

## The general reaction of dogs in the acute stage babesia invasion

V.A. Gryshchenko, D.S. Bilokur

National University of Life and Environmental Sciences of Ukraine, Ukraine

\*Corresponding author E-mail: viktoriya\_004@ukr.net

Received: 30.06.2021. Accepted: 10.07.2021.

Canine babesiosis is a parasitic blood disease manifested by fever, anemia, jaundice of the visible mucous membranes, and hemoglobinuria. Generalized damage to internal organs and corresponding systems for this pathology significantly complicates its course, requires constant monitoring of the functional state of the organism of sick animals. The paper summarizes six cases of babesiosis in dogs of the Labrador breed at the age of 3 to 5 years. Morphological and biochemical blood tests and clinical analysis of urine parameters, and microscopy of its sediment were carried out. In particular, we found that during the acute stage of babesiosis in sick dogs, characteristic changes in the morphological blood profile are leukopenia with a decrease in the number of stab neutrophils with the simultaneous compensatory manifestation of basophilia and monocytosis, as well as erythrocytopenia, hypochromia, thrombocytopenia against the background of a decrease in hematocrit and thrombocytopenia. The most pronounced changes in canine babesiosis relate to the aminotransferase activity of blood plasma, particularly the development of hyperenzymemia of aspartate aminotransferase and alanine aminotransferase, respectively, 5 and 3 times compared with the control. In addition, in sick animals, hypoproteinemia, hypoalbuminemia and hyperazotemia are noted, which indicates a violation of homeostasis and the predominance of catabolic processes in the cells of internal organs primarily the liver. We registered a pronounced brown color and turbidity of urine, erythrocyturia, hemoglobinuria, leukocyturia, and proteinuria, which indicates the simultaneous development of nephropathy in dogs with babesiosis. Regularities have been established regarding changes in morphological and biochemical parameters of blood and urine at an early stage of babesiosis, which is essential for elucidating the pathogenesis of this pathology, determining the features of functional changes in the body of sick dogs, and for developing new approaches in their diagnosis, prevention of complications and treatment of animals.

**Keywords:** Canine babesiosis, acute stage, *Babesia canis*, hematological studies, clinical urinalysis, functional and metabolic disorders.

### Introduction

Babesiosis is a transmissible, natural focal disease of dogs, cats, fur-bearing animals, and wild carnivores caused by protozoa of the genus *Babesia*, which are carried by ticks the genus *Ixodidae* (Yisaschar-Mekuzas et al., 2013). It is distributed worldwide, including in most regions of Ukraine (Mokry & Ksyonz, 2017; Panti-May & Rodriguez-Vivas, 2020; Dantas-Torres et al., 2021).

People who are sick with babesiosis are also of concern (Herwaldt et al., 1996). More than 400 human cases have already been described in the United States and 21 in Europe (Solano-Gallego et al., 2016). If we consider that after recovery, animals develop non-sterile immunity lasting 1–2 years, then the problem of further study of this invasion remains relevant (Mierzejewska et al., 2014; Strobl et al., 2020).

*Babesia* parasitizes mainly in erythrocytes and can be found in blood plasma and cytoplasm of cells of the reticuloendothelial system (Solano-Gallego et al., 2008; Scheepers et al., 2011). In sick animals, *Babesia canis* causes intravascular destruction of erythrocytes, which leads to hypotensive shock and complete tissue damage due to oxygen deficiency (Miro et al., 2015). At the same time, the most characteristic changes in erythrocytes in the peripheral bloodstream are oligocythemia with anisocytosis and poikilocytosis, development of oligochromemia, and a decrease in the hematocrit index, and macrocytosis. Along with this, significant changes in the morphofunctional state of erythrocytes are found in sick animals. In particular, this concerns the population composition of erythrocytes, the number of "old" cells increases, which are rapidly destroyed, the number of "young" forms decreases, and the time of their hemolysis decrease. There is an increase in the level of free iron in the blood and a decrease in the saturation of transferrin with a trace element. This leads to a disruption in the synthesis of hemoglobin in the red bone marrow, which is manifested by anemia, jaundice of the visible mucous membranes, hemoglobinuria (Strobl et al., 2020).

