



Evaluation of hematological parameters of small ruminants affected by zoonoses at the municipal abattoir of Korhogo (Côte d'Ivoire)

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ABSTRACT. This study was conducted to highlight the effect of zoonotic diseases on the hematological parameters of small ruminants from the municipal abattoir of Korhogo. A total of 170 small ruminants, comprising 85 sheep and 85 goats, some of which were detected with zoonotic diseases, were recruited for blood analysis. Blood samples were collected from the jugular vein using EDTA anticoagulant tubes. Complete Blood Count (CBC) was performed on these blood samples. The main results indicate that 34.71% of the small ruminants were sick, with 38.82% among sheep and 30.58% among goats. Tuberculosis was detected in 20.59% of the total population, compared to 14.12% with fascioliasis. Comparison of hematological parameters between healthy and sick animals revealed that blood parameters were more altered in sick animals than in healthy ones. Anemia was the most observed hematological complication in sick animals, with average hemoglobin levels of 7.77 ± 0.39 g L⁻¹ in sick sheep and 7.42 ± 0.49 g L⁻¹ in sick goats. Statistical analysis showed a significant correlation between hemoglobin levels and zoonotic pathology in both sheep and goats, with coefficients of 0.261 and 0.254, respectively. These results suggest that zoonotic pathologies are responsible for hematological complications especially anemia in small ruminants slaughtered at the municipal abattoir in Korhogo. These diseases should thus be detected through blood tests before slaughter to preserve their health and provide high-quality meat to the population.

Keywords: Small ruminants; zoonotic diseases; hematological parameters; abattoir; Korhogo.

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Introduction

In many Sub-Saharan African countries, sheep and goat farming is now considered a viable alternative for promoting rural economies (Communauté économique des États de l'Afrique de l'Ouest–Club du Sahel et de l'Afrique de l'Ouest/Organisation de coopération et de développement économiques, 2008). The meat from small ruminants is highly valued and consumed by the Ivorian population, according to a Food and Agriculture Organization [FAO] survey in 2018. Thus, livestock farming requires careful attention. Many sanitary constraints encountered in this sector are managed. Studies on sheep and goats have revealed animal pathologies such as brucellosis, tuberculosis, babesiosis, anaplasmosis, Q fever, chlamydiosis, and trypanosomiasis (Gwida et al., 2010; Acapovi et al., 2019; Lisette et al., 2020; Kouadio, 2020). At the municipal abattoir of Korhogo, it was found that disease detection by veterinarians was done solely based on symptoms without any blood exploration (Kamagaté et al., 2020; Yeo et al., 2020). Additionally, these authors reported very high prevalences of hematological abnormalities in slaughtered sheep (Kamagaté et al., 2020; Yeo et al., 2020). Studies have demonstrated a close correlation between the prevalence of zoonotic diseases and abnormalities in hematological parameters. Some authors have observed anomalies in sheep and goats slaughtered at the Korhogo abattoir. For instance, Tapé Bi Sehi (2019) reported a prevalence of brucellosis in sheep and goats at 29% in the Poro region (Korhogo, Côte d'Ivoire).

Therefore, it is necessary to compare animal pathologies with the hematological parameters of animals destined for consumption. Such data could help diagnose many diseases, including subclinical forms, and establish a prognosis.

In Côte d'Ivoire, no significant scientific study has been reported on hematological abnormalities due to zoonotic diseases in small ruminants (sheep and goats) in abattoirs to date. Given the lack of data, studying the influence of zoonotic diseases on the hematological parameters of small ruminants admitted to the municipal abattoir of Korhogo is a crucial research focus.

Materials and methods

Study area

The study was conducted in the commune of Korhogo, specifically at the small ruminant abattoir. This abattoir is located in Natio Kobadara, a small village in Korhogo that has become a neighborhood. The study spanned a period of seven (07) months, from June 2021 to January 2022.

Inclusion and Exclusion Criteria

The study focused on all sheep and goats presented at the Korhogo abattoir for slaughter for human consumption.

Blood sample collection and analysis

Blood was collected in the morning between 8:00 and 12:00. On each sampling day, after bleeding the sheep and goats, approximately 3-4 ml of blood were immediately collected into tubes with Ethylene Diamine Tetraacetic Acid (EDTA) anticoagulant. After collection, the blood in the tubes was homogenized for a few seconds to prevent coagulation. The samples were then placed on tube holders and transferred to a cooler with ice packs to be transported to the laboratory for Complete Blood Count analysis using a hematology analyzer (URIT 2900+, China).

