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Research Article

Journal of Veterinary and Animal Sciences
ISSN (Print): 0971-0701, (Online): 2582-0605
https://doi.org/10.51966/jvas.2025.56.1.32-39

Clinico-haematological alterations in *Theileria orientalis* infection in cattle and correlation with level of parasitaemia#

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Citation: Prathyusha, S., Radhika, R., Bindu Lakshmanan, Gleeja, V.L., Syamala, K., Marykutty, T., Anjaly, S. and Justin, K.D. 2024. Clinico- haematological alterations in *Theileria orientalis* infection in cattle and correlation with level of parasitaemia. *J. Vet. Anim. Sci.* **56** (1):32-39

Received: 05.09.2024 Accepted: 19.11.2024 Published: 31.03.2025

Abstract

Oriental theileriosis caused by protozoan parasite Theileria orientalis, is one of the most economically important diseases of cattle in humid tropics. The pathogenesis of disease is primarily caused by extravascular haemolysis, which leads to anaemia in infected cattle. This study investigated the relationship between parasitaemia levels, clinical signs and haematological parameters in cattle infected with T. orientalis. By examining haematological parameters like Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC), Haemoglobin (Hb), Platelet Count, Volume of Packed Red Cells (VPRC), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin concentration (MCHC), a significant correlation between parasitaemia and haematological parameters were observed. A significant negative correlation was observed between level of parasitaemia and TEC ($r= -0.158$, $p<0.05$) as well as VPRC ($r= -0.158$, $p<0.05$). Conversely, a highly significant positive correlation was noted between level of parasitaemia and TLC ($r= 0.203$, $p<0.01$) and MCH ($r= 0.283$, $p<0.01$). Clinical symptoms such as pyrexia, lethargy, anaemia and anorexia were also observed, clinical signs intensified with increasing parasitaemia, correlating with the haematological changes. The findings provided a comprehensive understanding of clinico-haematological alterations in different levels of parasitaemia in T. orientalis infection, which is vital for improving diagnosis, prognosis and treatment protocols in infected cattle.

Keywords*: Theileriosis, parasitaemia, haematology, anaemia*

Oriental theileriosis, caused by *T. orientalis*, is an economically important protozoan infection in cattle, particularly in tropical and subtropical regions. The disease is characterised by parasite invading and proliferating inside erythrocytes as piroplasms (George *et al*., 2015). During this intraerythrocytic stage, *T. orientalis* can induce haemolysis, leading to anaemia, which is a predominant clinical manifestation. This results in varying degrees of parasitaemia, which in turn causes alterations in the host's haematological parameters (Jenkins and Bogema, 2016). The associated clinical symptoms in oriental theileriosis include pyrexia, lethargy, anaemia and anorexia. Haematological indicators such as Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC), haemoglobin concentration (Hb), Volume of Packed Red Cells (VPRC), platelet count and mean corpuscular volume (MCV) provide crucial insights into the health status

#Part of PhD thesis submitted to Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala

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of infected animals and help to evaluate the disease's severity. A significant decrease in TEC, Hb and VPRC in *T. orientalis* infection in cattle was attributed to extravascular and intravascular haemolysis (Goud *et al*., 2021; Patial *et al*., 2021; Selim *et al*., 2021).

The level of parasitaemia is widely different in various cattle in endemic areas where subclinical carriers predominate. Hence the intensity of parasitaemia need to be assessed in field conditions as this is intricately linked with pathogenesis. There are limited studies on the association of haematological changes and levels of parasitaemia in *T. orientalis* infection in Kerala. This is significant in field conditions especially in endemic areas as a decision marker for treatment and prognosis. This study aims to investigate the correlation between parasitaemia levels, clinical signs and the haematological parameters to understand the impact of *T. orientalis* in cattle and to provide valuable insights into devising appropriate therapeutic approaches.

Materials and methods

Sample collection

A total of 519 blood samples were collected from south, central and north zones of Kerala. Blood samples from apparently healthy cattle as well as cattle exhibiting clinical signs such as pyrexia, pale mucous membranes, anorexia, lethargy and drop in milk yield was examined. Thin blood smears were prepared on glass slides using a drop of blood collected from the ear vein. Blood was collected from the jugular vein of cattle using an 18-gauge needle and a 10 mL disposable syringe and transferred to a sterile Ethylene Diamine Tetra Acetic acid (EDTA) coated vial for haematological analysis. Two-year-old cattle (n=10), confirmed free of *T. orientalis* and other haemoparasites through microscopic examination of blood smears, were used as healthy controls for comparison.