*Babesia* metabolic products exhibit toxic properties and act as pyrogens, which irritate the thermoregulatory center, resulting in persistent fever. Moreover, during the first hours of the disease, normocytic, normochromic, and non-regenerative anemia develops, and on days 2-3 - macrocytic, hypochromic with reticulocytosis. In addition, in the pathogenesis of babesiosis in dogs, there is a violation of the activity of the organs of the cardiovascular, urinary, and digestive systems, and for a severe form - cerebral pathology (Mohr et al., 2000; Fraga et al., 2011; Henning et al., 2020). Simultaneous damage to the kidneys (violation of filtration, excretory and secretory functions), liver, and heart significantly complicate the course of the disease, provides for constant monitoring of the functional state of the organism of sick animals (Dvir et al., 2004; Fraga et al., 2011). Therefore, a general analysis of blood and urine for this pathology is a standard approach in determining the functional state of the body but also the degree of damage to internal organs in sick animals. The problem of multiple organ failure in babesiosis invasion of dogs remains relevant at present, which prompts further study of the pathogenesis of the disease and the search for new informative methods for assessing the functional state of internal organs.

Now clinical laboratory diagnostics is distinguished by a significant arsenal of tests and methods for early and relatively accurate diagnosis of a significant part of the known forms of animal pathologies, including babesiosis, and also allows for tracking the course

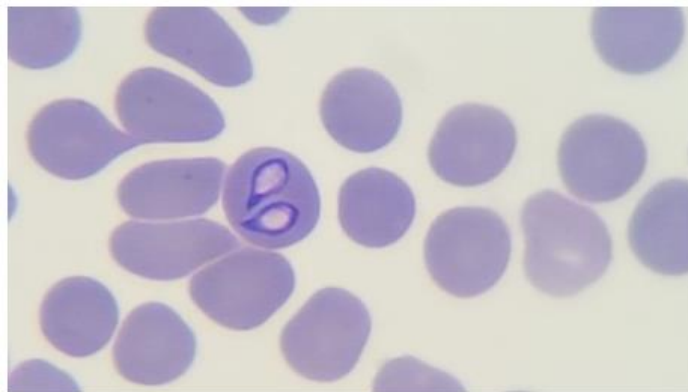
of the pathological process, the development of possible complications and the effectiveness of treatment (Panti-May & Rodriguez-Vivas, 2020; Torti et al., 2020). In the case of babesiosis, changes in the biochemical parameters of biological material samples are not specific. However, comparing them with the norm indicators, it is possible to assess the degree and nature of metabolic disorders in the body of a sick animal.

Our study aimed to determine the characteristic functional and metabolic changes in dogs' bodies in the acute stage of babesiosis using blood and urine parameters.

## Materials and Methods

The paper summarizes six cases of the disease in dogs of the Labrador breed with babesiosis at the age of 3 to 5 years. All types of research were carried out based on the diagnostic laboratory of the clinic "Zoolux" (Kyiv, Dmitrievskaya st., 39).

The subject of the study was blood and urine. Blood was collected from sick dogs from the anterior saphenous vein of the forearm. Urine was obtained by cystocentesis. In all dogs, the diagnosis was confirmed microscopically by the presence of *B. canis* blood smears in erythrocytes (Fig. 1).



**Fig. 1.** Blood smear with *Babesia canis* in erythrocytes of dogs with Babesiosis.

At the same time, the lesion of erythrocytes with babesia corresponded to the low and medium intensity of invasion and the acute stage of the development of the disease (1-2 days of clinical manifestation).

Blood samples were taken from animals for hematological (morphological and biochemical) studies. Morphological analysis of heparin-stabilized blood was carried out on a Dymind DF50 analyzer (China). The study of the morphological profile of blood included determining the absolute number of leukocytes and the ratio of their types (leukogram), the absolute number of erythrocytes, platelets, thrombocytes, hematocrit, and hemoglobin content (for the diagnosis of anemia).