Statistical analysis

Results were expressed as means with their standard error. Various statistical tests were used for data analysis. Data normality was tested using the Shapiro-Wilk test to determine whether to use parametric (Student's t-test) or non-parametric tests. Spearman's correlation test was used to analyze correlations between hematological parameters and the nature of zoonotic pathologies. Significance was set at a probability threshold of $p < 0.05$.

Results and discussion

Characterization of the study population

The study involved eighty-five (85) sheep and eighty-five (85) goats presented at the Korhogo abattoir for veterinary inspection and slaughter. The average age of the animals was 1.56 ± 0.05 years. Among sheep, the average age was 1.57 ± 0.07 years, and among goats, it was 1.58 ± 0.08 years. By sex, the animals consisted of 36 males (about 21.18%) and 134 females (about 78.82%). The sample included 61 young animals (age < 1 year) or 35.88%, and 109 adults (age ≥ 1 year) or 64.12%. Sheep included 31 young animals (36.47%) and 54 adults (63.53%). Goats included 30 young animals (35.29%) and 55 adults (64.71%). The selected animals were composed of 87.65% Djallonké breed and 12.35% Sahelian breed. Among the sheep, 100% were of the Djallonké breed. Among the goats, 75.29% were of the Djallonké breed and 24.71% were of the Sahelian breed (Table 1).

Table 1. Data on the Characteristics of the total population and the population by species.

Characteristics	Total population (N=170)			Sheep (N=85)			Goats (N=85)		
	n	M $\pm$ SEM	%	n	M $\pm$ SEM	%	n	M $\pm$ SEM	%
Age		1.56 $\pm$ 0.05			1.57 $\pm$ 0.07			1.58 $\pm$ 0.08	
<1	61		35.88	31		36.47	30		35.29
≥ 1	109		64.12	54		63.53	55		64.71
Sex									
Males	36		21.18	18		21.18	18		21.18
Females	134		78.82	67		78.82	67		78.82
Race									
Djallonké	149		87.65	85		100	64		75.29
Sahélienne	21		12.35	–		–	21		24.71

N: Total Number of Individuals per Group; n: Observed Count in Each Group; SEM: Standard Error of the Mean.

Distribution of diseases in the total population by species

The health status results revealed that 65.3% of the study population (170 subjects) was healthy, comprising 61.18% sheep and 64.41% goats. Among the total population, the prevalence of sick animals was 34.71%, with

38.82% among sheep and 30.58% among goats. The results in Table 2 indicate that tuberculosis was detected in 20.59% of the total population compared to 14.12% with fascioliasis. Tuberculosis was present in 22.35% of sheep and 18.82% of goats. Fascioliasis was present in 16.47% of sheep and 11.76% of goats (Table 2).

Table 2. Prevalence of different types of zoonotic diseases.

Animal health conditions	Total population (N=170)		Sheep (N=85)		Goats (N=85)	
	n	%	n	%	n	%
Healthy	111	65.30	52	61.18	59	64.41
Tuberculosis	35	20.59	19	22.35	16	18.82
Dismatosis	24	14.12	14	16.47	10	11.76

N : Total Number of Individuals per Group; n : Observed Count in Each Group.

Average hematological parameters of sheep and goats compared to reference values

The results showed that the average values of hematological parameters such as hematocrit, MCV, MCHC, leukocytes, lymphocytes, monocytes, neutrophils, and thrombocytes in goats were abnormal. Among these abnormal values, the mean MCHC and lymphocytes values in goats were lower than the reference means. In contrast, all other abnormal average values were higher than the reference means.

For sheep, the average values of red blood cells, hemoglobin, lymphocytes, eosinophils, basophils, and thrombocytes were normal compared to the reference values. However, all other mean hematological parameters were abnormal (Table 3).

Table 3. Mean values of hematological parameters in sheep and goats.