Blood smear examination

Thin peripheral blood smears were stained with Field's/Giemsa's stain and examined under the oil immersion objective of a light microscope to detect the presence of piroplasms.

The level of parasitaemia was determined from stained blood smears by counting the number of parasitised erythrocytes per 2,000 red blood cells and expressing it as a percentage of parasitaemia (Shiono *et al*., 2003). The cattle were categorised based on their parasitaemia levels into the following groups: 0.05-0.14, 0.15-0.19, 0.2-0.5, 0.6-1, 1-5, 5-10 and >10 per cent (Haron *et al*., 2014).

Evaluation of haematological parameters

A complete blood count, including the following parameters such as TLC (10^3/µL), TEC (10^6/µL), Hb (g/dL), VPRC (per cent), platelet count (10^3/µL), MCV (fL), mean corpuscular haemoglobin (MCH) (pg), mean corpuscular haemoglobin concentration (MCHC) (g/dL), lymphocytes (10^3/µL), monocytes (10^3/µL), neutrophils (10^3/µL), eosinophils (10^3/µL), basophils (10^3/µL), red cell distribution width- coefficient of variation (RDW_CV) (per cent), red cell distribution width- standard deviation (RDW_SD) (fL), mean platelet volume (MPV) (fL), platelet distribution width (PDW) (fL), plateletcrit (PCT) (per cent), platelet large cell ratio (P_LCR) (per cent), platelet large cell concentration (P_LCC) (10^3/µL), nucleated red blood cells (NRBC) (10^3/µL), atypical lymphocytes (ALY) (10^3/µL), large immature cells (LIC) (10^3/µL) were analysed using an automatic haematological analyser (Orphee Mythic 5 Vet Pro) for blood smear positive *Theileria* infected cattle and compared with healthy control cattle.

Statistical analysis

Independent sample t test was performed for comparing haematological parameters of blood smear positive *Theileria* infected and healthy control cattle (Goud *et al*., 2021). Pearson correlation analysis was employed to assess the relationship between level of parasitaemia and haematological parameters (Haron *et al*., 2014).

Results and discussion

Microscopic examination

Microscopic examination of stained peripheral blood smears from 519 cattle revealed theilerial piroplasms in 36.8 per cent of samples (n=191). Of these, 184 cattle exhibiting clinical signs of theileriosis revealed intra erythrocytic theilerial piroplasms in 81 cases (44 per cent). The piroplasms were pleomorphic, *viz.* predominantly rod-like forms, comma forms, thick and thin rods with trailing cytoplasm (Fig 1), compared to annular forms such as signet ring and parachute forms (Fig 2). Examination of blood smears from 335 apparently healthy cattle revealed the presence of theilerial piroplasms in 110 cattle (32.83 per cent) identifying them as subclinical carriers. The results showed that the high prevalence of subclinical carriers suggested that *Theileria* infection might have been widespread in the state and often undetected without overt symptoms. The infection primarily affects grazing cattle that encountered the parasite early in life and subsequently became carriers after recovery (Stewart *et al*., 1990). Then they act as a source of infection for ticks, maintaining an endemic status in the herd (Shimizu *et al*., 2000). Aparna *et al*. (2011) reported prevalence rates of 52.65, 34.11, 42 and 32.16 per cent for *T. orientalis* infection in the Wayanad district of Kerala during 2007, 2008, 2009 and 2010, respectively on blood smear examination. In 2017, 46.4 per cent prevalence was reported by Priya *et al.* (2017) in cattle of the state for *Theileria* spp. and a higher rate (57.6 per cent) was observed in apparently healthy animals. The prevalence of infection observed in apparently healthy cattle in our study indicated that *T. orientalis* is acquiring

endemic stability in the state.

Haematological profile in Theileria infected cattle

Infected cattle showed significant changes in haematological parameters compared to control cattle (Table 1).