To obtain plasma, native blood was centrifuged at 3000-3500 thousand rpm for 15 minutes. Biochemical studies of blood plasma included: measurements of the activity of Aspartate transaminase (AST, EC 2.6.1.1), Alanine transaminase (ALT, EC 2.6.1.2),  $\gamma$ -glutamyl transpeptidase (GGT, EC 2.3.2.2), alkaline phosphatase (ALP, EC 3.1.3.1), the content of total protein, albumin, creatinine, urea, total bilirubin and its conjugated fraction, glucose, cholesterol, potassium, calcium, magnesium, phosphorus, which were carried out on a StatFax 4500 biochemical analyzer (USA).

According to the following scheme, the study of organoleptic, physical, and biochemical parameters of urine was carried out according to the following scheme: determination of its color, transparency, and relative density; the presence and content of glucose, protein, creatinine, and ketones. After centrifugation of urine samples at 2000-2500 thousand rpm for 5 min, sediment microscopy was performed. Biochemical analysis of urine parameters was carried out using StatFax 4500 (USA) and Rayto RT-9600 (China) analyzers.

In carrying out these studies, reagents from Global Scientific (USA) were used.

The experimental data were statistically processed using the STATISTICA 5.0 software package (Stat Soft, USA) using Student's criteria with normal distribution. Differences between the data were considered significant at  $p < 0.05$ .

## Results and Discussion

During the acute stage of babesiosis development in Labrador dogs, a 38% decrease in the number of leukocytes in the blood (leukopenia) was noted, which was manifested against the background of a 1.9-fold decrease in the number of stab neutrophils compared to the control. The established fact of leukopenia with a decrease in the number of young forms of neutrophils is an indicator of a decrease in the reactivity of the body in sick animals, which may be due to inhibition of the function of the organs of leukocytopoiesis (bone marrow, spleen, lymph nodes) (Gryshchenko, 2017) in response to the infection of blood cells with babesia and the development of intoxication. At the same time, in the animals of this group, in comparison with the control, an increase of 1.8 times was noted in both the number of basophils (basophilia) and monocytes (monocytosis), which is a manifestation of the protective reaction of the dog's body and indicates the active development of phagocytosis of protozoa, products breakdown of erythrocytes and endotoxins (Table 1).

Indicator	Reference norms	Control	Dogs with Babesiosis
Leukocytes, $10^9/l$	4.5–15.5	$7.1 \pm 0.9$	$4.4 \pm 0.7^*$
Stab leukocytes, %	0–3	$1.7 \pm 0.2$	$0.9 \pm 0.1^*$
Segmental leukocytes, %	60–77	$68.5 \pm 2.7$	$70.2 \pm 1.9$
Eosinophiles, %	2–10	$2.4 \pm 0.5$	$1.6 \pm 0.4$

Basophils, %	0–1	0.5 ± 0.1	0.9 ± 0.1*
Monocytes, %	0–10	7.3 ± 0.8	13.0 ± 1.5*
Lymphocytes, %	12–30	21.6 ± 2.8	15.4 ± 1.7
Erythrocytes, 10 <sup>12</sup> /l	4.8–9.3	6.1 ± 0.8	4.5 ± 0.4*
Hemoglobin, g/l	120–180	127.0 ± 4.2	105.1 ± 2.1*
Hematocrit, %	36–55	43.5 ± 1.2	33.0 ± 1.7*
Platelets, 10 <sup>9</sup> /l	170–500	339.3 ± 17.1	51.3 ± 2.2*
Thrombokrit, %	0.14–0.46	0.3 ± 0.1	0,04 ± 0.01*

**Note:** \*P<0,05, statistically significant differences compared to control.

**Table 1.** Morphological and biochemical parameters in the blood of dogs in the acute course of babesiosis (M ± SD, n=6).

In addition, as a result of the morphological study of blood in sick dogs, anemia was diagnosed, which was confirmed for four out of six animals. At the same time, a decrease in the number of erythrocytes by 26% (erythrocytopenia) and hemoglobin content by 17% (hypochromaemia) was noted in the blood, while the hematocrit value decreased by 24% (Table 1).