Hematological parameters	Sheep N=85		Goats N=85	
	Moy $\pm$ ESM	Val. réf.	Moy $\pm$ ESM	Val. réf.
Red blood cells ($10^{12} L^{-1}$)	9.99 $\pm$ 0.45	9-15	10.68 $\pm$ 0.42	8-18
Hemoglobin (g dL ⁻¹)	9.47 $\pm$ 0.26	9-15	9.71 $\pm$ 0.28	8-12
Hematocrit (%)	60.14 $\pm$ 2.79	27-45	43.32 $\pm$ 2.11	22-38
VGM (fl)	58.01 $\pm$ 0.59	28-40	42.41 $\pm$ 1.58	16-25
TCMH (pg)	12.28 $\pm$ 0.86	8-12	10.97 $\pm$ 0.63	5.2-8
CCMH (g dL ⁻¹)	21.53 $\pm$ 1.47	31-34	28.40 $\pm$ 1.95	30-36
White blood cells ($10^9 L^{-1}$)	15.37 $\pm$ 0.68	4-12	13.93 $\pm$ 0.52	4-13
Lymphocytes (%)	49.34 $\pm$ 2.28	40-75	48.21 $\pm$ 2.25	50-70
Monocytes (%)	8.41 $\pm$ 0.51	0-6	8.30 $\pm$ 0.49	0-4
Neutrophils (%)	13.72 $\pm$ 0.78	10-50	13.68 $\pm$ 0.77	30-48
Eosinophils (%)	1.22 $\pm$ 0.09	0-10	1.22 $\pm$ 0.09	1-8
Basophils (%)	0.05 $\pm$ 0.02	0-3	0.04 $\pm$ 0.02	0-1
Thrombocytes ($10^9 L^{-1}$)	622.65 $\pm$ 23.31	250-750	609.18 $\pm$ 22.05	300-600

N : Total number of individuals per group; Avg: average; SEM: standard error of the mean; Val. réf.: reference values (Usual_animal_hematology_values_A12008.pdf); MCV: Mean corpuscular volume; TCMH: Mean corpuscular hemoglobin content; CCMH: Mean corpuscular hemoglobin concentration.

Comparison of average hematological values of sheep by health status

In the total sheep population, significant differences were observed only in the average values of hemoglobin, MCH, and MCHC. The mean hemoglobin level was significantly higher ($p < 0.001$) in healthy sheep compared to sick sheep. In contrast, the mean MCH and MCHC values were significantly higher ($p < 0.05$) in healthy sheep compared to sick sheep.

By sex, no significant difference was observed between the hematological parameters of healthy and diseased males. In females, a significant difference was observed only in the average hemoglobin level. This value was highly significant in healthy females compared to diseased females (Table 4).

Table 4. Average values of hematological parameters of sheep according to state of health.

Hematological parameters	Total population N=85		Male N=18		Female N=67	
	Healthy sheep n= 52	Sick sheep n= 33	Healthy sheep n= 13	Sick sheep n= 5	Healthy sheep n= 39	Sick sheep n= 28
	Moy $\pm$ ESM	Moy $\pm$ ESM	Moy $\pm$ ESM	Moy $\pm$ ESM	Moy $\pm$ ESM	Moy $\pm$ ESM
Red blood cells ($10^{12} L^{-1}$)	10.21 $\pm$ 0.56	9.65 $\pm$ 0.76	8.98 $\pm$ 0.07	10.88 $\pm$ 2.31	10.63 $\pm$ 0.58	9.43 $\pm$ 0.80
Hemoglobin (g dL ⁻¹)	10.55 $\pm$ 0.25***	7.77 $\pm$ 0.39	11.18 $\pm$ 0.58	9.08 $\pm$ 0.85	10.35 $\pm$ 0.28*	7.53 $\pm$ 0.43
Hematocrit (%)	61.02 $\pm$ 3.57	58.75 $\pm$ 4.52	50.51 $\pm$ 8.23	61.8 $\pm$ 14.31	64.53 $\pm$ 3.79	58.21 $\pm$ 4.80

MCV (fl)	57.88±0.87	58.21±0.64	56.5±2.90	56.54±1.64	58.33±0.88	58.51±0.69
MHC (pg)	13.56±1.15*	10.26±1.20	16.62±2.84	10.46±2.63	12.54±1.19	10.23±1.36
MCHC (g dL ⁻¹)	23.99±2.03*	17.65±1.93	30.31±5.23	19.09±4.98	21.88±2.01	17.39±2.14
White blood cells (10 ⁹ L ⁻¹)	15.79±0.90	14.71±1.02	18.71±2.33	14.08±1.71	14.23±1.18	14.83±1.17
Lymphocytes (%)	12.67±0.80	12.2±0.88	15.86±1.71	11.6±1.05	11.61±0.82	12.30±1.02
Monocytes (%)	8.42±0.64	8.39±0.84	7.77±0.78	6.4±1.25	8.64±0.82	8.75±0.95
Neutrophils (%)	13.79±1.00	13.51±1.25	12.46±1.86	12.2±3.98	14.23±1.18	13.75±1.32
Eosinophils (%)	1.36±0.14	1.00±.00	1.54±0.22	1.00±0.00	1.30±0.17	1.00±0.00
Thrombocytes ((10 ⁹ L ⁻¹)	615.46±29.67	662.21±37.72	703.38±69.87	689.4±105.14	586.15±33.16	657.35±41.09

