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Original Research Paper

Impact of Bovine Fascioliasis on Hemato-Metabolic Status and Postpartum Ovarian Activity in Montbeliarde Dairy Cows in Northeastern of Algeria.

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Abstract

This study was designed to focus on the relationship between postpartum ovarian activity and fascioliosis of dairy cattle in northeastern Algeria associated haematological and biochemical alterations. Specifically, non-infected cows showed significantly higher ($p < 0.001$) in all erythrogram parameters including, red blood cell counts (7.98 ± 1.31 x 10^6/µL *vs* 4.56 ± 1.16 10^6/µL), haemoglobin (12.37 ± 1.27 g/dL *vs* 4.23 ± 0.67 g/dL), haematocrit (36.51 ± 3.30% *vs* 18.93 ± 6.35%), the mean corpuscular volume (48.30 ± 6.27 fL *vs* 41.39 ± 1.95 fL), the mean corpuscular hemoglobin (14.57 ± 1.38 pg *vs* 12.18 ± 0.94 pg) and the mean corpuscular hemoglobin concentration (31.76 ± 2.90 % *vs* 29.05 ± 2.11 %,). The leukogram of infected animals characterized by significantly elevated ($p < 0.001$) in total white blood cells counts, eosinophil and basophil. Conversely, this group exhibited concurrent lymphopenia and monocytopenia ($p < 0.001$). The levels of liver enzyme activity in relation to fasciola infected cows were significantly (< 0.001) increased compared to uninfected animals. This included AST (213.65 ± 44.52 U/L *vs* 102.21 ±18.08 U/L), ALT (68.63 ±22.68 U/L vs32.12 ±7.33 U/L) and ALP (182.52 ±61.18 U/L *vs* 92.95 ±32.34 U/L. In contrast, infected cows demonstrated significant hypoproteinemia (3.51 ±0.85 g/dL *vs* 6.02 ± 1.18 g/dL, $p < 0.001$) and hypoalbuminemia (2.29 ±0.66 g/dL vs 3.62 ± 0.66 g/dL $p < 0.001$). Serum progesterone levels at 30 days post-calving were significantly higher in uninfected cows (1.30 ± 0.16 ng/mL) than in those infected with *F. hepatica* (0.25 ± 0.13 ng/mL). Consequently, 71.6% (63/88) of uninfected cows resumed ovarian activity within 30 days postpartum, whereas only 31.25 % (10/32) of fluke-infected cows exhibited ovarian cyclicity within the same timeframe. Furthermore, the calving to conception interval was significantly prolonged in *Fasciola*-infected animals (120,50± 14,52 days *vs* 91,51± 20,92 days, $p < 0.001$). The average number of services per conception in infected cows increased by three (+ 3) compared to healthy controls, which ranged from 1.7 to 2.3 services. These results suggest that *F. hepatica* infection significantly alters systemic haematological parameters and hepatic metabolic status, thereby impairing postpartum fertility success. This emphasises the urgent need for continuous surveillance and targeted parasite control measures as well as structured prophylactic programme interventions.

Key words **:** *Cattle ; Erythrogram; Fasciola hepatica ; luteal activity ; Progesterone ; Liver.*

1. Introduction

Dairy farming products plays a vital role in ensuring global food security and the health of the agricultural economy. However, the profitability of this sector remains heavily dependent on herd health, particularly with regard to helminth infections [1]. Fasciolosis, which is primarily caused by Digenea trematodes of the family Fasciolidae, the *Fasciola hepatica (F. hepatica)* [2] is a significant parasitic zoonosis. It is also known as the common liver fluke with a global worldwide distribution [3] ; [4]. This parasite affects a wide range of mammalian species, particularly herbivorous livestock. Among these, ruminant, most notably cattle, sheep, goats, horses and camels which are the most common definitive hosts [5]. The mature flukes targets the bile ducts and liver parenchyma, resulting in a parasitic disease called fascioliasis [6]. The eggs usually pass out of the final host in faeces, and the larvae develop in a molluscan intermediate host [7].