Minor deviations from the reference boundaries of these indicators are explained by identifying the causative agent of babesiosis in dogs at an early stage of the development of the disease. At the same time, the most pronounced changes were established by the number of platelets in the blood of sick animals and the value of thrombocytes. So, in sick animals, the number of platelets differed by values seven times less from the control ones (thrombocytopenia), and the value of thrombocyte decreased by eight times compared to clinically healthy animals. In particular, thrombocytopenia was detected in the blood smears of all studied dogs.

So, in dogs with babesiosis, characteristic changes in the morphological blood profile are leukopenia (due to a decrease in stab neutrophils), basophilia, monocytosis, erythrocytopenia, hypochromia, thrombocytopenia, manifested against the background of a decrease in hematocrit and thrombocyte. A significant decrease in the number of erythrocytes and hemoglobin content in sick animals due to intravascular hemolysis provokes the development of anemia and, consequently, circulatory and tissue hypoxia, which causes changes in homeostasis (Liebenberg et al., 2013).

Due to the vital activity of *Babesia canis* and pathological changes in the circulatory system of sick dogs, there is an increase in the activity of some enzymes in the blood plasma. Thus, in patients with babesiosis of dogs during the acute stage of invasion, hyperenzymemia of aspartate aminotransferase (AST) by five times, alanine aminotransferase (ALT) by three times,  $\gamma$ -glutamyltranspeptidase ( $\gamma$ -GTP) and alkaline phosphatase (ALP) by two times, respectively, were established compared with control (Table 2). Thus, the enzymes AST and ALT were sensitive during the acute stage of babesiosis in dogs. Since the studied enzymes belong to the nonspecific group, regularities have been established that indicate the generalized nature of structural and functional changes in the internal organs of sick dogs (Gryshchenko, 2017). Moreover, they are relatively specific for organs such as the liver, heart, skeletal muscles, kidneys, and brain, which indicates their involvement in the pathological process. Disorders of the functional state of these organs in this blood-parasitic disease, first of all, are associated with general intoxication of the body with waste products of babesia, damage to erythrocytes, and their intravascular hemolysis, as well as pronounced hepatotoxicity of medicinal preparations.

Indicator	Reference norms	Control	Dogs with Babesiosis
Aspartate aminotransferase, U/L	5–55	30.3 ± 0.8	157.2 ± 6.9*
Alanine aminotransferase, U/L	5–107	56.1 ± 1.9	160.3 ± 8.5*
$\gamma$ -glutamyl transpeptidase, U/L	0–14	6.7 ± 0.6	14.1 ± 0.8*
Alkaline phosphatase, U/L	10–150	80.5 ± 2.6	128.7 ± 5.7*

**Note:** \*P<0,05, statistically significant differences compared to control.

**Table 2.** Plasma enzymes in dogs with acute babesiosis (M ± SD, n=6).

Along with this, among the biochemical parameters of blood plasma, the content of total protein undergoes significant changes against the background of hypoalbuminemia, which decreases by 15% concerning the control, which leads to a natural increase in the concentration of urea by 28% and is a reflection of the increased course of catabolic processes (Gryshchenko & Minina, 2020), primarily in hepatocytes (Table 3).

Due to the intensive development of tissue hypoxia, the primary source of energy for parasites is anaerobic glycolysis, the intensive course of which leads to excessive formation of lactate. An increase in the latter's concentration in the blood causes the development of lactic acidosis (Torti et al., 2020). The latter's emergence also enhances the increase in vascular permeability, vasodilation, arterial hypotension, and blood stagnation, which are characteristic of the pathogenesis of this blood-parasitic disease. A shift in the active reaction of the blood and the intracellular environment to the acidic side also provokes a decrease in sensitivity to circulating catecholamines, an increase in lipid peroxidation of cell membranes, a violation of oxidative phosphorylation processes, a sharp decrease in the production of adenosine triphosphoric acid and, in general, affects the activity of enzymes. As a result, changes occur in the direction and intensity of metabolic processes. Further progression of this condition is known (Mohr et al., 2000; Dvir et al., 2004; Defauw et al., 2012; Henning et al., 2020; Strobl et al., 2020) leads to irreversible violations of the structural organization of specialized cells and the functional state of several internal organs (in particular, liver, heart, kidneys, brain). At the same time, at this stage of the disease in dogs, the total bilirubin level and its conjugated fraction remained unchanged (Table 3).