The RBC values in *T. orientalis* infected cattle were significantly lower ($p<0.05$) compared to that of the healthy control group ($8.32 \pm 0.13 \times 10^6/\mu L$). The observed mean±SE values were $4.36 \pm 0.11 \times 10^6/\mu L$ for infected cattle, indicating anaemia likely due to haemolysis or reduced erythropoiesis. These findings were in accordance with Kim *et al*. (1999), Stockham *et al*. (2000), Shiono *et al*. (2001), Goud *et al*. (2021), Shivakumar *et al*. (2022) and Kim *et al*. (2024).

Mean value of White Blood Cells (WBC) ($14.86 \pm 0.50 \times 10^3/\mu L$) in affected group was higher than control group ($10.46 \pm 0.21 \times 10^3/\mu L$) with statistically significant difference ($p<0.05$), which reflected an active immune response to infection. These findings were consistent with Goud *et al*. (2021). Conversely, Choi *et al*. (2016), Patial *et al*. (2021) and Selim *et al*. (2021) reported a significant decrease in TLC counts in *T. orientalis* infection, while Kim *et al*. (1999) found no significant reduction in TLC.

A statistically significant difference was observed in mean±SE values of eosinophils ($10^3/\mu L$) count between

Table. 1 Haematological profile in *Theileria* infected cattle

Haematology parameters	Infected cattle (Mean±SE)	Control cattle (Mean±SE)	t-value
Total RBC count ($10^6/\mu L$)	4.36 ± 0.11	8.32 ± 0.13	-22.838*
Total WBC count ($10^3/\mu L$)	14.86 ± 0.50	10.46 ± 0.21	8.194*
Hemoglobin (g per cent)	6.17 ± 0.17	10.51 ± 0.53	-6.714
Platelet count (per µL)	230.70 ± 8.49	290.80 ± 14.29	-1.862
VPRC (%)	23.58 ± 0.44	33.73 ± 1.60	-5.959
MCV	48.40 ± 0.60	45.73 ± 1.44	1.161
MCH	16.59 ± 0.31	14.40 ± 0.53	1.873
MCHC	34.28 ± 0.87	32.34 ± 0.48	0.590
Lymphocytes (%)	61.94 ± 1.22	59.75 ± 3.22	0.468
Monocytes (%)	7.81 ± 0.45	5.88 ± 0.28	1.129
Neutrophils (%)	36.92 ± 1.32	31.41 ± 2.10	1.096
Eosinophils (%)	3.39 ± 0.25	2.95 ± 0.33	1.056*
Basophils (%)	0.14 ± 0.02	0.15 ± 0.05	-0.167
Lymphocytes ($10^3/\mu L$)	9.75 ± 0.57	3.80 ± 0.46	8.096*
Monocytes ($10^3/\mu L$)	0.67 ± 0.03	0.62 ± 0.09	0.406
Neutrophils ($10^3/\mu L$)	3.06 ± 0.18	2.44 ± 0.23	0.898
Eosinophils ($10^3/\mu L$)	0.18 ± 0.02	0.14 ± 0.03	1.361*
Basophils ($10^3/\mu L$)	0.01 ± 0.00	0.01 ± 0.00	-0.669
RDW-CV	19.76 ± 0.34	16.75 ± 0.63	2.296
RDW-SD	38.47 ± 0.44	37.72 ± 0.85	0.447
MPV	8.43 ± 0.18	5.83 ± 0.36	3.896
PDW	14.69 ± 0.27	12.80 ± 1.11	1.768
PCT	0.29 ± 0.45	0.34 ± 0.07	-0.39
P_LCR	35.57 ± 10.56	31.87 ± 1.78	3.53*
P_LCC	106.43 ± 52.18	101.02 ± 14.41	0.86*
NRBC%	44.58 ± 33.59	41.36 ± 26.06	0.30
NRBC#	23.97 ± 31.09	23.11 ± 12.61	0.09
ALY%	0.70 ± 0.45	0.72 ± 0.60	-0.13
ALY#	0.06 ± 0.05	0.06 ± 0.04	0.13
LIC%	0.62 ± 0.83	0.59 ± 0.35	0.13
LIC#	0.04 ± 0.0035	0.05 ± 0.006	-0.87

