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Original article

Values of white and red blood cell parameters in Polish mixed breed rabbits in the annual cycle

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Abstract

The aim of the study was to develop reference values for such haematologic values as haemoglobin concentration, haematocrit value, volume of erythrocytes, thrombocytes, leucocytes, lymphocytes, neutrophils, basophils, eosinophils and monocytes in peripheral blood in Polish mixed-breed rabbits, considering the impact of the season (spring, summer, autumn, winter), and sex of the animals. The results reveal, that the season of the year has a small impact in Polish mixed-breed rabbits, and it principally referred to spring and summer. Finally it was shown, that sex has average impact on the studied values of haematological parameters.

Key words: haematology, reference values, mixed breed rabbits, annual cycle

Introduction

The analysis of haematological indices, both in physiological and pathological conditions in mammals, constitute the starting point for determining their health. Moreover, due to their relatively easy determination, they belong to generally measured, both in farming and laboratory animals, including rabbits (also in Polish mixed-breed rabbit), animals used in experimental research and diagnostics. Furthermore, in Polish conditions, Polish mixed-breed rabbits are commonly bred animals, what additionally causes the need for monitoring their health, including blood parameters, for which there are no standards for such animals in Poland.

Domestic haematological studies leading to the development of reference values in Polish mixed-breed rabbits are rather modest (Table 1), and even fewer of them refer to the assessment of the impact of environmental elements, namely the season of the year (Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005) and physiological factors, namely sex (Niedźwiedzka-Rystwej and Deptuła 2010), on haematological picture in such animals. Also in domestic books (Knorr 1980, Katkiewicz 1989, Brylińska and Kwiatkowska 1996, Deptuła et al. 2003, Winnicka 2011, Szarek et al. 2013), despite presenting values for haematological factors in rabbits, there is no indication of the type of rabbit, or environmental and physiological factors. The research by foreign authors have been performed

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on rabbits of many races (New Zealand, Agora, Czech and Sylvilagus Bachmani Riparius, cottontail, Soviet Chinchilla, grey giant, albino), many unspecified mixed-breed rabbits (Table 2), but only some of them have analysed the impact of the season of the year (Pintor and Grassini 1957, Black et al. 2009, Cetin et al. 2009, Abdel-Azeem et al. 2010, Yaqub et al. 2013), sex (Fox and Laird 1970, Kabata et al. 1991, Aleman et al. 2000, Kim et al. 2002, Burnett et al. 2006, Chineke et al. 2006, Black et al. 2009, Çetin et al. 2009, Poljičak-Milas et al. 2009, Abdel-Azeem et al. 2010, Ozkan et al. 2012, Yaqub et al. 2013), age (Bortolotti et al. 1989, Chineke et al. 2006, Olayemi and Nottidge 2007, Archetti et al. 2008, Jeklova et al. 2009, Yaqub et al. 2013), and race of rabbits (Cazabon et al. 2000, Rohilla et al. 2000, Burnett et al. 2006, Chineke et al. 2006, Martinec et al. 2012, Yaqub et al. 2013). Also, worldwide book elaborations (Feldman et al. 2000, Harkness et al. 2007) regarding reference values for haematological parameters in rabbits, present such values only for New Zealand rabbits.

The general use of mixed-breed rabbits in Poland, both for scientific and diagnostic research, and their general breeding to obtain meat and fur, caused the need for developing reference values for haemoglobin concentration, haematocrit value, volume of erythrocytes, thrombocytes, leucocytes, lymphocytes, neutrophils, basophils, eosinophils and monocytes in peripheral blood in Polish mixed-breed rabbits, considering the impact of the season (spring, summer, autumn, winter), and sex of the animals.

Materials and Methods

The study involved 200 Polish mixed-breed rabbits, originating from a licensed farm, remaining under continuous veterinary and zoo-technical supervision (Annon 1987), weighing 3.2-4.2 kg, aged 6-8 months, females and males, in four seasons of the year: spring, summer, autumn, and winter. During the experiment, the animals remained at the vivarium of the Department of Microbiology and Department of Immunology of the Faculty of Biology at the University of Szczecin, where zoo-technical parameters were in line with the recommended Polish standards developed in line with the European Union Directive as regards temperature and humidity, as well as lighting and size of cages for animals (Annon 2010). After transportation to the Department vivarium, the animals were provided with a two-week adaptation period. The animals were fed with all-mash rabbit feed (16% Królik z Motycza), at volume of 0.15-0.20 kg/day, and had unlimited access to water.

