Part 1. Veterinary medicine

UDC 619:616.993.1:576.893.161.22:612.11:636.7(477-25) **DOI 10.36016/JVMBBS-2025-11-2-1**

IMPACT OF GIARDIA ON HEMATOLOGICAL PARAMETERS OF DOGS IN THE CASE OF SPONTANEOUS INFECTION

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Summary. *Giardia duodenalis* is a globally distributed intestinal protozoan parasite that infects a variety of hosts, including humans and domestic and wild mammals. *G. duodenalis* is localized in the small intestine, mainly in the duodenum and jejunum, and causes gastrointestinal disease in infected hosts. This study aimed to determine the effect of giardia on the hematological parameters of infected dogs. The study was conducted in a private veterinary clinic 'ZooLux' (Kyiv, Ukraine). Four groups of dogs were formed, in which coproscopic and immunologic examinations confirmed spontaneous infection. During the experiment, it was found that regardless of the presence or absence of clinical manifestations of the disease, as well as the degree of parasite load in the body of the animal, the infection was accompanied by changes in hematological parameters. In dogs of the first experimental group, the hematological changes were characterized by a slight leukocytosis (by 16.8%). At the same time, in dogs of the second experimental group, when giardia was detected in the feces, but in the absence of disease manifestations, hematological changes were characterized by the appearance of anemia, where the number of erythrocytes decreased (by 17.5%), hemoglobin content (by 5.6%), hematocrit (by 9.2%), and the average concentration of hemoglobin in erythrocytes (by 6.3%). Leukocytosis was also more pronounced (by 23.2%). In dogs of the third experimental group, in which the disease was manifested by severe diarrhea, hematological changes were characterized by severe anemia, accompanied by a decrease in the number of erythrocytes (by 22.2%), hemoglobin content (by 13.3%), hematocrit (by 14.3%), average hemoglobin concentration in erythrocytes (by 16.1%), as well as a decrease in platelets (by 27.8%) and an even greater increase in the number of leukocytes (by 46.3%)

Keywords: protozoan infection, giardiasis, blood, *Giardia duodenalis*

Introduction. The fight against domestic animal invasions is becoming increasingly important due to climate change, urbanization, and the dynamics of parasite ecology (Bogach et al., 2022; Paliy et al., 2022). The widespread prevalence of animal parasitic pathogens requires constant monitoring and the development of modern strategies to combat them (Paliy et al., 2018; Kiptenko et al., 2024).

Giardiasis is a common protozoan infection affecting both humans and domestic animals worldwide. Scientific research indicates that *Giardia duodenalis* species is domestic dogs' most prevalent gastrointestinal parasite (Palmer et al., 2008; Epe et al., 2010; Halliez and Buret, 2013; Rumsey and Waseem, 2023). The infection caused by *G. duodenalisis* is responsible for diarrhea in approximately 280 million people globally. In the United States specifically, *G. duodenalis* causes enteritis in 15,000 to 17,000 children each year. Genetic studies have identified eight genotypes of *Giardia*, with genotypes A and B primarily found in humans and other animals, making them potentially zoonotic. In contrast, genotypes C and D are specialized for infecting dogs (Capelli et al., 2006; Paoletti et al., 2008; Popruk et al., 2023).

The life cycle of the causative agent of giardiasis consists of stages that include trophozoites and cysts. Trophozoites are the vegetative form of the parasite, which are binucleate, pear-shaped flagellate structures with bilateral symmetry that colonize the proximal parts of the small intestine, especially the duodenum and, less commonly, the jejunum and ileum. In contrast, cysts are an environmentally stable phase of the parasite's life cycle. They enter the environment with the host's feces and are subsequently transmitted by the fecal-oral route. Fecal excretion of cysts facilitates zoonotic transmission of *G. duodenalis* from one host through the environment to another host (Efstratiou, Ongerth and Karanis, 2017; Ryan et al., 2019; Zahedi et al., 2020; Rojas-López, Marques and Svärd, 2022).

The widespread occurrence of *Giardia* infection is evidenced by the scientific work of many authors. In particular, in Vietnam, *G. duodenalis* was diagnosed in 8.6% of dogs based on fecal smears, and in Thailand, in 7.9% of dogs (Traub et al., 2009; Li et al., 2012). In other regions where PCR or ELISA methods were used, the prevalence of *Giardia* infection in dogs was 11–16% in China (Yang et al., 2015), 25% in Trinidad and Tobago (Mark-Carew et al., 2013), 15% in the USA (Munoz and Mayer, 2016), 21% in the UK (Upjohn et al., 2010), and 57.9% in Italy (Simonato et al., 2015).