*Significance at $p<0.05$

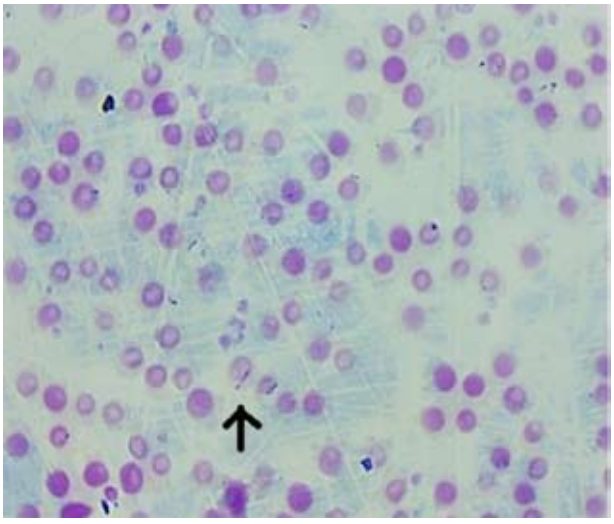

Fig. 1 Rod forms of *T. orientalis* in the erythrocytes (1000X)

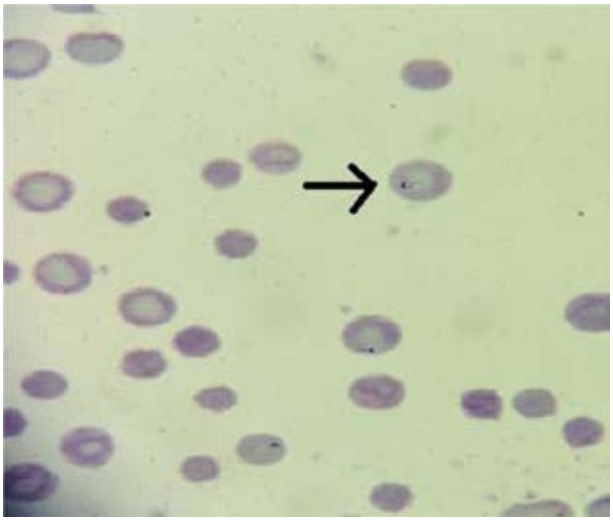

Fig. 2 Annular forms of *T. orientalis* in the erythrocytes (1000X)

healthy and infected groups ($p<0.05$). The infected group exhibited a significantly higher eosinophils count (0.18 ± 0.02× 10^3/µL) compared to control (0.14 ± 0.03× 10^3/µL). The eosinophils (mean±SE, %) count significantly differed among the groups. The observed values in *Theileria* infected cattle (3.39 ± 0.25 per cent) were significantly higher ($p<0.05$) compared to that of the healthy control group (2.95 ± 0.33 per cent). Both eosinophil percentage and counts were elevated in infected cattle, suggesting a parasitic response. This eosinophilia reflected the body's attempt to eliminate parasitic infestations. Eosinophilia observed was in agreement with findings of Selim *et al*. (2021) and Shivakumar *et al*. (2022).

A statistically significant difference was observed in mean±SE values of lymphocyte (10^3/µL) counts between the groups ($p<0.05$). The infected group exhibited a significantly higher lymphocyte count (9.75 ± 0.57 × 10^3/µL) compared to control (3.80 ± 0.46 × 10^3/µL), indicating chronic immune activation. These findings were in agreement with Stockham *et al*. (2000) and Goud *et al*. (2021). However, Shivakumar *et al*. (2022) reported lymphocytopaenia in infected cattle.

There were significant differences ($p<0.05$) in mean±SE values of Platelet Large Cell Ratio ((P_LCR) between the groups. The observed values for infected cattle (35.57 ± 10.56× 10^3/µL) were higher compared to that of control group (31.87 ± 1.78 × 10^3/µL).

The Platelet Large Cell Concentration (P_LCC) mean±SE values significantly ($p<0.05$) differ among the groups. The observed values were higher for infected (106.43 ± 52.18 × 10^3/µL) compared to control group (101.02 ± 14.41× 10^3/µL), suggested higher platelet turnover and activation.