N: Total number of individuals per group; n: Number observed for each characteristic; MCV: Mean corpuscular volume; MCH: Mean corpuscular hemoglobin content; MCHC: mean corpuscular hemoglobin concentration; Avg: average; SEM: standard error of the mean; Min: minimum; Max: maximum; *: statistically different for $p < 0.05$.

Comparison of average hematological values in goats based on their health status

In the total population of goats, significant differences were observed only in the average values of hemoglobin, MCH, and MCHC. The average hemoglobin level was highly significant ($p < 0.001$) in healthy goats compared to diseased goats. The average MCH value was significantly higher ($p < 0.01$) in healthy goats compared to diseased goats. Similarly, the average MCHC value was significantly higher ($p < 0.05$) in healthy goats compared to diseased goats.

In male goats, significant differences were observed only in the average values of hemoglobin, MCH, and MCHC. The average hemoglobin and MCH values were significantly higher ($p < 0.01$) in healthy males compared to diseased males. However, the average MCHC value was significantly ($p < 0.05$) higher in healthy males compared to diseased males.

In female goats, a significant difference was observed only in the average hemoglobin level. This value was highly significant in healthy females compared to diseased females (Table 5).

Table 5. Comparison of average values of hematological parameters of goats according to state of health.

Hematological parameters	Total population N=85		Male N=18		Female N=67	
	Healthy goats n= 59	Sick goats n= 26	Healthy goats n= 9	Sick goats n= 9	Healthy goats n= 50	Sick goats n= 17
	Moy ± ESM	Moy ± ESM	Moy ± ESM	Moy ± ESM	Moy ± ESM	Moy ± ESM
Red blood cells (10 ¹² L ⁻¹)	10.93±0.50	10.3±0.74	7.38±1.41	10.86±1.24	11.57±0.48	9.69±0.91
Hemoglobin (g dL ⁻¹)	10.71±0.25***	7.42±0.49	11.63±0.67***	7.57±0.65	10.55±0.27***	7.35±0.67
Hematocrit (%)	42.64±2.35	44.84±4.33	38.11±7.06	55.11±8.15	43.46±2.48	39.41±4.51
MCV (fl)	41.07±1.83	45.46±2.99	53.4±4.60	52.33±4.72	38.85±1.85	41.83±3.53
MHC (pg)	12.02±0.80*	8.58±0.78	19.82±2.21***	8.40±1.65	10.61±0.70	8.67±0.82
MCHC (g dL ⁻¹)	31.63±2.45**	21.04±2.66	37.00±5.33*	18.75±4.84	30.67±2.72	22.25±3.13
White blood cells (10 ⁹ L ⁻¹)	14.24±0.91	13.34±0.85	14.85±1.57	13.36±0.95	14.13±0.72	13.32±1.20
Lymphocytes (%)	10.72±0.55	9.88±0.81	10.44±0.68	9.43±0.97	10.77±0.64	10.12±1.12
Monocytes (%)	8.97±0.65	7.15±0.70	2.69±0.90	6.78±0.91	9.14±0.75	7.35±0.95
Neutrophils (%)	14.56±0.91	11.69±1.39	13.33±2.25	11.44±2.42	1.24±0.14	11.82±1.69
Eosinophils (%)	1.25±0.12	1.15±0.09	1.33±0.24	1.44±0.22	14.78±1.00	1.00±0.00
Thrombocytes (10 ⁹ L ⁻¹)	0.05±0.02	0.04±0.03	0.33±0.2	0.11±0.11	0.02±0.02	0.03±0.03

N: Total number of individuals per group; n: Number observed for each characteristic; MCV: Mean corpuscular volume; TCMH: Mean corpuscular hemoglobin content; CCMH: Mean corpuscular hemoglobin concentration; Avg: average; SEM: standard error of the mean; *: Statistically different for $p < 0.05$; **: Statistically different for $p < 0.01$; ***: Statistically different for $p < 0.001$.

Correlation between pathologies and hematological parameters

The correlation between various pathologies and hematological parameters in sheep and goats was elucidated using Spearman's analysis. In Tables 6 and 7, only the first vertical and horizontal lines should be considered for analysis.