Blood was drawn in four seasons of the year (spring, summer, autumn, winter) twice, by placing a port, for three consecutive days, namely at 0, 24 and 48 h from the commencement of the study, each time at 8 am, from marginal vein of the ear (every seven days). In the blood the following parameters were determined: haemoglobin concentration, haematocrit value, volume of erythrocytes, thrombocytes, leucocytes, lymphocytes, neutrophils, basophils, eosinophils and monocytes, due to commonly known and used standards.

The results of haematological tests were subject to the statistical analysis with t-Student test in Statistica 6.0 software, and have been presented in Table 3.

Results

When assessing the results regarding haematological parameters in such animals (Table 3), it must be stated that the values of haemoglobin concentration remain within the range from 10.23 to 12.10 mmol/l, haematocrit values from 0.33 to 0.36, number of erythrocytes from 4.72 to 5.73 x 10^{12}/l, number of thrombocytes from 330.78 to 569.60 x 10^{9}/l, and the number of leucocytes from 4.46 to 5.90 x 10^{9}/l; lymphocytes from 51.00 to 62.00%; neutrophils from 35.12 to 45.00%; basophils from 0.00 to 2.00%; eosinophils from 0.00 to 1.00%, while monocytes from 0.00 to 3.00%.

However, when analysing the impact of the seasons on the analysed peripheral blood parameters in such rabbits, without considering their sex (in total for males and females) (Table 3), significant differences were only found between spring and autumn in the number of monocytes, between spring and winter (monocytes and lymphocytes), and between summer and winter (haemoglobin concentration). It must be, therefore, stated that the season of the year affects the analysed peripheral blood factors to a small extent, as the changes referred to just three out of ten factors analysed, namely the number of monocytes (two significant changes), lymphocytes and haemoglobin concentration (one significant change each), and their highest values were determined in spring (number of monocytes and lymphocytes) and summer (haemoglobin concentration). In turn, analogical analysis of factors in the red- and blood-cell image, but considering sex of the rabbits (Table 3) showed that sex of the animals also affects their values to a rather small extent, as the increase in the value of factors analysed was recorded both in females and in males, exclusively in autumn and winter, whereas in males this referred to the number of lymphocytes and thrombocytes, while in females – exclusively to monocytes (Table 3).

Table 1. Haematological parametes in mix-breed rabbits in Polish studies.

