares. Veterinarski Glasnik. 2014;68(3-4):241-250.
23. Nosal P, Petryszak A, Nowosad B, Sobolewska M. Gastrointestinal parasites of rabbits in coproscopic investigations. Wiadomosci Parazytologiczne. 2006;52(4): 327-330.
24. Ashmawy K, El-Sokkary M, Abu-Akkada S, Dewair A. Incidence of *Passalurus ambiguus* in domestic rabbits in Behera province. Alexandria Journal of Veterinary Sciences. 2010;30(1):115-120.
25. Pakandl M, Hlásková L, Poplštein M, Chromá V, Vodička T, Salát J, Mucksová J. Dependence of the immune response to coccidiosis on the age of rabbit suckling. Parasitology Research. 2008;103(6):1265-1271.
26. Abdel-Baki AAS, Al-Quraishy S. Prevalence of coccidia (Eimeria spp.) infection in domestic rabbits*, Oryctolagus cuniculus*, in Riyadh, Saudi Arabia. Pakistan Journal of Zoology. 2013;45(5).
27. Keyyu J, Kassuku A, Kyvsgaard NC, Willingham A. Gastrointestinal nematodes in indigenous Zebu cattle under pastoral and nomadic management systems in the lower plain of the southern highlands of Tanzania. Veterinary Research Communications. 2003;27(5):371-380.
28. Yap P, Utzinger J, Hattendorf J, Steinmann P. Influence of nutrition on infection and re-infection with soil-transmitted helminths: A systematic review. Parasites Vectors. 2014;7:229.
29. Mavrogianni, V, Papadopoulos E, Fragkou I, Gougoulis D, Valasi I, Orfanou D, Fthenakis G. Administration of a long-acting antiparasitic to pre-pubertal ewe-lambs in Greece results in earlier reproductive activity and improved reproductive performance. Veterinary parasitology, 2011;177(1-2):139-144.
30. Kusiluka L, Kambarage D. Diseases of small ruminants: a handbook. Common Diseases of sheep goats in Sub-Saharan Africa; 1996
31. Participatory G. Decentralised Rural Development Project-GP-DERUDEP. Baseline Study of the North West Province,'sponsored by the African Development Bank , elaborated by the Society for Initiatives in Rural Development Environmental Protection –Cameroon, Bamenda; 2006.

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