Beesley et al. [8] reported that the risk of *F. hepatica* infection in dairy cattle (*Bos taurus*) herds varies due to differences in weather conditions, geographical location, and management practices. At the farm level, Charlier et al. [9] identified key risk factors related to grazing management, including pasture location, soil type, drainage, and the specific timing of pasture and also has been ropported that, the infections with *F. hepatica* cause substantial and significant economic losses in ruminants livestock industry. For the Dutch dairy cattle industry and European countries. *Fasciola hepatica* infection significantly reduces livestock productivity: cows infected showed reductions in milk yield range from 3% to 15% per cow [9] ; [10] , additionally, the fasciolosis in cattle and sheep

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revealed a 9% reduction in daily weight gain and a 6% in live weight [11].

The profitability of a dairy farm depends on calf production and milk yield. Parameters such as calving interval, age at puberty, services per pregnancy and interval to onset of post-partum heat are considered important in measuring farm economy. Therefore, several studies has recordes the affect of fasciolosis in dairy fertility. López-Díaz et al. [12] observed delayed onset of puberty and reduced growth rates in replacement heifers under fluke challenge, Schweizer et al. [13] estimated extended service periods of up to 13 days, Charlier et al. [9] recorded an average increase of 4,7 days in inter-calving interval. Measuring and changes in haematological and biochemical parameters reflect the physiological balance between host immunity and parasite adaptation, offering vital diagnostic value during infection [14]. Direct examination of the biliary and vascular systems presents major diagnostic challenges in animals. Consequently, serum biochemical profiling is a vital tool for identifying clinicopathological alterations, such as changes in important liver enzymes and metabolic markers. Lala et al. [15] recorded that, standard biochemical testing focuses on liver enzymes in order to detect primary hepatocellular damage and help to quantify cholestasis and assess hepatic synthetic function.

In Northen Algeria, fascioliasis is one of the most widespread helminth infections in livestock. This is largely due to favourable ecological conditions that support populations of the intermediate snail host. Although the general pathology of fasciolosis is well understood, the precise mechanisms by which liver biochemical disruption leads to impaired reproductive performance in dairy cows need to be clarified in our study area. In addition, assessing the extent postpartum reproductive problem associated with *F. hepatica* is critical and essential for guiding and designing sustainable local producers and control programs that optimizing herd health, and formulating sustainable parasite management strategies to improve dairy farm profitability. To date, in our knowledge, no previous or recent studies have documented and investigated the relationship between alterations of the hematobiochemical profile change and fertility disorders in cattle remains unexplored in the study area. In order to address this gap, this study therefore aimed to evaluate the effects of *F. hepatica* infection on the hemogram counts and liver biochemical parameters as well as their relationship with reproductive performance through the resumption of postpartum luteal activity in Montbeliarde dairy cattle in northeastern Algeria.

2. Materials and methods

2.1. Study Area

For the geographic location, the present study was carried out in the north-eastern Algeria (36° 46′ N, 8° 19′ E). The climate and rainfall, the region is characterised by high humidity and heavy precipitation, with an average annual rainfall of 700-1000 mm. This makes it one of the wettest regions in the country, particularly in its coastal and forested areas. The sector of agricultural and economic activity, the province is a major agricultural stronghold, renowned for its olive orchards and vineyards. It also serves as a crucial national centre for livestock farming, particularly dairy cattle.

2.2. Farm, Animal sampling and feeding system

Farms were selected using convenience sampling based on the livestock owners' agreement to participate in the research. The study focused on Montbéliarde cattle, the leading imported dairy breed in specialised regional herds. Valued for their milk productivity, environmental capacity and rusticity, they are the dominant imported dairy breed in the area and suit local husbandry conditions. The animals were managed according to traditional regional practices, combining winter barn housing with spring and summer pasture grazing. A mixed ration of hay and straw was provided ad libitum throughout the year, with concentrate feed provided to all groups as a supplement. To ensure a representative sample of herds was covered in terms of variability in key physiological parameters, including age, body condition score (BCS) and lactation stage (early, mid and late), a total of 120 Montbéliarde dairy cows were recruited for the study. Basic farm records were kept for parity, and animals were managed according to standard protocols. However, the statistical model focused on prospective post-insemination outcomes in relation to fasciola infection status and did not incorporate detailed historical fertility metrics.

Cows diagnosed with one or more pathological events such as dystocia, retained fetal membranes, mastitis, metritis/endometritis, or other reproductive problems were excluded from the analysis.

To synchronize the study cohort, cows were selected based on expected calving dates in close proximity. This design allowed and enabled us to assess how *F. hepatica* infection affects postpartum ovarian activity, artificial insemination (AI) conception rates, and early embryonic loss.