Furthermore, no statistically significant differences were observed in platelet counts and Plateletcrit (PCT) between *Theileria* infected cattle and the control group. Although the platelet counts in the infected cattle were lower than those in the control cattle, these differences were not statistically significant. Therefore, the findings indicated that there was no marked thrombocytopenia or significant changes in platelet function or morphology as a result of infection. The infection appeared to have had a minimal impact on platelet dynamics, potentially masked by compensatory mechanisms. These results were consistent with the observations of Lawrence *et al*. (2018) and Goud *et al*. (2021), who reported that thrombocytopaenia was not a characteristic feature of *T. orientalis* infection in cattle. However, Kim *et al*. (2024) reported marked thrombocytopaenia.

Level of parasitaemia

The level of parasitaemia in apparently healthy cattle infected with *T. orientalis* was examined (Fig. 3). Among 110 cattle examined, 64.56 per cent (n=71) exhibited a parasitaemia level between 0.05 and 0.14 per cent. A total of 20.91 per cent (n=23) had parasitaemia levels ranging from 0.15 to 0.19 per cent. Additionally, 7.27 per cent (n=8) of the cattle showed parasitaemia levels between 0.2 and 0.5 per cent. A smaller proportion, 4.54 per cent (n=5), exhibited parasitaemia levels ranging from 0.6 to 1 per cent, while only 2.72 per cent (n=3) of the cattle had a parasitaemia level between 1 and 5 per cent. Cattle that had previously been exposed to and recovered from *T. orientalis* infection exhibited low parasitaemia upon subsequent exposure. However, the piroplasms persisted lifelong and relapses of clinical disease occurred under stress conditions such as pregnancy, lactation and sudden changes in environmental or management conditions (Shimizu *et al*., 2000).

The level of parasitaemia in clinically ill cattle infected with *T. orientalis* was also examined. Among 81 positive cattle, 43.21 per cent (n=35) exhibited a parasitaemia level between 0.2 and 0.5 per cent. A total of 29.63 per cent (n=24) had a parasitaemia level ranging from 0.6 to 1.0 per cent. Additionally, 20.99 per

cent (n=17) of the cattle showed parasitaemia levels between 1 and 5 per cent. A smaller proportion, 3.70 per cent (n=3), exhibited parasitaemia levels between 5 and 10 per cent, while only 2.47 per cent (n=2) of the cattle had a parasitaemia level exceeding 10 per cent (Fig. 3). These findings were consistent with those of Chae *et al*. (1996), who reported parasitaemia levels between 0.1 and 6.2 per cent in *T. sergenti* infected cattle. However, in contrast to our results, Song and Sang (2003) reported lower parasitaemia levels, ranging from 0.1 to 3 per cent, in cattle infected with *T. sergenti*. The wide variation in parasitaemia levels detected in this study was likely due to differences in parasite proliferation in cattle (Terada *et al*., 1995).

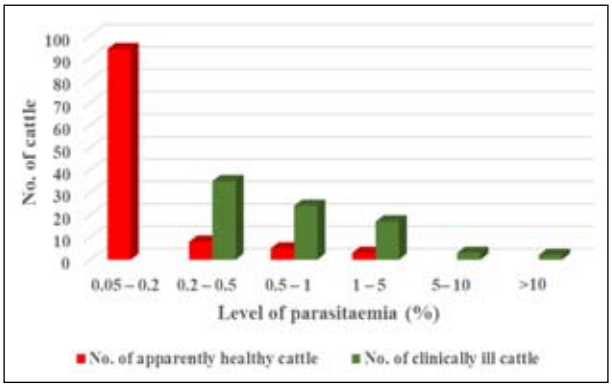

Fig. 3. Level of parasitaemia in *T. orientalis* infected apparently healthy and clinically ill cattle