Indicator	Reference norms	Control	Dogs with Babesiosis
Total protein, g/L	51–78	64.5 ± 1.4	55.0 ± 1.1*
Albumin, g/L	24–44	32,1 ± 1,1	27.3 ± 0.9*
Creatinine, µmol/L	44–138	79.2 ± 3.1	80,9 ± 2.2
Urea, mmol/L	2,5–9,6	6.1 ± 0.2	7,8 ± 0.5*
Cholesterol, mmol/L	2.4–8.4	4.8 ± 0.3	4.2 ± 0.2
Glucose, mmol/L	3.9–8.3	6.1 ± 0.3	5.5 ± 0.2
Total bilirubin, µmol/L	0–5	2.5 ± 0.3	2.9 ± 0.1
Direct bilirubin, µmol/L	0–3	1.5 ± 0.1	1.4 ± 0.2
Potassium, mmol/L	3.6–5.5	4.6 ± 0.2	4.4 ± 0.3
Calcium, mmol/L	2.2–3.0	2.6 ± 0.1	2.3 ± 0.4
Phosphorus, mmol/L	0.68–2.00	1.34 ± 0.15	1.43 ± 0.19
Magnesium, mmol/L	0.7–1.1	0.9 ± 0.1	0.8 ± 0.1

**Note:** \*P<0,05, statistically significant differences compared to control.

**Table 3.** Biochemical parameters of blood plasma in dogs with an acute course of babesiosis (M ± SD, n=6).

So, the most pronounced changes among the biochemical parameters of blood plasma in dogs in the acute course of babesiosis invasion were tested: the activity of aminotransferases -AST and ALT, the content of total protein, albumin, urea, confirming the presence of structural and functional changes in hepatocytes with this pathology and may be a consequence of not only the toxic effects of babesia on the liver parenchyma but also the result of the use of potent drugs.

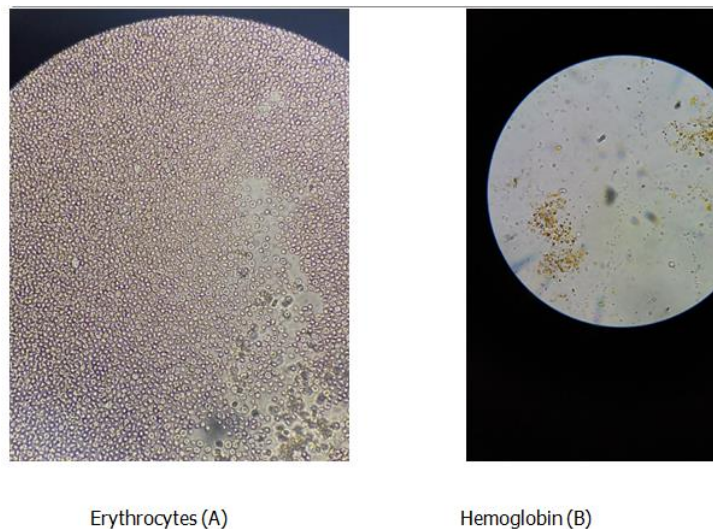
Urine samples from three babesiosis dogs were also examined. Urine was collected using the cystocentesis method.

Analysis of urine samples obtained from sick animals indicates changes in the parameters of all studied parameters. In particular, the urine of selected sick animals was brown and cloudy (Fig. 2). Its relative density, which is a morphofunctional characteristic of renal tubule cells and reflects the body's state of hydration, averaged 1.038. In most cases, microscopy of a native smear revealed the presence of erythrocytes, leukocytes, and epithelial cells (Fig. 3).



**Fig. 2.** The appearance of a urine sample from a dog with babesiosis.





**Fig. 3.** Erythrocytes (A) and hemoglobin (B) in the native urine sediment preparation, 40x magnification.

The protein content in urine samples averaged 3.1 mmol/L, which indicates an increase in the permeability of the glomerular capillary wall for high molecular weight compounds. The concentration of creatinine corresponded to an average value of 5840.4 mmol/L.