2.3. Study design

The cows were classified according to *F. hepatica* infection status : **uninfected**

(n= 88/120 ; 73,34 %) and an **infected** group (n = 32/120 ; 26,66 %).

2.4. Coprological Examination

These cows were diagnosed as *F. hepatica* positive using the standard sedimentation technique as described by Anon (2007) [16]. The individual faecal samples were collected directly from the rectum of selected cows using disposable gloves and placed into clean containers. Each sample was immediately transferred to a labeled vial containing 10% formalin transported to the parasitology laboratory for processing. After this the sedimentation technique included approximately 5 g of feces was mixed with 40 mL of tap water, filtered through a tea strainer, and allowed to settle for 20 to 25 minutes. The supernatant was discarded, a drop of the resulting sediment was taken place on a slide glass. The staining method was occurs with 1% methylene blue, and examined under a microscope to identify the parasite eggs. *F. hepatica* eggs were identified by their yellowish-brown color, large oval shape, and distinct operculum at one pole.

2.5. Blood sampling and Biochemical processing

Jugular venipuncture was performed by a veterinarian to obtain blood samples. To reduce stress during sampling, 22-gauge (0,64 mm × 25,4 mm) needles were used. For hematological parameter analysis, blood was drawn into 10 mL EDTA tubes using an automated haematology analyser (Celltac α MEK-6510J/MEK-6510K; Nihon Kohden, Japan). For the determination of liver function markers, blood was collected into dry tubes (10 mL) without anticoagulant to obtain serum and were evaluated using an automated clinical chemistry analyser (Cobas 6000; Roche Diagnostics, Switzerland). All tubes were systematically labeled, numbered, and immediately transported to the clinical biochemistry laboratory for processing.

2.6. Hormone assay

To track early postpartum ovarian activity, blood samples were collected twice per week through day 30 post-calving for plasma progesterone (P4) quantification. Plasma P4 levels were determined using an electrochemiluminescence immunoassay (ECLIA) with dedicated commercial reagent kits (Progesterone, Roche Diagnostics GmbH, Mannheim, Germany) on an automated Cobas e 411 analyser (Roche Diagnostics), according to the manufacturer's instructions. The assay's analytical sensitivity (minimum detectable concentration) was 0.01 ng/mL. Standard calibration curves were generated using standard progesterone solutions provided by the manufacturer. Intra- and inter-assay coefficients of variation of 3.6% and 7.4%, respectively, were obtained, confirming high analytical accuracy and reproducibility. Resumption of postpartum ovarian cyclicity was defined as two consecutive progesterone concentrations of P4 ≥1 ng/mL, measured in samples taken twice weekly, prior to or on day 30 postpartum indicating functional luteal activity and ovulation.

2.7. Fertility parameters

Reproductive performance in dairy cattle was monitored between 40 and 90 days postpartum in order to assess postpartum fertility. This period is critical for the resumption of ovarian activity and artificial insemination (AI) success at 30 days postpartum. The calving conception rate was measured up to 120 days postpartum. These parameters were measured and compared in cows diagnosed with fasciolosis and in uninfected animals. Oestrus detection was conducted via visual observation, followed by AI using standardised semen sources. Oestrus was identified through routine visual monitoring. Subsequent AI was performed by a licensed veterinarian using standardised, uniform semen doses. All of the cows included in the reproductive analysis (n = 120) were artificially inseminated following visual oestrus detection. Pregnancy diagnosis was performed 30–35 days after insemination using transrectal ultrasonography, which provides a highly reliable early assessment of embryonic viability by confirming the presence of cardiac activity by the fifth week. Cows exhibiting repeat breeding (defined as requiring three or more artificial inseminations without successful conception) were purposely retained within the study cohort to reflect realistic field-level reproductive efficiency and their relatioships by *F. hepatica* infection. Early embryonic loss was determined through sequential transrectal ultrasonography (or manual rectal palpation) performed at day 30 and confirmed at day 60 post-insemination; cows initially confirmed pregnant at day 30 that subsequently tested negative at day 60 were classified as having experienced embryonic loss.