Parameters		Values of haematological parameters with references									
		Tokarz--Deptuła and others 2005	Nowaczyk and others 2005	Buczma and others 1997	Niedźwiedzka--Rystwej and others 2010	Winnicka 2011	Deptuła and others 2003	Knorr 1980	Brylińska and Kwiatkowska 1996	Szarek and others 2013	Katkiewicz 1989
Haemoglobin [mmol/l]	$\bar{x}$	6.40	nb	5.64-6.27	M: 7.69 F: 7.82	5.59-11.79	6.37	7.44-8.06	12.00	10.00-15.50	13.4
	SD ±	1.10	nb	nb	0.97-1.12	nb	nb	nb	nb	nb	nb
Hematocrit [l/l]]	$\bar{x}$	nb	nb	nb	F: 35.91 M: 36.80	30.00-53.00	nb	nb	nb	33.00-48.00	nb
	SD ±	nb	nb	nb	4.89-5.09	nb	nb	nb	nb	nb	nb
Erythrocytes [10^{12}/l]	$\bar{x}$	5.80	nb	5.33-5.82	F: 3.78 M: 3.87	4.00-9.00	5.80	4.00-6.00	5.25	4.00-9.00	6.20
	SD ±	0.68	nb	nb	0.52-0.53	nb	nb	nb	nb	nb	nb
Trombocytes [10^{9}/l]	$\bar{x}$	834.10	nb	nb	F: 474.79 M: 483.26	120-800	834.1	125-1000	170-798	120-800	650
	SD ±	157.75	nb	nb	80.71-88.77	nb	nb	nb	nb	nb	nb
Leukocytes [10^{9}/l]	$\bar{x}$	5.70	W: 4.27; L: 3.89; J: 4.98; Z: 5.13	5.37-6.30	F: 3.93 M: 4.17	nb	5.70	nb	3.8-12	5.1-18.4	9.0
	SD ±	1.31	0.52-0.77	nb	0.94-1.09	nb	nb	nb	nb	nb	nb
Blood picture-1 Lyphocytes	$\bar{x}$	0.72	W: 0.665; L: 0.765; J: 0.781; Z: 0.724	62.13-71.00	F: 0.57 M: 0.61	0.5-14.25	0.72	nb	20-90	2.6-11.2	63
	SD ±	0.06	0.013-0.067	nb	0.12-0.14	nb	nb	nb	nb	nb	nb
Neutrophils	$\bar{x}$	0.270	W: 0.336; L: 0.223; J: 0.197; Z: 0.260	28.75-75.50	F: 0.32 M: 0.35	0.20-12.00	0.27	0.08-5.00	8-50	0.6-99	32
	SD ±	0.062	0.005-0.053	nb	0.11-0.12	nb	nb	nb	nb	nb	nb
Basophils	$\bar{x}$	0.020	W: 0.015; L: 0.011; J: 0.014; Z: 0.011	0.00-0.25	F: 0.006 M: 0.0036	0-1.2	0.016	0.05-0.3	1-3	0-07	2.4
	SD ±	0.020	0.005-0.008	nb	0.012-0.014	nb	nb	nb	nb	nb	nb
Eosinophils	$\bar{x}$	0.010	W: 0.004; L: 0.001; J: 0.005; Z: 0.001	0.00-0.88	F: 0.016 M: 0.020	0-1.2	0.01	0.01-0.3	1-3	0-0.2g/l	1.3
	SD ±	0.007	0.000-0.005	nb	0.024-0.025	nb	nb	nb	nb	nb	nb
Monocytes	$\bar{x}$	0.010	W: 0.003; L: 0.001; J: 0.003; Z: 0.002	0.13-0.75	F: 0.001 M:0.002	0.02-2.4	0.014	0.01-0.4	1-4	0-0.9	4.1
	SD ±	0.010	0.001-0.003	nb	0.0023-0.026	nb	nb	nb	nb	nb	nb

Legend: nb – not studied; W – spring, L – summer, J – autumn, Z – winter

Table 2. Haematological parameters in rabbits in foreign studies.