## Conclusion

In the acute stage of babesiosis invasion in sick Labrador dogs, the hematological profile is leukopenia (due to a decrease in stab neutrophils) with a simultaneous compensatory manifestation of basophilia and monocytosis, erythrocytopenia, hypochromia, thrombocytopenia with a decrease in hematocrit and thrombocyte. As a result of studying the activity of many enzymes, the most pronounced changes at this stage of parasitic blood disease in dogs experience aminotransferase activity of blood plasma. In particular, the development of hyperenzymemia of both AST and ALT was established, respectively, 5 and 3 times, which indicates structural and functional changes in the internal organs, are of a generalized nature and, first of all, concern the liver, heart, skeletal muscles, kidneys and brain as a result of their toxic damage by waste products of babesia. In addition, in sick animals, hypoproteinemia, hypoalbuminemia, and hyperazotemia are noted, which indicates a violation of homeostasis and the predominance of catabolic processes in the cells of internal organs, primarily the liver. This makes it possible to use these indicators as biochemical markers to determine the functional state of dogs' body in the acute stage of babesiosis.

In these dogs, changes in the organoleptic, physical, and biochemical parameters of urine are also noted. In particular, it is a pronounced brown color and its turbidity, erythrocyturia, hemoglobinuria, leukocyturia, proteinuria. The results obtained indicate the development of nephropathy in dogs with babesiosis in the acute course and the need to take this fact into account when prescribing therapeutic regimens, including those aimed at restoring the functional state of the kidneys.

The severity of changes in the blood and urine can be influenced by the degree and duration of invasion and individual characteristics of the dog's organism. Regularities have been established regarding changes in the morphological and biochemical parameters of blood and urine, which are essential in elucidating the pathogenesis of this pathology, determining the features of functional changes in the body of sick animals, and also for developing new approaches in their diagnosis, prevention of complications and treatment of animals.

## References


- Dantas-Torres, F., Alexandre, J., de Oliveira Miranda, D.E., Figueredo, L.A., da Silva Sales, K.G., de Sousa-Paula, L.C., Altreuther, G. (2021). Molecular epidemiology and prevalence of babesial infections in dogs in two hyperendemic foci in Brazil. *Parasitology Research*, pp:1-7.
- Defauw, P., Schoeman, J.P., Smets, P., Goddard, A., Meyer, E., Liebenberg, C., Daminet, S. (2012). Assessment of renal dysfunction using urinary markers in canine babesiosis caused by *Babesia rossi*. *Veterinary Parasitology*, 190:326-332.
- Dvir, E., Lobetti, R.G., Jacobson, L.S., Pearson, J., Becker, P.J. (2004). Electrocardiographic changes and cardiac pathology in canine babesiosis. *Journal of Veterinary Cardiology*, 6:15-23.
- Fraga, E., Barreiro, J.D., Goicoa, A., Espino, L., Fraga, G., Barreiro, A. (2011). Abdominal ultrasonographic findings in dogs naturally infected with babesiosis. *Veterinary Radiology & Ultrasound*, 52:323-329.
- Gryshchenko, V. (2017). Biohimichnyj profil' plazmy krovi shhuriv za eksperymental'nogo gepatytu na tli vvedennja natriju dyklofenaku [Biochemical properties of the plasma of rats with the experimentally induced hepatitis after oral administration of sodium diclofenac]. *Regulatory Mechanisms in Biosystems*, 8:191-196.
- Gryshchenko, V.A. (2017). Gematologichnyj profil'u shhuriv pry eksperymental'nomu dyklofenak-indukovanomu gepatyti [Hematological profile of rats in experimental diclofenac-induced hepatitis]. *Ukrainian Journal of Ecology*, 7:78-83.
- Gryshchenko, V.A., Minina, V.S. (2020). Marker changes of blood plasma proteinogram in rats with toxic hepatitis. *Regulatory Mechanisms in Biosystems*, 11:360-366.
- Henning, A., Clift, S.J., Leisewitz, A.L. (2020). The pathology of the spleen in lethal canine babesiosis caused by *Babesia rossi*. *Parasite Immunology*, 42:e12706.
- Herwaldt, B.L., Persing, D.H., Precigout, E.A., Goff, W.L., Mathiesen, D.A., Taylor, P.W., Gorenflot, A.F. (1996). A fatal case of babesiosis in Missouri: identification of another piroplasm that infects humans. *Annals of Internal Medicine*, 124:643-650.
- Liebenberg, C., Goddard, A., Wiinberg, B., Kjelgaard-Hansen, M., Van der Merwe, L.L., Thompson, P. N., Schoeman, J.P. (2013). Hemostatic abnormalities in uncomplicated babesiosis (*Babesia rossi*) in dogs. *Journal of Veterinary Internal Medicine*, 27:150-156.