2.8. Management and statistical analysis

The data were entered into Microsoft Excel (version 2010) and analysed using IBM SPSS (Statistical software Package for Analysis for window 7, Chicago, version 21 ; IBM Corp., Armonk, NY, USA). Descriptive statistics were computed to summarise the variability of parameters across the study groups, and the results were expressed as the mean ± standard deviation (SD). A one-way

completely randomised analysis of variance (ANOVA) was performed to compare the results of the analysis of haematological parameters, liver function markers and reproductive parameters between *F. hepatica*-infected and uninfected dairy cows. Statistical significance was declared at $p < 0.05$ (95% confidence interval).

3. Results

All 32 infected cows exhibited severe *Fasciola hepatica* infections, with fecal egg outputs consistently exceeding the critical threshold of 500 eggs per gram (EPG). The cohort demonstrated a mean excretion level of 667.3 ± 101.4 EPG, corresponding to absolute counts of 2,550 to 4,250 eggs per 5 gram fecal sample. Such pronounced egg shedding patterns reflect a massive, established chronic fasciolosis across the entire evaluated cohort.

Table 1 illustrates the mean haematological parameters of *Fasciola*-infected and non-infected cows. Regarding the erythrogram profile, uninfected cows exhibited significantly higher values across all parameters compared to infected animals. Specifically, non-infected cows showed significantly higher red blood cell counts (7.98 ± 1.31 x 10^6/µL *vs* 4.56 ± 1.16 x 10^6/µL; $p < 0.001$). They also had higher haemoglobin concentrations (12.37 ± 1.27 g/dL *vs* 4.23± 0.67 g/dL, $p < 0.001$) and higher haematocrit levels (36.51 ± 3.30 % *vs* 18.93 ± 6.35%, $p < 0.001$).

Similarly, the red cell indices presented by the mean corpuscular volume (MCV) were significantly higher in non infected cows (48.30 ± 6.27 fL) than in infected controls (41.39 ± 1.95 fL) ($p < 0.001$) as were the mean corpuscular hemoglobin (MCH) (14.57 ± 1.38 pg *vs* 12.18 ± 0.94 pg respectively, $p < 0.001$) and for the mean corpuscular hemoglobin concentration (MCHC) (31.76 ± 2.90 % *vs* 29.05 ± 2.11 % respectively, $p < 0.001$). The leukogram response, on the other hand, notably and demonstrated marked activation, with infected animals characterized by significantly elevated ($p < 0.001$) in total white blood cells (leukocyte) counts, as well as elevated counts of eosinophil and basophil in *Fasciola*-infected cows relative to uninfected animals or the healthy group, in fact this group exhibited concurrent lymphopenia and monocytopenia ($p < 0.001$) (Table 1).

Hematological profiles in *Fasciola*-infected cows revealed the mean total leukocyte count as well as granulocytic differentials monocyte, eosinophil, and basophil counts were exceeding normal physiological intervals standard. In fact, erythrogram parameters including erythrocytes count, hemoglobin, hematocrit, and lymphocyte levels were suppressed below baseline reference limits. Meanwhile, the mean erythrocyte indices specifically MCV, MCH, and MCHC remained strictly within established physiological reference ranges **(Table 1)**.

Table 1. Heamatological parameters changes of Fasciola-infected and non-infected cow

Hemogram Parameters	Non-infected (n = 88) (73.33 %)	Infected (n = 32) (26.66 %)	*P value*	Reference value (Sirois and Hendrix 2015) [17]
Erythrogram Red cell count (x 10^6/µL^3)	7.98 ±1.31^a	4.56 ±1.16^b	< 0.001	**5-10**
Hemoglobin (g/dL)	12.37 ±1.27^a	4.23 ±0.67^b	< 0.001	**8-14**
Hematocrit (%)	36.51 ±3.30^a	18.93 ±6.35^b	< 0.001	**24-42**
Mean Corpuscular Volume (fL)	48.30 ± 6.27^a	41.39 ±1.95^b	< 0.001	**40-60**
Mean Corpuscular Hemoglobin (pg)	14.47 ±1.38^a	12.18 ± 0.94^b	< 0.001	**11-17**
Mean Corpuscular Hemoglobin Concentration (%)	31.76 ± 2.90^a	29.05 ±2.11^b	< 0.001	**28-36**
Total Leukocyte Count (10^3/µL)	7.25 ± 2.49^a	14.42 ±1.15^b	< 0.001	**4-12**
Lymphocytes (x10^3/µl)	4.96 ± 1.60^a	1.15 ±0.95^b	< 0.001	**2.5-7.5**
Monocytes (x10^3/µl)	0.52 ±0.24^a	0.15 ± 0.16^b	< 0.001	**0.02-0.85**
Neutrophils (x10^3/µl)	2.49 ± 1.34^a	5.37 ±1.50^b	< 0.001	**0.6-4.00**
Eosinophils (x10^3/µl)	0.23 ± 0.47^a	3.08 ±1.14^b	< 0.001	**0-2.4**
Basophils (x10^3/µl)	0.03 ± 0.10^a	0.31 ±0.16^b	< 0.001	**0-0.2**