Parameters		Values of haematological parameters with references											
		Aleman and others 2000	Bortolotti and others 1989	Hewitt and others 1989	Hillyer 1994	Jeklova and others 2009	Kabata and others 1991	Kim and others 2002	Pinna Pintor and Grassini 1957	Rohilla and others 2000	Sabolovic and others 1977	Özkan and others 2012	Black and others 2009
Haemoglobin [mmol/l]	$\bar{x}$	M: 12.92 F: 13.28	12.1 mmol/l	128 g/L	10-16 g/dL	nb	M: 140 g/L F: 127 g/L	F: 12.6 g/dL	M: 11.185 g/dL	NZ: 13.0 g/dL SC: 3.83 GG: 13.56 LC: 13.30 CB: 13.33	F: 12.36-14.93 g/dL M: 11.91--14.12	M: 175.2 g/l F: 148.1 g/l	M: 9.7 g/dL F: 10.6 L: 10.1 J: 9.5 Z: 11.1
	SD ±	M: 1.62 F: 0.92	nb	10	nb	nb	nb	nb	nb	nb	nb	nb	nb
Hematocrit [%]	$\bar{x}$	M: 44.2 F: 42.4	36	38	33-48	nb	M: 43 F: 39	F: 38.3	nb	nb	F: 37.88--43.54 M: 37.60--42.05	M: 48.91 F: 42.18	M: 29.9 F: 32.6 L: 32.0 J: 29.5 Z: 32.7
	SD ±	M: 2.59 F: 2.07	nb	3.1	nb	nb	nb	nb	nb	nb	nb	nb	nb
Erythrocytes [10^{12}/l]	$\bar{x}$	nb	5.7 x 10^6/mm^3	nb	5.5-7.5 x 10^6/mm^3	3.85-5.41 10^{12}/l	M: 6.4 F: 6.0 x 10^6/mm^3	F: 5.2 x 10^6/mm^3	M: 5.4 x 10^6/mm^3	NZ: 5.68, SC: 5.82 GG: 5.92, LC: 5.95 CB: 5.98	nb	nb	M: 4.6 x 10^9/l F: 5.1, L: 4.5 J: 4.7, Z: 5.4
	SD ±	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
Trombocytes [10^9/l]	$\bar{x}$	nb	nb	nb	300-600 10^3/mm^3	nb	nb	F: 363.0 x 10^3/mm^3	M: 743 x 10^3/mm^3	nb	nb	M: 496.3, F: 589.4 x 10^9/L	M: 150 x 10^9/l F: 124 L: 189 J: 150 Z: 161
	SD ±	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
Leukocytes [10^9/l]	$\bar{x}$	nb	8.1 x 10^3/mm^3	nb	6-12 x 10^3/mm^3	2.17-6.62 x 10^9/l	M: 6.8 x 10^9/l F: 5.6 x 10^9/l	F: 13.49 x 10^9/l	M: 7.073 x 10^9/l	NZ: 5.67, S.C.: 5.52 GG: 5.98, LC: 5.78 CB: 5.93	nb	M: 11.40 F: 10.44 x 10^9/l	M: 2.9 x 10^9/l F: 3.5, L: 3.9 J: 3.4, Z: 2.4
	SD ±	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb

Legend: nb – not studied; NZ – New Zeland, S.C. – Sowiet Chinchilla, GG – Grey Giant; LC – local white; CB – crossbred, W – spring, L – summer, J – autumn, Z – winter

cd. table 2. Haematological parameters in rabbits in foreign studies.

Parameters			Values of haematological parameters with references											
			Aleman and others 2000	Bortolotti and others 1989	Hewitt and others 1989	Hillyer 1994	Jeklova and others 2009	Kabata and others 1991	Kim and others 2002	Pinna Pintor and Grassini 1957	Rohilla and others 2000	Sabolovic and others 1977	Özkan and others 2012	Black and others 2009
Blood picture-1	Lymphocytes	$\bar{x}$	M: 69 F: 71	68	nb	30-85	30.8-76.4	nb	nb	nb	nb	nb	nb	M: 1.7 x 10^9/l F: 1.9, L: 2.1 J: 2.0, Z: 1.0
		SD±	M:9 F: 13	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
	Neutrophils	$\bar{x}$	M: 38 F:35	32	nb	20-52	13.5-57.5	nb	nb	nb	nb	nb	M: 51.91 F: 61.87	M: 0.6 x 10^9/l F: 0.5 L: 0.5 J: 0.6 Z: 0.5
		SD±	M:11 F: 12	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
	Basophils	$\bar{x}$	nb	nb	nb	2-7	5.1-8.5	nb	nb	nb	nb	nb	nb	M: 0.05 x 10^9/l F: 0.4 L: 0.08 J: 0.05 Z: 0.04
		SD±	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
	Eosynophils	$\bar{x}$	M: 2 F: 1	nb	nb	0-5	1.1-2.7	nb	nb	nb	nb	nb	nb	M: 0.01 x 10^9/l F: 0.01, L: 0.00, J: 0.02 Z: 0.02
		SD±	M: 2 F:2	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb
	Monocytes	$\bar{x}$	M: 3 F: 2	nb	nb	1-12	1,8-3,9	nb	nb	nb	nb	nb	nb	M: 0,04 x 10^9/l F: 0,07 L: 0,04 J: 0,04 Z: 0,02
		SD±	M: 1 F: 2	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb	nb

Legend: nb – not studied; NZ – New Zeland, S.C. – Sowiet Chinchilla, GG – Grey Giant; LC – local white; CB – crossbred, W – spring, L – summer, J – autumn, Z – winter