The haematological analysis of *Theileria* spp. positive samples, across various parasitaemia levels, demonstrated distinct patterns. (Table 2). The TEC counts consistently declined as parasitaemia levels increased. At the lowest parasitaemia level (0.05-0.14 per cent), the TEC was recorded at 4.63 × 10^6/µL, while at the highest parasitaemia levels (>10 per cent), TEC had decreased to 3.315 × 10^6/µL. Similarly, the VPRC reduced from 24.67 per cent at lower parasitaemia levels to 18.35 per cent at the highest levels, indicating a progressive decline in red cell mass. The results demonstrated a clear association between increasing parasitaemia in *Theileria* spp. infections and significant haematological changes. The consistent decrease in TEC and VPRC with rising parasitaemia levels suggested that the parasitic infection contributed to erythrocyte depletion, leading to anaemia. The anaemia appeared to be haemolytic, as reflected by the decreasing TEC and VPRC, which aligned with haemolytic processes commonly observed in *Theileria* spp. infections. Clinically, these cattle presented with severe pallor of the mucous membranes, which were consistent with the anaemia observed. Severe anaemia caused by haemolysis from *T. orientalis* infection has been reported in endemic regions such as Australia and New Zealand by McFadden *et al*. (2011) and Lawrence *et al*. (2018), respectively. Shiono *et al*. (2001) demonstrated that anaemia in *T. orientalis* infected animals was linked to oxidative stress and erythrocyte oxidation. Elevated methaemoglobin (MetHb) levels were predominantly associated with oxidative stress, where the release of superoxide radicals from haemoglobin induced oxidative damage to erythrocytes. Shiono *et al*. (2001) also observed a significant correlation between increased MetHb levels and reduced VPRC, indicating that haemoglobin oxidation had exacerbated anaemia in infected cattle. The mean value of TEC, Hb and VPRC decreases in cattle affected by the *T. orientalis* with increase in parasitaemia in the present study, indicating severe anaemia in infected cattle. These findings were in accordance with Kim *et al*. (1999), Stockham *et al*. (2000), Shiono *et al*. (2001), Goud *et al*. (2021), Shivakumar *et al*. (2022) and Kim *et al*. (2024).

The TLC counts exhibited an upward trend with increasing parasitaemia, rising from 12.9 × 10^3/µL at the lowest parasitaemia to 17.06 × 10^3/µL at the highest parasitaemia level. The increase in leucocyte count reflected an active immune response to the parasitic infection. Clinically, these cattle exhibited fever, which was consistent with the inflammatory response and immune activation. The pyrexia in *T. orientalis* infected cattle was likely caused by interleukins IL-1 and IL-6, which stimulated the hypothalamic thermoregulatory system, while *T. orientalis* piroplasms induced interleukin production that regulated immune responses and contributed to inflammation (Stockham *et al*., 2000). However, pyrexia was not consistently observed in all infected cattle in this study. Izzo *et al.* (2010) also reported temperature

Table 2. Haematological alterations with varying levels of parasitaemia in *Theileria* spp. Infections

Level of parasitaemia (%)	TEC (10^6/µL)	TLC (10^3/µL)	Hb (g/dL)	Platelet count (10^3/µL)	VPRC (%)	MCV (fL)	MCH (pg)	MCHC (g/dL)
0.05-0.14	4.63	12.9	6.22	247.73	24.67	46.97	15.68	35.05
0.15-0.19	4.55	13.79	6.61	252.73	23.143	49.44	15.97	31.04
0.2-0.5	4.51	14.61	6.65	245.4	23.8	47.51	16.32	34.69
0.6-1	4.25	14.06	6.22	216.29	22.67	48.8	17.35	35.27
1-5	4.02	15.76	5.82	212.44	21.42	49.51	17.51	35.65
5-10	3.32	15.91	5.08	190.33	19.26	54.53	24.1	37.3
>10	3.315	17.06	4.74	210.55	18.35	58.15	24.5	40.45

Table 3. Correlation between level of parasitaemia and haematological parameters

Level of parasitaemia with	Correlation	P-value
TEC	-0.158*	0.029
TLC	0.203**	0.005
VPRC	-0.158*	0.029
MCH	0.283**	<0.001
Hb	-0.125^{ns}	0.085
Platelet count	-0.122^{ns}	0.093
MCV	0.138^{ns}	0.058
MCHC	0.044^{ns}	0.545

** Significant at 0.01 level; * Significant at 0.05 level

variations in *T. orientalis* infected cattle, with some animals exhibiting subnormal temperatures and others showing fever. These findings suggested that temperature variations in *T. orientalis* infected cattle might depend on the stage of infection.

Haemoglobin levels demonstrated a gradual decline, decreasing from 6.22 g/dL at the lowest parasitaemia to 4.74 g/dL at the highest level, indicating anaemia. The Hb levels decreased as parasitaemia increased, reinforcing the anaemic effects of *Theileria* infection. However, the relatively stable MCHC suggested that despite reductions in erythrocyte count and size, haemoglobin content per cell remained relatively consistent, possibly due to compensatory erythropoiesis mechanisms (Jackson, 2018).