Different superscript letters within the same row indicate statistically significant differences ($p < 0.05$). Data are presented as the ***mean ± standard deviation****.*

As shown in **Table 2**, the levels of liver enzyme activity in relation to *fasciola* infected cows were significantly elevated compared to uninfected animals. This included AST (213.65 ± 44.52 U/L *vs* 102.21 ±18.08 U/L), ALT (68.63 ±22.68 U/L *vs* 32.12 ±7.33 U/L) and ALP (182.52 ±61.18 U/L *vs* 92.95 ±32.34 U/L, all $p < 0.001$). In contrast, infected cows demonstrated significant hypoproteinemia (3.51 ±0.85 g/dL *vs* 6.02 ± 1.18 g/dL, $p < 0.001$) and hypoalbuminemia (2.29 ±0.66 g/dL *vs* 3.62 ± 0.66 g/dL, $p < 0.001$). Notably, in *Fasciola*-infected cows, the mean values recorded for the serum liver enzymes AST, ALT and ALP were all markedly elevated above the physiological standard reference limits. Conversely, total protein and albumin mean concentrations were depleted below the standard reference range.

Table 2. Biochemical parameters changes of Fasciola-infected and non-infected cow

Biochemical parameters	Non-infected (n = 88) 73.33 %	Infected (n = 32) 26.66 %	*P value*	Reference value (Sirois and Hendrix 2015) [17]
AST (U/L)	102.21 ±18.08^b	213.65 ±44.52^a	< 0.001	**46-176**
ALT (U/L)	32.12 ±7.33^b	68.63 ±22.68^a	< 0.001	**5-35**
ALP (U/L)	92.95 ±32.34^b	182.52 ±61.18^a	< 0.001	**18-153**
Total Protein (g/dL)	6.02 ± 1.18^a	3.51 ±0.85^b	< 0.001	**6-7.5**
Albumin (g/dL)	3.62 ± 0.66^a	2.29 ±0.66^b	< 0.001	**3.4-4.3**

Different superscript letters within the same row indicate statistically significant differences ($p < 0.05$). Data are presented as the mean ± standard deviation. ***Abbreviations: ALT*** *: Alanine aminotransferase,* ***AST*** *: Aspartate aminotransferase,* ***ALP*** *: Alkaline phosphatase*

In accordance with established criteria for bovine reproductive monitoring, circulating blood progesterone values ≥ 1ng/mL across sequential sampling points were interpreted as the presence of a active corpus luteum and the resumption of ovarian cyclicity [18] and [19]. Serum progesterone concentrations were monitored twice weekly from calving through Day 30 postpartum. Resumption of postpartum ovarian cyclicity was defined as two consecutive sampling points displaying P4 ≥1ng/mL. Animals failing to meet this threshold by Day 30 were classified as acyclic. Table 3 was not intended to classify animals based solely on a single static Day-30 value. Rather, it reflects the cumulative status by Day 30 postpartum (i.e., whether an animal successfully resumed cyclicity during the 30-day window based on sequential P4 ≥1 ng/mL.

The data summarised in **Table 3** indicate that there was severe disruption to postpartum reproductive performance markers and distinct impairment in *Fasciola*-infected cows. Serum progesterone levels at 30 days post-calving were significantly higher in uninfected cows (1.30 ± 0.16 ng/mL) than in those infected with *F. hepatica* (0.25 ± 0.13 ng/mL). Consequently, 71.6% (63/88) of uninfected cows resumed ovarian activity within 30 days postpartum, whereas only 31.25% (10/32) of fluke-infected cows exhibited ovarian cyclicity within the same timeframe. Furthermore, the calving to conception interval was significantly prolonged in *Fasciola*-infected animals (120,50± 14,52 days *vs* 91,51± 20,92 days, $p < 0.001$). The number of services per conception was also higher in the infected group (+3 services) than in healthy cows (1.7-2.3 services). While, no cases of embryonic mortality were recorded in any of the study groups that were evaluated.