- Mierzejewska, E.J., Welc-Faleciak, R., Bednarska, M., Rodo, A., Bajer, A. (2014). The first evidence for vertical transmission of *Babesia canis* in a litter of Central Asian Shepherd dogs. *Annals of Agricultural and Environmental Medicine*.
- Miró, G., Checa, R., Papparini, A., Ortega, N., González-Fraga, J. L., Gofton, A., Irwin, P. (2015). *Theileria annae* (syn. *Babesia microti*-like) infection in dogs in NW Spain detected using direct and indirect diagnostic techniques: clinical report of 75 cases. *Parasites & Vectors*, 8:1-11.
- Mohr, A.J., Lobetti, R.G., Van der Lugt, J.J. (2000). Acute pancreatitis: a newly recognised potential complication of canine babesiosis. *Journal of the South African Veterinary Association*, 71:232-239.
- Mokryi, Y.O., Ksyonz, I.M. (2017). Epizootology monitoring of babesial invasion among dogs in Poltava. *Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies named after SZ Gzhytskyj*, 19:149-153.
- Panti-May, J.A., Rodríguez-Vivas, R.I. (2020). Canine babesiosis: A literature review of prevalence, distribution, and diagnosis in Latin America and the Caribbean. *Veterinary Parasitology: Regional Studies and Reports*, 21:100417.
- Scheepers, E., Leisewitz, A.L., Thompson, P.N., Christopher, M.M. (2011). Serial haematology results in transfused and non-transfused dogs naturally infected with *Babesia rossi*. *Journal of the South African Veterinary Association*, 82:136-143.
- Solano-Gallego, L., Sainz, Á., Roura, X., Estrada-Peña, A., Miró, G. (2016). A review of canine babesiosis: the European perspective. *Parasites & Vectors*, 9:1-18.
- Solano-Gallego, L., Trotta, M., Carli, E., Carcy, B., Caldin, M., Furlanello, T. (2008). *Babesia canis canis* and *Babesia canis vogeli* clinicopathological findings and DNA detection by means of PCR-RFLP in blood from Italian dogs suspected of tick-borne disease. *Veterinary parasitology*, 157:211-221.
- Stępień-Pyśniak, D., Marek, A., Banach, T., Adaszek, Ł., Pyzik, E., Wilczyński, J., Winiarczyk, S. (2016). Prevalence and antibiotic resistance of *Enterococcus* strains isolated from poultry. *Acta Veterinaria Hungarica*, 64:148-163.
- Torti, M., Kuleš, J., Matijatko, V., Brkljačić, M., Kiš, I., Gotić, J., Šmit, I. (2020). Acid-base status in canine babesiosis caused by *Babesia canis*. *Veterinarski Arhiv*, 90:603-610.
- Yisaschar-Mekuzas, Y., Jaffe, C.L., Pastor, J., Cardoso, L., Baneth, G. (2013). Identification of *Babesia* species infecting dogs using reverse line blot hybridization for six canine piroplasms, and evaluation of co-infection by other vector-borne pathogens. *Veterinary parasitology*, 191:367-373.

---

**Citation:**

Gryshchenko, VA., Bilokur, DS. (2021). The general reaction of dogs in the acute stage babesian invasion. *Ukrainian Journal of Ecology*, 11 (5), 85-90.

 This work is licensed under a Creative Commons Attribution 4.0. License

---