Correlation between various pathologies and hematological parameters in sheep

The analysis indicates that hematological parameters such as hemoglobin, MCH, MCHC, eosinophils, monocytes, lymphocytes, and thrombocytes are positively correlated with different pathologies. The correlation is very strong between hemoglobin and pathologies and very weak for other parameters. No correlation was observed between pathologies and hematological parameters such as red blood cells, hematocrit, MCV, white blood cells, neutrophils, and basophils (Table 6).

Table 6. Values of correlation coefficients between pathologies and hematological parameters in sheep (R^2).

Variables	Pathologies and hematological parameters													
	PATH	GR	HB	HT	VGM	TCMH	CCMH	GB	PNN	PNE	PNB	MONO	LYMP	PLAQ
PATH	1	0.000	0.261	0.000	0.000	0.050	0.057	0.000	0.000	0.040	0.000	0.007	0.001	0.020
RBC	0.000	1	0.001	0.934	0.002	0.515	0.485	0.010	0.028	0.034	0.038	0.014	0.011	0.050
HB	0.261	0.001	1	0.000	0.010	0.163	0.212	0.054	0.006	0.002	0.000	0.024	0.061	0.001
HT	0.000	0.934	0.000	1	0.063	0.490	0.521	0.014	0.026	0.015	0.039	0.026	0.020	0.034
MCV	0.000	0.002	0.010	0.063	1	0.005	0.033	0.004	0.003	0.010	0.001	0.020	0.025	0.006
MHC	0.050	0.515	0.163	0.490	0.005	1	0.916	0.054	0.000	0.003	0.019	0.010	0.054	0.000
MCHC	0.057	0.485	0.212	0.521	0.033	0.916	1	0.068	0.000	0.003	0.016	0.009	0.061	0.000
WBC	0.000	0.010	0.054	0.014	0.004	0.054	0.068	1	0.294	0.010	0.022	0.387	0.853	0.190
PNN	0.000	0.028	0.006	0.026	0.003	0.000	0.000	0.294	1	0.002	0.008	0.432	0.227	0.165
PNE	0.040	0.034	0.002	0.015	0.010	0.003	0.003	0.010	0.002	1	0.004	0.003	0.005	0.001
PNB	0.000	0.038	0.000	0.039	0.001	0.019	0.016	0.022	0.008	0.004	1	0.011	0.001	0.000
MONO	0.007	0.014	0.024	0.026	0.020	0.010	0.009	0.387	0.432	0.003	0.011	1	0.455	0.124
LYMP	0.001	0.011	0.061	0.020	0.025	0.054	0.061	0.853	0.227	0.005	0.001	0.455	1	0.171
PLT	0.020	0.050	0.001	0.034	0.006	0.000	0.000	0.190	0.165	0.001	0.000	0.124	0.171	1

PATH: Pathology; GR: Red blood cells; HB: Hemoglobin; HT: Hematocrit; MCV: Mean corpuscular volume; MHC: Mean corpuscular hemoglobin content; MCHC: Mean corpuscular hemoglobin concentration; WBC: white blood cells; PNN: Polynuclear neutrophils; PNE: Polynuclear eosinophils; GNP: Basophilic polynuclear cells; MONO: Monocytes; LYMP: Lymphocytes; PLT: Platelets.

Correlation between various pathologies and hematological parameters in goats

The analysis shows that hematological parameters such as red blood cells, hemoglobin, hematocrit, MCV, MCH, MCHC, neutrophils, eosinophils, monocytes, and thrombocytes are positively correlated with different pathologies. The correlation is very strong between hemoglobin and pathologies and very weak for other parameters. No correlation was observed between pathologies and hematological parameters such as white blood cells and basophils (Table 7).

Table 7. Values of correlation coefficients between pathologies and hematological parameters in goats (R^2).