Table 3. Fertility parameters of Fasciola-infected and non-infected cow

Fertility parameters	Non-infected (n = 88) 73.33 %	Infected (n = 32) 26.66 %	*P value*
P4 positive at 30 day post partum (ng/mL)	1.30 ± 0.16^{a} (n= 63)	0.25 ± 0.13^{b}(n= 10)	0.01
P4 negative at 30 day post partum (ng/mL)	0.19 ± 0.17^{b} (n= 25)	0.28 ± 0.29^{a}(n= 22)	0.20
Calving Conception Interval (days)	91.51 ± 20.92^{b}	120.50 ± 14.52^{a}	< 0.001
Number of services	1.7-2.3	+ 3	//
Embryonic loss	0	0	//

Different superscript letters within the same row indicate statistically significant differences ($p < 0.05$). Data are presented as the ***mean ± standard deviation***

4. Discussion

The present study established a diagnosis of bovine fasciolosis in Montbéliarde cows from north-eastern Algeria based on distinct through key haematobiochemical parameters alterations. As illustrated in **table 1**, the hematological profiling further revealed a higher significant reductions were observed in total red blood cells, hemoglobin and hematocrit as well as red indice MCV, MCH and MCHC. Similar haematological changes have been observed in several studies, including those by Egbu et al. [20], Van Wyk et al. [21], Gattani et al. [22] and Brahmbhatt et al. [23]. Our results were in agreement with the finding of Ahmed et al. [24], Matanović et al. [25] and Yesuf et al. [26] who previously found significant reductions in hematocrit, total erythrocyte counts and hemoglobin level in sheep. A non-significant reduction in MCV was identified by Coppo et al. [27], along with increase in MCH and MCHC, in infected cattle.

A pronounced decline in total erythrocyte numbers, hemoglobin levels, and red cell indices leading to have anaemia with largely normocytic, normochromic indices has previously bee described in cases of chronic liver fluke infection. This clinical picture is characteristic of distomatosis a hepatic infection primarily driven by parasitic blood loss caused by the haematophagous feeding behaviour activity of mature adult flukes resulting in haemorrhaging from traumatised mucosa within the biliary ducts, as well as structural tissue destruction caused by migrating juvenile larvae (immature fluke stages) [12] ; [28]

The present data **(tabla 1),** The hematological response to bovine fasciolosis is typically characterized by leukocytosis, eosinophilia, basophilia and neutrophilia, offset by concurrent lymphocytopenia and monocytopenia, consistent with documented literature [20] ; [23] and [29]. Comparative observations in small ruminants reveal subtle differences. For instance, one study of Ganguly et al. [30] who found that *Fasciola* infection in sheep resulted in pronounced leukocytosis and lymphocytopenia, alongside subtle eosinophil and monocyte responses. In contrast, another study, Yesuf et al. [26] found that Fasciola infection triggered significant eosinophilic leukocytosis, but no notable changes in lymphocytes or monocytes. In bovine hosts, however, concurrent leukocytosis, neutrophilia, and eosinophilia remain prominent features [31] , indicating a generalised cellular immune response aimed at reducing tissue damage caused by flukes [32]. Our finding of a marked concurrent rise in circulating eosinophils and monocytes in the infected group is consistent with the observations of Matanović et al. [25] and Egbu [21], who also documented elevated levels of these leukocyte subsets in parasitised hosts. Conversely, this cellular profile diverge from data presented by

Shinkafi et al. [33]. These conflicting patterns observed in variations could be attributed to heterogeneity in infection chronicity, fluke density, duration or severity of infection or host-specific immunomodulatory mechanisms regulation. As shown in **table 1,** our finding indicate that the significant increase marked rise in circulating eosinophils is a critical immune response to helminth invasion and plays a pivotal role in the host's anti-parasitic defense [26].

This response is potentially mediated, by the release involving the discharge of cytotoxic particle that Target and against the damage parasite's outer surface membrane [34].