Table 2b. Haematological parameters in rabbits in foreign studies

Parameters		Values of haematological parameters with references						
		Jacobson and others 1978	Abdel-Azeem and others 2010	Burnett and others 2006	Cazabon and others 2000	Fox and Laird 1970	Çetin and others 2009	Ragab and others 2013
Haemoglobin [mmol/l]	$\bar{x}$	nb	M: 11.215 F: 11.218	NZ: 110.2 g/L CB: 113.1 M: 116.7 F: 106.6	NZ: 126 gm/L CB: 125 M: 124 F: 122	M: 15.56 g/100 ml F: 14.21	M: 10.20 g/100 ml F: 9.75 Z: 10.90 g/dl W: 6.95 L: 6.05 J: 6.57	8.90 g/dl
	SD±	nb	nb	nb	nb	nb	nb	nb
Hematocrit [%]	$\bar{x}$	nb	M: 29.952 F: 29.962	nb	NZ: 38.6 CB: 37.4 M: 38.5 F: 38.1	M: 44.99 F: 41.26	M: 38.66 F: 34.90 Z: 37.66 W: 38.25 L: 42.43 J: 58.12	28.33
	SD±	nb	nb	nb	nb	nb	nb	nb
Erythrocytes [10^{12}/l]	$\bar{x}$	nb	M: 4.106 F: 4.111	NZ: 5.20 x 10^{12}/L CB: 5.80 M: 5.80 F: 5.30	nb	M: 7.21 x 10^6/mm^3 F: 6.41	M: 8.05 x 10^6/mm^3 F: 6.20 Z: 7.05 W: 6.95 L: 6.05 J: 6.57	3.43 x 10^6/ml
	SD±	nb	nb	nb	nb	nb	nb	nb
Trombocytes [10^9/l]	$\bar{x}$	nb	nb	NZ: 327.9 x 10^9/L CB: 337.9 M: 328.9 F: 328.7	nb	nb	nb	nb
	SD±	nb	nb	nb	nb	nb	nb	nb
Leukocytes [10^9/l]	$\bar{x}$	nb	nb	NZ: 8.00 x 10^9/L CB: 9.20 M: 8.90 F: 8.20	NZ: 8.1 x 10^3/uL CB: 6.4 M: 6.7 F: 6.8	nb	M: 9.55 x 10^3/mm^3 F: 6.44 Z: 11.85 W: 10.98 L: 8.71 J: 9.42	7.38 x 10^3/ml
	SD±	nb	nb	nb	nb	nb	nb	nb

Legend: nb – not studied; NZ – New Zeland, S.C. – Sowiet Chinchilla, GG – Grey Giant; LC – local white; CB – crossbred, W – spring, L – summer, J – autumn, Z – winter

Table 2c. cd. Haematological parameters in rabbits in foreign studies.