The role of giardia in causing a wide range of clinical manifestations, from asymptomatic to acute and chronic, remains a subject of debate among scientists. Despite the fact that giardia are often found in animals with diarrhea, especially in puppies, many hosts are asymptomatic, where they are also a source of large numbers of environmentally resistant cysts (Tysnes, Skancke and Robertson, 2014). This is since the attachment of the parasite causes a loss of intestinal epithelial barrier function, facilitating the penetration of intestinal bacteria into the intestinal wall, resulting in permanent damage to the mucosal epithelium. In particular, pathological signs of the small intestine affected by giardia include villous atrophy, infiltration of granulocytes, lymphocytes, and plasma cells into the lamina propria, and mesenteric lymph node hyperplasia (Cotton, Beatty and Buret, 2011; Bartelt et al., 2013; Chen et al., 2013). Some authors suggest that alterations in the beneficial intestinal microflora are a factor contributing to the development of *Giardia* infection. However, the host-parasite interaction is not a one-way process, and changes in the host microbiome itself lead to negative effects of the parasite on the host organism as a whole (Singer and Nash, 2000).

Thus, the violation of the host-parasite equilibrium in giardiasis indicates the pathogenic effect of giardia, which may explain the variations in host symptoms, as well as changes in hematological and biochemical parameters of blood serum.

This study **aimed** to determine the effect of giardia on the hematological parameters of infected dogs.

Materials and methods. The work was carried out during 2024–2025 in a private veterinary clinic 'ZooLux' (Kyiv, Ukraine). To determine the effect of the agent of giardiasis on the hematological parameters of the infected animals, four groups of dogs (seven animals in each) were formed, including one control group, which included clinically healthy dogs with negative results of coproscopic and immunological examinations for giardiasis, as well as three experimental groups of dogs spontaneously infected with giardia. The first experimental group included dogs with a positive rapid test (VetExpert Rapid Giardia Ag, Poland), a negative coproscopic examination for giardiasis, and no clinical manifestations of infection; the second experimental group included dogs with a positive rapid test, a positive coproscopic examination for giardiasis, and no clinical manifestations of infection; the third experimental group included dogs with a positive rapid test, a positive coproscopic examination for giardiasis, and clinical manifestations of infection in the form of diarrhea.

Hematological parameters were determined using an automatic analyzer 'BC-30s' ('Mindray', China). The number of erythrocytes, leukocytes, and thrombocytes, mean concentration of hemoglobin in erythrocytes, hemoglobin content, and hematocrit were determined in the blood of control and experimental dogs.

Experiments performed on animals were conducted following the recommendations of the 'European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes' (CE, 1986) and Council Directive 2010/63/EU (CEC, 2010), and under Art. 26 of the Law of Ukraine No. 3447-IV of 21.02.2006 'About protection of animals from cruel treatment' (VRU, 2006) and basic bioethical principles (Simmonds, 2017). Under the current procedure, the research program was reviewed and approved by the Bioethics Committee of the National Scientific Center 'Institute of Experimental and Clinical Veterinary Medicine'.

The mathematical analysis of the data was performed using the Microsoft Excel software package by determining the arithmetic mean (M), standard deviation (SD), and probability level (p) using the one-factor analysis of variance technique with Fisher's test.

Results and discussion. The experimental studies revealed only a slight increase in the number of leukocytes by 16.8% (11.1 ± 1.3 G/l, $p < 0.05$) in the blood of dogs of the first experimental group compared to the same indicator in dogs of the control group (Fig. 1). All other blood parameters in the experimental dogs did not have significant deviations from those in the blood of control animals.

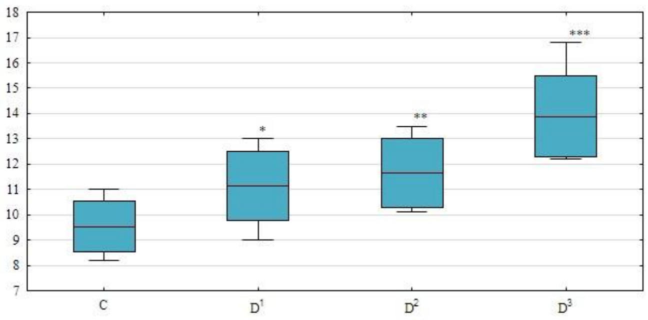

Figure 1. Indicators of the number of leukocytes (G/l) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

More significant changes were noted in the blood of dogs in the second experimental group. These changes were characterized by a 17.5% decrease in the number of erythrocytes (5.2 ± 0.4 T/l, $p < 0.05$) (Fig. 2), hemoglobin content decreased by 5.6% (135.4 ± 6.8 g/l, $p < 0.05$) (Fig. 3), the average hemoglobin concentration in erythrocytes decreased by 6.3% (309.9 ± 21.1 g/l, $p < 0.05$) (Fig. 4), and the hematocrit decreased by 9.2% (44.4 ± 3.2%, $p < 0.05$) (Fig. 5). Meanwhile, the number of leukocytes in the blood of the second experimental group increased by 23.2% (11.7 ± 1.4 G/l, $p < 0.01$) (Fig. 1), which was significantly higher than the control group. Thrombocyte counts did not differ significantly between the control group and the second experimental group.