Variables	Pathologies and hematological parameters													
	PATH	GR	HB	HT	VGM	TCMH	CCMH	GB	PNN	PNE	PNB	MONO	LYMP	PLAQ
PATH	1	0,023	0,254	0,001	0,004	0,043	0,026	0,000	0,029	0,009	0,000	0,012	0,000	0,016
RBC	0,023	1	0,006	0,542	0,064	0,496	0,232	0,020	0,002	0,011	0,043	0,000	0,009	0,024
HB	0,254	0,006	1	0,013	0,061	0,207	0,269	0,022	0,031	0,004	0,000	0,060	0,012	0,000
HT	0,001	0,542	0,013	1	0,154	0,299	0,536	0,035	0,006	0,004	0,016	0,006	0,036	0,051
MCV	0,004	0,064	0,061	0,154	1	0,011	0,151	0,021	0,008	0,002	0,003	0,015	0,041	0,028
MHC	0,043	0,496	0,207	0,299	0,011	1	0,401	0,004	0,008	0,002	0,030	0,033	0,002	0,003
MCHC	0,026	0,232	0,269	0,536	0,151	0,401	1	0,020	0,008	0,008	0,005	0,000	0,017	0,024
WBC	0,000	0,020	0,022	0,035	0,021	0,004	0,020	1	0,322	0,002	0,064	0,401	0,586	0,137
PNN	0,029	0,002	0,031	0,006	0,008	0,008	0,008	0,322	1	0,002	0,008	0,432	0,225	0,208
PNE	0,009	0,011	0,004	0,004	0,002	0,002	0,008	0,002	0,002	1	0,004	0,003	0,016	0,000
PNB	0,000	0,043	0,000	0,016	0,003	0,030	0,005	0,064	0,008	0,004	1	0,011	0,012	0,013
MONO	0,012	0,000	0,060	0,006	0,015	0,033	0,000	0,401	0,432	0,003	0,011	1	0,418	0,135
LYMP	0,000	0,009	0,012	0,036	0,041	0,002	0,017	0,586	0,225	0,016	0,012	0,418	1	0,085
PLT	0,016	0,024	0,000	0,051	0,028	0,003	0,024	0,137	0,208	0,000	0,013	0,135	0,085	1

GR: Red blood cells; HB: Hemoglobin; HT: Hematocrit; MCV: Mean corpuscular volume; MHC: Mean corpuscular hemoglobin content; MCHC: Mean corpuscular hemoglobin concentration; WBC: white blood cells; PNN: Polynuclear neutrophils; PNE: Polynuclear eosinophils; GNP: Basophilic polynuclear cells; MONO: Monocytes; LYMP: Lymphocytes; PLT: Platelets.

Discussion

Veterinary meat inspections play a crucial role in controlling animal diseases and protecting public health against zoonoses (Regassa et al., 2013). In this context, studies conducted since 2019 on the hematological parameters of small ruminants slaughtered at the municipal slaughterhouse of Korhogo have indicated that the prevalence of hematological abnormalities in slaughtered sheep is very high (Kamagaté et al., 2020; Yeo et al., 2020). According to these authors, these abnormalities may be due to the presence of certain zoonotic pathogens, which could be bacterial, viral, or parasitic in origin. To verify this, a study on the influence of zoonotic diseases on the hematological parameters of 170 small ruminants (85 sheep and 85 goats) at the municipal slaughterhouse of Korhogo was conducted.

During this study, tuberculosis and fascioliasis were the two zoonotic diseases detected during inspections. Indeed, the objective of inspecting animals at a slaughterhouse is to detect and remove all meat and offal

showing pathological lesions and unfit for human consumption. Similar findings were reported by Acapovi et al. (2019), Lisette et al. (2020) and Kouadio et al. (2020), who, in addition to these two zoonotic diseases, identified echinococcosis and trichinosis in their studies conducted at the Port Bouet slaughterhouse and the Ivorian Society of Slaughter and Charcuterie in Yopougon.

The prevalences of tuberculosis and fascioliasis in this study were 20.59% and 14.12%, respectively, among the small ruminants. This corroborates the findings of Kiki et al. (2021) in the Parakou slaughterhouse in northern Benin, who observed tuberculosis lesions in the livers and lungs of slaughtered small ruminants. Moreover, the work by Sahraoui et al. (2012) in Algeria on pathologies in small ruminants revealed tuberculosis prevalences of 3.89% and 4.40% in goats and sheep, respectively. These values are lower than those reported in this study. Contrary to this study, tuberculosis and fascioliasis were not among the pathologies observed in the study conducted by Tapé Bi Sehi (2019) on risk factors for zoonotic disease contamination in rural areas of Korhogo, northern Côte d'Ivoire. The pathologies encountered in domestic small ruminants included brucellosis, pasteurellosis, scabies, and foot-and-mouth disease.

To address the issue of the effect of zoonotic diseases on the hematological parameters of small ruminants slaughtered at the Korhogo slaughterhouse, the comparison of hematological parameters revealed that these parameters were more altered in diseased small ruminants than in healthy ones.