In parallel, neutrophilia is frequently observed and may be driven by secondary bacterial proliferation along the migration tracks of flukes within the liver parenchyma [29], as well as neutrophil-mediated phagocytosis directed at tegumental degradation. Concurrently, the inverse relationship between reduced lymphocyte counts (lymphocytopenia) coupled with elevated neutrophils counts reflects a systemic shift towards an acute inflammatory state during active infection as well as ongoing cellular immune rearrangement and a heightened inflammatory profile in response to the parasite [35].

A biochemical evaluation of *Fasciola*-infected cattle revealed significant hepatobiliary and systemic disturbances, demonstrating the substantial functional and metabolic strain imposed by the parasite. These serum alterations confirm extensive hepatic tissue injury and severe disruption to protein homeostasis during active fluke infestation.

The present study **(Table 2)** observed that in fluke-infected cattle, there is an increase in the activities of serum transaminases (AST and ALT) and cholestatic markers (ALP), alongside a reduction in total protein and albumin concentrations. This highlights the severity of hepatic trauma inflicted by migrating flukes in infected cattle and provides clear evidence of parasite-induced hepatobiliary injury. These biochemical shifts are consistent with previous literature [23] and [36] which states that elevated transaminases (AST and ALT) leak into the circulation as a direct consequence of larval parenchymal destruction and localised tissue inflammation. This directly signifies liver parenchymal inflammation, cellular necrosis and subsequent fibrotic changes. Concurrently, a rise in ALP levels indicates chronic irritation of the biliary tree and suggests the presence of biliary stasis and cholestatic injury caused by physical fluke obstruction of the bile ducts [23] and [27]. Metabolically, severe hepatic tissue breakdown impairs protein synthesis, manifesting as hypoproteinemia and hypoalbuminemia, which reflect compromised hepatic synthetic capacity due to parenchymal destruction, as previously researched [22], [25].

As illustrated in **Table 2**, the serum albumin and total protein concentrations consistently declined in parasitised cattle, indicating impaired hepatic synthetic capacity and chronic protein loss. This illustrates the intricate balance between reduced synthesis and systemic homeostatic adjustments during chronic infection. The hypoproteinemia and hypoalbuminemia observed in infected cows reflect a complex, multifactorial pathophysiology. In addition to the impaired hepatic synthetic capacity resulting from parenchymal damage and biliary fibrosis, other significant factors include direct blood loss caused by adult flukes, plasma protein leakage across damaged biliary mucosa and nutritional deficits induced by anorexia. Furthermore, since albumin acts as a negative acute-phase protein, systemic inflammatory signalling likely suppresses hepatic albumin synthesis, regardless of functional liver mass. In line with previous studies [23], [37], [38] and [39] has been found a significant increase in alkaline phosphatase activity, alongside other biochemical changes, suggests severe hepatobiliary impairment in cattle infected with flukes.

The leakage of these enzymes into the bloodstream reflects active parenchymal necrosis and intrahepatic cholestasis. Meanwhile, the concurrent depletion of total protein and albumin fractions indicates impaired hepatic anabolic function combined with the loss of biliary proteins [24]

Taken together, these systemic haematobiochemical disturbances demonstrate that subclinical or moderate distomatosis induces severe metabolic stress and tissue injury, resulting in persistent anaemia, systemic inflammation, and reduced livestock productivity.

Reproductive performance deficits coupled with helminthic infections are a major constraint on the efficiency of cattle production, leading to substantial financial losses within the livestock sector [21].

As summarised in **Table 3,** evaluation of postpartum reproductive metrics revealed clear functional differences between host groups. Thirty days after calving, non-infected cows had significantly higher progesterone levels in their blood than their *Fasciola* hepatica-infected counterparts. Similarly, a much greater proportion of parasite-free animals resumed ovarian cyclicity within the first month postpartum (71.6%, or 63 / 88), compared to those suffering from fasciolosis (31.25%, or 10 / 32).