Platelet counts decreased with higher parasitaemia, dropping from 247.73 × 10^3/µL at the lowest parasitaemia to 190.33 × 10^3/µL at parasitaemia levels between 5-10 per cent. However, platelet counts increased slightly to 210.55 × 10^3/µL at parasitaemia levels exceeding 10 per cent, suggesting variability among subjects.

Erythrocyte indices, such as MCV and MCH, increased with higher parasitaemia levels. The MCV values increased from 46.97 fL at lower parasitaemia to 58.15 fL at the highest levels, while MCH rose from 15.68 pg to 24.5 pg. The MCHC values increased slightly with parasitaemia, ranging from 35.05 g/dL to 40.45 g/dL. In apparently healthy cattle with exclusively low parasitaemia levels (0.05–0.19 per cent), haematological changes were evident but remained relatively mild compared to those observed in clinically ill cattle with higher parasitaemia levels (5–10 per cent). The TEC, Hb and VPRC values in cattle with a parasitaemia level of 0.05–0.19 per cent were significantly higher than those with 5–10 per cent in this study. This finding aligned with Haron *et al*. (2014), who reported that total RBC, Hb and VPRC values in cattle with a parasitaemia level of 1–3 per cent were significantly lower compared to those with below 1 per cent. Goud (2020) similarly noted that total RBC, Hb and VPRC values in apparently healthy cattle with parasitaemia levels of 0.05–0.25 per cent were higher than those in clinically ill cattle with 5–10 per cent.

Pearson correlation was employed to assess the relationship between level of parasitaemia and haematological parameters in blood smear positive cases of *Theileria* spp. (Table 3). A significant negative correlation existed between level of parasitaemia and TEC (r= -0.158, p<0.05) and VPRC (r= -0.158, p<0.05) indicating that parasitic infections likely contributed to erythrocyte depletion and anaemia. These findings were consistent with those of Goud (2020). Despite reductions in TEC and VPRC, haemoglobin levels remained unaffected, potentially due to compensatory mechanisms or variations in parasitaemia severity.

A highly significant positive correlation was found between level of parasitaemia and TLC (r= 0.203, p<0.01) and MCH (r= 0.283, p<0.01). As parasitaemia increases, TLC increases, suggesting an elevated immune response characterised by increases in neutrophil and lymphocyte counts. This response was typical of parasitic infections, in which the host's immune system attempts to combat the parasite (Izzo *et al*., 2010).

The significant increase in MCH was attributed to altered erythropoiesis or selective destruction of erythrocytes during the infection (Jackson, 2018). This finding was consistent with Sivakumar *et al*. (2017), who demonstrated that MCH increased early in host's response to haemolysis, even before significant changes in other indices affected the development of anaemia.

However, no significant correlation was found between parasitaemia levels and platelet count, implying that thrombocytopenia, a recognised consequence of parasitic infections, might have been masked by variability in parasitaemia severity among subjects. These results were consistent with the observations of Lawrence *et al*. (2018) and Goud *et al*. (2021), who reported that thrombocytopaenia was not a characteristic feature of *T. orientalis* infection in cattle. However, Kim *et al*. (2024) reported marked thrombocytopaenia.

Furthermore, no significant correlation was found between level of parasitaemia and other haematological parameters like haemoglobin, MCV and MCHC. These results highlighted the impact of level of parasitaemia on haematological parameters and its potential role in anaemia and immune response.

Conclusion

This study demonstrated the significant impact of level of parasitaemia on haematological parameters like TEC, TLC.VPRC and MCH in cattle infected with *T. orientalis*. However, in apparently healthy cattle, haematological changes were evident but remained relatively mild compared to those observed in clinically

ill cattle. The findings emphasised the importance of monitoring TEC, TLC, Hb and VPRC for diagnosing and assessing the severity of theileriosis. These indicators can guide veterinarians in formulating appropriate treatment and management strategies for affected cattle. Further research is needed to explore the specific mechanisms behind these haematological changes and to explore novel therapeutic approaches to mitigate the impact of *Theileria* infection on cattle health.

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