Significant deviations from the indicators of healthy dogs were noted in the blood of dogs in the third experimental group. Specifically, the erythrocyte count decreased by 22.2% (4.9 ± 0.6 T/l, $p < 0.01$) (Fig. 2), and the hemoglobin content decreased by 13.3% (124.3 ± 11.7 g/l, $p < 0.01$) (Fig. 3), hemoglobin concentration in erythrocytes by 16.1% (277.3 ± 38.4 g/l, $p < 0.05$) (Fig. 4), hematocrit by 14.3% (41.9 ± 3.5%, $p < 0.01$) (Fig. 5), and platelet count by 27.8% (221.0 ± 40.6 G/l, $p < 0.05$) (Fig. 6).

Additionally, the number of leukocytes in the blood of the third experimental group increased significantly by 46.3% (13.9 ± 1.6 G/l, $p < 0.001$) compared to the control group and the first and second experimental groups (Fig. 1).

It is well-known that the relationship between parasites and their hosts is based on delicate molecular biology. In this regard, the pathogenic role of parasites extends beyond mechanical, toxic, and inoculatory effects on the host organism. The reactivity state of the host organism and its immunological and allergic reorganization are also important factors (Huang et al., 2020; Ruiz et al., 2024). Furthermore, the criterion for the pathogenic effect of parasites on the body includes not only a change in body weight, but also significant changes in the blood that nourishes the affected organs and tissues (Still and Konrád, 1985; Bai et al., 2017). Therefore, our research aimed to determine the effect of giardia on the hematological parameters of infected dogs.

During the experiment, it was found that the negative impact of the giardia pathogen on the hematological parameters of the experimental dogs depended on the pathogen load in their bodies and the presence or absence of clinical manifestations of the disease. In dogs confirmed to be parasitized by giardia only by rapid testing and exhibiting no clinical symptoms, hematological changes were characterized by a 16.8% increase in leukocytes.

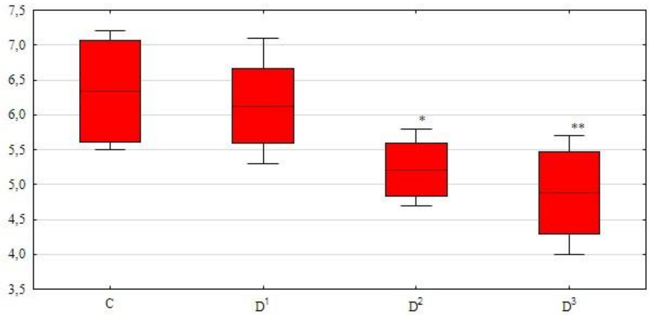

Figure 2. Indicators of the number of erythrocytes (T/l) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

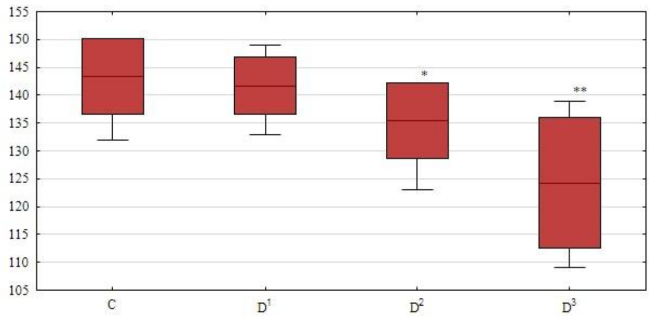

Figure 3. Indicators of hemoglobin content (g/l) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

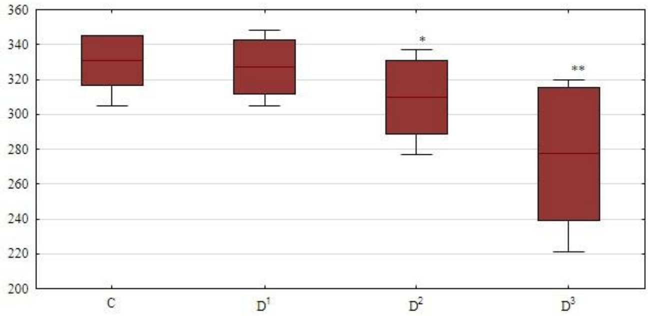

Figure 4. Indicators of the average concentration of hemoglobin in the erythrocyte (g/l) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