In terms of erythrocytic parameters, the main observation is the predominance of anemia, especially in females, macrocytosis in both healthy and diseased animals, and hypochromia in diseased sheep. These erythrocytic abnormalities could be due to nutritional or pathological causes.

Our results are consistent with those of Martin (1983) and N'doutamia and Ganda (2005), who reported that the causes of anemia, macrocytosis, and hypochromia in these small ruminants were due to deficiencies in iron, vitamin B12, copper, or gastrointestinal parasites (*Haemonchus contortus*, *Trichostrongylus axei*, *Fasciola hepatica*, mycoplasmas, *Trypanosoma congolense*).

The study also reported hematological abnormalities in leukocyte parameters with no significant difference between the average values of healthy and diseased animals. These abnormalities included leukocytosis, lymphopenia, and neutropenia. Similar observations were made by Mawuena (1986) and Okeudo and Moss (2005). According to these authors, leukocyte abnormalities are due to viral, bacterial, fungal, protozoan, and parasitic infections. The increase in leukocyte levels is often a normal response of the organism to fight infections. At an advanced stage, these infections can also lead to a decrease in lymphocyte levels. Neutropenia is thought to result from the massive recruitment of neutrophils to the site of inflammation (Zagaouch & Jamal Edine, 2020).

Moreover, the relationships between various zoonotic diseases and hematological parameters, elucidated through principal component analysis, showed a positive correlation between zoonoses and hematological parameters such as hemoglobin, MCH, MCHC, eosinophils, monocytes, lymphocytes, and platelets in sheep. In goats, this positive correlation was observed between zoonoses and parameters such as red blood cells, hemoglobin, hematocrit, MCV, MCH, MCHC, neutrophils, eosinophils, monocytes, and platelets. The most significant correlation was observed between zoonoses and hemoglobin.

This positive correlation between zoonoses and hemoglobin levels could explain the high prevalence of anemia observed in sheep and goats. Indeed, anemia has been shown to be a more or less direct result of parasitic infestation. These parasites can disseminate hematogenously to various organs such as the lungs, liver, intestines, meninges, and hematopoietic organs (Trabelsi et al., 2014).

Conclusion

This study evaluated the effect of the most recurrent zoonotic diseases at the municipal slaughterhouse of Korhogo on hematological parameters. It appears from this study that tuberculosis and fascioliasis were the two zoonotic diseases detected during inspections. Furthermore, hematological parameters in sheep and goats affected by these two types of zoonotic diseases were the most deteriorated. The results of this study, through principal component analysis, suggest that the zoonotic diseases revealed in this study could be responsible for the observed hematological disorders. These hematological disorders were more pronounced in hemoglobin levels than in other parameters. Anemia was therefore the most recurrent hematological complication in this study.

In response to these zoonoses, it is crucial to strengthen veterinary surveillance measures in slaughterhouses, improve hygiene conditions, and promote targeted antiparasitic and antibiotic treatments

in animals. Raising awareness among livestock farmers and slaughterhouse workers about zoonotic risks is essential to reduce the likelihood of transmission to humans. These diseases may pose a significant threat to human health, potentially leading to chronic infections and severe complications.

To build on these findings, further studies could be undertaken to identify the specific bacterial or parasitic strains involved, assess their resistance to treatments, and gain deeper insights into their pathogenic mechanisms. Moreover, expanding the study to include other regional slaughterhouses would enhance the representativeness of the data and support the development of more effective disease control policies.