Parasitism also had a severe impact on breeding performance, with infected cattle demonstrating a markedly extended calving-to-conception interval and requiring more services per successful conception. These findings align with those of López-Díaz et al. [12], who observed reduced

progesterone concentrations in fluke-infected heifers. They hypothesised that hepatic parasite migration disrupts normal sex steroid metabolism and endocrine regulation. The significant reproductive impact of fasciolosis is further emphasised by Şimşek et al. (2007) [40], who found that 58.4% of cows with repeat breeding syndrome were seropositive for Fasciola hepatica. In this context, the suppression or complete cessation of ovarian activity following parasitic infection is a secondary consequence of systemic health deterioration characterised by anorexia, progressive weight loss, severe anaemia and chronic metabolic stress [24]. Broad epidemiological evidence confirms that *Fasciola* challenge severely impairs reproductive and developmental parameters across female cattle cohorts. The detrimental impact of *Fasciola hepatica* on reproductive efficiency is well-quantified across field and epidemiological studies. Schweizer et al. [13] who demonstrated that infection significantly suppresses first-service conception rates, requiring infected cows to undergo an average of 0.75 additional inseminations per pregnancy and extending the days open by 13 days a fertility decline estimated to drive 27% of total economic losses in dairy operations. This relationship is further supported on a herd level by Charlier et al. [9], who used bulk-tank milk antibody profiling to demonstrate that high parasite exposure correlates with reduced first-service success and an extension of the inter-calving interval by 4.7 to 8 days. In replacement stock, subclinical infections similarly compromise first-service fertility by suppressing weight gain, lowering body condition scores, and altering steroidogenesis, though targeted pre-breeding anthelmintic therapy successfully restores metabolic balance and conception rates [12]. The cascade of reproductive failures induced by Fasciola hepatica stems from endocrine disruption and severe energy depletion acting in tandem.

The destruction of hepatic parenchyma by the parasite impairs cholesterol biosynthesis, the fundamental precursor of sex steroids, leading to subnormal progesterone secretion [41]. This progesterone deficit compromises luteal function and alters endometrial receptivity, inducing early embryonic mortality shortly after the first insemination [42]. At the same time, damaged liver tissue suppresses gluconeogenesis, exacerbating the negative energy balance (NEB) during the early lactation period [22]. This severe metabolic deficit suppresses pulsatile pituitary luteinising hormone (LH) secretion, impairing follicular maturation and manifesting as silent or weak oestrus at first service [43]. As a low body condition score (BCS <2.5–3.0) at insemination strongly correlates with conception failure [44], the accelerated postpartum weight loss caused by the fluke acts as a critical compound stressor that severely depresses first-service fertility. In north-eastern Algeria, the impaired reproductive performance observed in Montbéliarde dairy cattle appears to be closely linked to local eco-climatic factors that favour liver fluke transmission. The region's environmental conditions, characterised by an average annual rainfall of 700–1,000 mm and abundant vegetation, create an ideal habitat for the intermediate host snails. The presence of these vectors facilitates subclinical Fasciola hepatica infections, inducing metabolic and physiological stress in cows and ultimately compromising their reproductive efficiency and herd fertility.

5. Conclusion

In conclusion, this study demonstrates that bovine fasciolosis induces profound systemic and pathophysiological disturbances, characterised by anaemia with normocytic and normochromic indices, significant leukocytic shifts, hyperenzymemia (AST, ALT and ALP), hypoproteinemia and hypoalbuminemia. These haematobiochemical alterations directly reflect the relationship between parasite-induced hepatic parenchymal destruction and chronic metabolic impairment. This impairment is closely associated with suppressed ovarian resumption, prolonged calving-to-conception intervals and increased services per pregnancy in Montbéliarde dairy cows. Blood and metabolic analyses from this study suggest that *Fasciola hepatica* infections cause significant systemic changes, even when the disease burden in the herd appears to higher. These physiological disruptions confirm that subclinical or low-level liver fluke infestation poses a persistent threat to cattle health and productivity. Therefore, relying solely on clinical symptoms is insufficient, and livestock management frameworks must incorporate continuous epidemiological screening alongside targeted prophylactic measures to mitigate the parasite's impact effectively. Likewise, routine haematological and biochemical screening should be integrated into clinical diagnostics to facilitate early disease detection and evaluation of liver function. The cattle evaluated in this study were considered the main source of contamination as they continuously infected pastures with metacercariae due to their high levels of faecal egg shedding. To mitigate the substantial economic and reproductive burden of distomatosis, targeted educational programmes for livestock farmers, veterinarians and slaughterhouse personnel are essential to enhance field control. Further investigations into seasonal epidemiological dynamics, regional risk factors and anthelmintic resistance are also crucial to formulate sustainable management strategies.

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