	Parameters		Values of haematological parameters with references						
			Jacobson and others 1978	Abdel-Azeem and others 2010	Burnett and others 2006	Cazabon and others 2000	Fox and Laird 1970	Çetin and others 2009	Ragab and others 2013
Blood picture-1	Lyphocytes	$\bar{x}$	J: 90.5 Z: 86.5 W: 83.0 L: 71.00	nb	NZ: 2.70 x 10^9/L CB:2.60 M: 2.80 F: 2.50	NZ: 36.7 CB: 28.9 M: 40.9 F: 38.3	M: 89.50 F: 85.38	M: 59.80% F: 66.80 Z: 59.80 W: 58.10 L: 54.10 J: 55.52	43.33
		SD±	nb	nb	nb	nb	nb	nb	nb
	Neutrophils	$\bar{x}$	J: 4.5 Z: 9.0 W: 7.0 L: 22.0	nb	NZ: 4.30 x 10^9/L CB: 5.60 M: 5.00 F: 4.80	NZ: 45.4% CB: 53.0 M: 43.4 F: 48.9	M: 8.25 F: 11.38	nb	48.33
		SD±	nb	nb	nb	nb	nb	nb	nb
	Basophils	$\bar{x}$	J: 0 Z: 0.7 W: 1.0 L: 1.0	nb	NZ: 0.20 x 10^9/L CB: 0.20 M: 0.30 F: 0.20	NZ: 2.4 CB: 2.0 M: 1.4 F: 2.6	M: 1.13 F: 1.50	M: 1 F: 1.20 Z: 1.00 W: 0.70 L: 1.20 J: 1.40	0.67
		SD±	nb	nb	nb	nb	nb	nb	nb
	Eosinophils	$\bar{x}$	J: 1.0 Z: 0.0 W: 2.0 L: 10.5	nb	NZ: 0.40 x 10^9/L CB: 0.40 M: 0.40 F: 0.30	NZ: 0.5 CB: 1.0 M: 1.0 F: 0.9	M: 0.13 F: 0.63	M: 1.50 F: 1.90 Z: 1.50 W: 1.70 L: 1.85 J: 1.98	3.33
		SD±	nb	nb	nb	nb	nb	nb	nb
	Monocytes	$\bar{x}$	J: 1.0 Z: 2.2 W: 1.5 L: 2.5	nb	NZ: 4.30 x 10^9/L CB: 5.60 M: 5.00 F: 4.80	NZ: 126 gm/L CB: 125 M: 124 F: 122	M: 1.00 F: 1.13	M: 3.40 F: 3.50 Z: 3.40 W: 4.30 L: 5.90 J: 4.95	3.67
		SD±	nb	nb	nb	nb	nb	nb	nb

Legend: nb – not studied; NZ – New Zeland, S.C. – Sowiet Chinchilla, GG – Grey Giant; LC – local white; CB – crossbred, W -spring, L – summer, J – autumn, Z – winter

Table 2d. Haematological parameters in rabbits in foreign studies.

Parameters		Values of haematological parameters with references							
		Archetti and others 2008	Chineke and others 2006	Olayemi and others 2007	Yaqub and others 2013	Poljičak-Milas and others 2009	Martinec and others 2012	Harkness and others 2007	Feldman and others 2000
Haemoglobin [mmol/l]	$\bar{x}$	nb	8.57 g/100 mL	11.98 g/dl	nb	M: 127.5 g/L F: 134.86	132.6 $1*l^{-1}$	10.0-15.5 g/dl	8.4-17.4 g/dl
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Hematocrit [%]	$\bar{x}$	nb	nb	nb	nb	nb	49.48 $1 * l^{-1}$	36-48	nb
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Erythrocytes [10^{12}/l]	$\bar{x}$	nb	3.47 * 10^6 um^{-3}	6.23 * 10^6/uL	nb	M: 5.86 * 10^{12}/L F: 6.21	6.38 T * l^{-1}	4-7.2	3.7-7.94 x $10^6/mm^3$
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Trombocytes [10^9/l]	$\bar{x}$	nb	nb	nb	nb	M: 529.75 * 10^9/L F: 499.93	nb	200-1000	nb
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Leukocytes [10^9/l]	$\bar{x}$	5.4 * 10^9/L	6.76 * 10^6 m^{-3}	3.95 * 10^6/uL	nb	M: 8.33 * 10^9/L F: 8.81	2.62 $G*l^{-1}$	7.5-13.5	5.2-16.5 x $10^3/mm^3$
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Blood picture-1 Neutrophils	$\bar{x}$	47	nb	nb	nb	nb	nb	55-80	20-90
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Lyphocytes	$\bar{x}$	35	nb	nb	nb	nb	nb	20-35	8-75
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Basophils	$\bar{x}$	0	nb	nb	nb	nb	nb	2-10	0-30
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Eosinophils	$\bar{x}$	0	nb	nb	nb	nb	nb	0-4	0-5
	SD±	nb	nb	nb	nb	nb	nb	nb	nb
Monocytes	$\bar{x}$	0.5	nb	nb	nb	nb	nb	1-4	1-13.4
	SD±	nb	nb	nb	nb	nb	nb	nb	nb

Objaśnienia: nb – nie badano; NZ – New Zeland, S.C. – Sowiet Chinchilla, GG – Grey Giant; LC – local white; CB – crossbred, W – spring, L – summer, J – autumn, Z – winter

Table 3. Haematological parameters in mix-breed Polish rabbits in annual cycle considering sex..