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References

- Acapovi, G. L. Y., Beugré, J. M. V., Yapi, C. B., & Sevidzem, S. L. (2019). Analysis of the situation of bovine cystic echinococcosis at the Port-Bouët abattoir: A retrospective study from 2008–2015. *International Journal of Biological and Chemical Sciences*, 13(3), 1527–1533. <https://doi.org/10.4314/ijbcs.v13i3.25>
- Communauté économique des États de l'Afrique de l'Ouest – Club du Sahel et de l'Afrique de l'Ouest / Organisation de coopération et de développement économiques. (2008). *Élevage et marché régional au Sahel et en Afrique de l'Ouest: Potentialités et défis*. Organisation de coopération et de développement économiques. <https://www.oecd.org/fr/csao/publications/40279092.pdf>
- Gwida, M., Al Dahouk, S., Melzer, F., Rösler, U., Neubauer, H., & Tomaso, H. (2010). *Brucellosis – regionally emerging zoonotic disease?* *Croatian Medical Journal*, 51(4), 289–295.
- Kamagaté, S., Kokore, A. B., Brou, G. K. G., & Yapo, A. P. (2020). Haematological profile of sheep declared healthy for slaughtering in the commune of Korhogo (Côte d'Ivoire). *Saudi Journal of Biomedical Research*, 5(6), 87–95. <https://doi.org/10.36348/sjbr.2020.v05i06.001>
- Kiki, P. S., Salifou, N., Ahounou, S. G., Youssao-Abdou-Karim, I., Tobou, I., & Djegui, F. (2021). Motifs de saisies partielles ou totales de la viande de petits ruminants à l'abattoir de Parakou au nord-Bénin. *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, 9(4), 689–693. https://www.agrimaroc.org/index.php/Actes_IAPH2/article/view/993
- Kouadio, J. N., Giovanoli Evack, J., Achi, L. Y., Fritsche, D., Ouattara, M., Silué, K. D., Bonfoh, B., Hattendorf, J., Utzinger, J., Zinsstag, J., Balmer, O., & N'Goran, E. K. (2020). Prevalence and distribution of livestock schistosomiasis and fascioliasis in Côte d'Ivoire: Results from a cross-sectional survey. *BMC Veterinary Research*, 16, 446.
- Lisette T., Naférima K., Alassane T., Touré, L., Koné, N., Touré, A., Mebourou, E. K., Senin, C. B. V., Lendzele, S. S., François, M. J., & Acapovi-Yao, G. L. (2020). *Prevalence and Associated Risk Factors of Porcine Echinococcosis at the Ivorian Pig Slaughter Company (SIVAC), Yopougon Abidjan: A Cross-Sectional Study*. *Journal of Biosciences and Medicines*, 8, 1–8.
- Martin, W. B. (1983). Les maladies respiratoires des petits ruminants, provoquées par les virus et les mycoplasmes. *Revue scientifique et technique de l'Office international des épizooties*, 2(2), 335–356
- Mawuena, K. (1986). Trypanosomose des moutons et des chèvres de race naine Djallonké des régions sud guinéenne du Togo. *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, 39(3–4), 307–315.
- N'doutamia, G., & Ganda, K. (2005). Détermination des paramètres hématologiques et biochimiques des petits ruminants du Tchad. *Revue Médicale Vétérinaire*, 156(4), 202–206.
- Okeudo, N. J., & Moss, B. W. (2005). Haematological characteristics of Djallonké sheep in a humid tropical environment. *Small Ruminant Research*, 57(1), 83–87.
- Regassa, A., Moje, N., Megersa, B., Beyene, D., Sheferaw, D., Debela, E., Abunna, F., & Skjerve, E. (2013). Major causes of organs and carcass condemnation in small ruminants slaughtered at Luna Export Abattoir, Oromia Regional State, Ethiopia. *Revue de Médecine Vétérinaire*, 164(2), 139–148.
- Sahraoui, N., Brahim Errahmani, M., Tazerart, F., Hadjadja, F. Z., Habbas, N., Chadi, H., & Guetarni, D. (2012). La tuberculose chez les petits ruminants en Algérie. *Bulletin of Animal Health and Production in Africa*, 60(4), 378–399. <https://www.ajol.info/index.php/bahpa/article/view/91852>

- Tapé Bi Sehi, A. (2019). Les zoonoses : un risque sanitaire en milieu rural dans la Sous-préfecture de Korhogo (Côte d'Ivoire). *Espace Géographique et Société Marocaine*, (30).
<https://doi.org/10.34874/IMIST.PRSM/EGSM/18280>
- Trabelsi, S., Oueslati, J., Aouinet, A., & Khaled, S. (2014). Les anémies d'origine parasitaire. *La Tunisie Médicale*, 92(6), 361–367.
https://applications.emro.who.int/imemrf/Tunisie_Med/Tunisie_Med_2014_92_6_361_367.pdf
- Yéo, N., Gagnon, B. G., & Karamoko, Y. (2020) Hémoparasites Chez Les Ruminants Domestiques Dans Les Départements De Korhogo Et Sinématiali En Côte d'Ivoire. *European Scientific Journal ESJ*, 16 (15) :183
- Zagaouch, D., & Jamal Eddine, B. (2020). Les anomalies hématologiques au cours d'une tuberculose pulmonaire active. *Revue des Maladies Respiratoires*, 37(1), Article 218.
<https://doi.org/10.1016/j.rmra.2020.11.482>