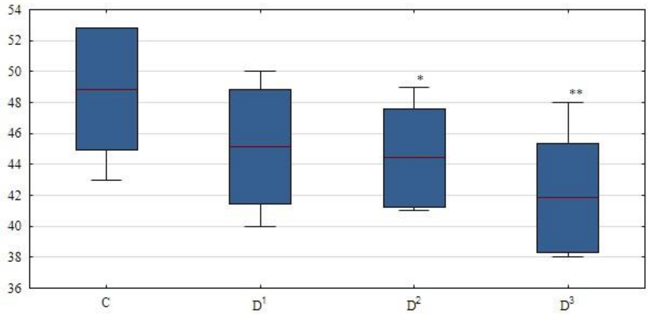

Figure 5. Hematocrit values (%) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

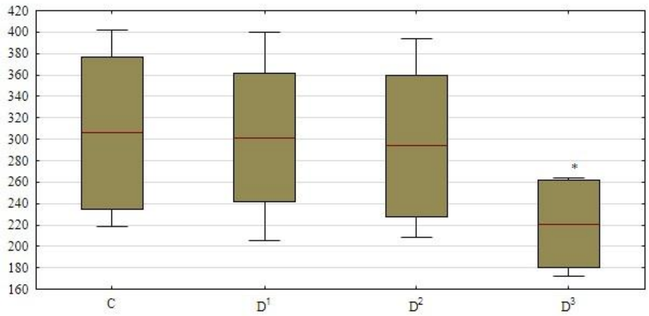

Figure 6. Thrombocyte counts (G/l) in the blood of dogs: C — control group; D^1, D^2, D^3 — 1st, 2nd, and 3rd experimental groups; * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.01$ relative to the control group.

In dogs confirmed to be infected with giardia by a rapid test and a coproscopic examination without clinical manifestations of the disease, hematological changes were characterized by a 17.5% decrease in erythrocyte count, a 5.6% decrease in hemoglobin content, a 9.2% decrease in hematocrit, a 6.3% decrease in average hemoglobin concentration in erythrocytes, and a 23.2% increase in leukocyte count. In dogs confirmed to be parasitized by giardia by a rapid test and a coproscopic examination with severe diarrhea, the hematological changes were more significant, characterized by a decrease in erythrocyte count by 22.2%, hemoglobin content by 13.3%, hematocrit by 14.3%, and average hemoglobin concentration in erythrocytes by 16.1%. There was also a decrease in thrombocytes by 27.8% and an even greater increase in leukocyte count by 46.3%.

Although there is little scientific data in the literature regarding the effects of giardiasis on hematological parameters in sick dogs, some reports do not reveal changes in hematological parameters in asymptomatic dogs (Peruzzo et al., 2023).

The results of these studies allow us to consider changes in dogs' blood depending on the parasite load and the characteristics of the clinical manifestation of the infection when prescribing complex treatment, thereby increasing its effectiveness.

Conclusions. It was found that the causative agent of giardiasis negatively affects the hematological parameters of infected dogs. The extent of the changes depends on the infection rate and manifestation of clinical signs in the dogs. Slight leukocytosis (16.8%, $p < 0.05$) was detected in the blood of dogs confirmed to have giardiasis by a rapid test, with no giardia found in their feces or clinical manifestations of infection. In dogs confirmed to have giardiasis by a rapid test and coproscopic examination, with no clinical signs of infection, signs of anemia were found due to a decrease in erythrocytes (17.5%, $p < 0.05$) and hemoglobin content (by 5.6%, $p < 0.05$). Hematocrit decreased by 9.2% ($p < 0.05$), and the average hemoglobin concentration in erythrocytes decreased by 6.3% ($p < 0.05$). A pronounced leukocytosis was also detected (by 23.2%, $p < 0.01$). In dogs confirmed to have giardiasis by a rapid test and coproscopic examination with severe diarrhea, significant changes were found in hematological parameters, characterized by a decrease in erythrocyte count (22.2%, $p < 0.01$), platelets (27.8%, $p < 0.05$), hemoglobin content (13.3%, $p < 0.01$), hematocrit (14.3%, $p < 0.01$), and average hemoglobin concentration in erythrocytes (16.1%, $p < 0.05$), as well as an increase in the number of leukocytes (46.3%, $p < 0.001$).

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Received 17.04.2025 **Accepted 11.05.2025** **Published 25.06.2025**

 0009-0001-2243-7372