Parameters		Values											
		spring			summer			autumn			winter		
		female (25)	male (25)	together (50)	female (25)	male (25)	together (50)	female (25)	male (25)	together (50)	female (25)	male (25)	together (50)
Haemoglobin [mmol/l]	$\bar{x}$	10.23	11.15	10.54	12.05	12.10	12.08^{b5}	11.58	11.79	11.64	10.27	10.59	10.33
	SD±	1.23	1.41	1.18	1.64	1.00	1.34	1.52	2.47	1.89	1.76	1.34	1.96
Hematocrit [l/l]	$\bar{x}$	0.33	0.35	0.34	0.35	0.33	0.33	0,34	0.33	0.33	0.35	0.33	0.34
	SD±	0.046	0.053	0.048	0.047	0.039	0.032	0.036	0.038	0.037	0.043	0.036	0.039
Erythrocytes [10^{12}/l]	$\bar{x}$	4.72	5.24	5.09	5.51	5.73	5.64	4.96	5.01	4.99	4.77	5.19	4.98
	SD±	0.57	0.78	0.89	0.62	0.53	0.52	0.52	0.36	0.47	0.46	0.87	0.42
Trombocytes [10^{9}/l]	$\bar{x}$	367.33	398.47	382.90	411.67	471.46	441.57	385.26	397.45	391.36	330.78	569.6^{a}	450.19
	SD±	182.89	150.27	164.23	204.61	185.94	194.87	142.95	162.58	158.75	129.90	215.18	176.34
Leukocytes [10^{9}/l]	$\bar{x}$	4.81	5.90	5.36	4.46	4.78	4.62	5.02	5.23	5.13	5.52	5.37	5.45
	SD±	0.11	0.82	0.52	0.66	0.79	0.69	0.62	0.85	0.75	0.79	0.54	0.63
Blood picture-1 Lymphocytes	$\bar{x}$	60.0	62.0	61.0^{b3}	59.0	58.0	58.50	54.0	61.0^{a}	57.50	51.0	52.0	51.5
	SD±	8.0	7.0	7.5	5.0	5.0	5.0	4.0	5.0	4.5	4.40	4.0	4.7
Neutrophils	$\bar{x}$	36.45	35.12	40.06	41.0	41.0	41.0	42.0	45.0	43.50	44.0	43.0	43.50
	SD±	7.9	7.5	7.7	5.0	4.0	4.5	4.0	3.0	3.5	4.30	4.0	4.7
Basophils	$\bar{x}$	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.50	2.00^{a}	1.00	1.50
	SD±	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.05
Eosinophils	$\bar{x}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
	SD±	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Monocytes	$\bar{x}$	1.00	1.00	1.00	1.00	0.00	1.00	2.00^{a}	1.00	2.00^{ba}	3.00^{a}	2.00	2.50^{b3}
	SD±	0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.00	0.01	0.02	0.02	0.02

Legend: () – number of animals; $\bar{x}$ – mean value; SD – standard deviation, ^{a} – statistically significant difference between male and female, ^{b} – statistically significant difference between seasons (together), where ^{b1} – statistically significant difference between spring and summer; ^{b2} – statistically significant difference between spring and autumn; ^{b3} – statistically significant difference between spring and winter; ^{b4} – statistically significant difference between summer and autumn; ^{b5} – statistically significant difference summer and winter; ^{b6} – statistically significant difference between autumn and winter.

It can be, therefore, stated that the environmental factor – season of the year, and physiological factor – sex, in Polish mixed-breed rabbits rather weakly affects the values, as changes were observed just for three blood indices out of ten analysed, whereas in the case of the season major changes were recorded in spring and summer and referred to monocytes, lymphocytes, and, to a smaller degree, haemoglobin concentration, while in the case of sex – they referred to autumn and winter, and were manifested in the number of lymphocytes, thrombocytes (males), and monocytes (females).

Discussion

When analysing the results obtained for haematological factors in Polish mixed-breed rabbits (Table 3), it must be stated that parameter's values obtained in these two animal groups can be, exclusively specifically, compared to the results of studies obtained by Polish authors performing observations also on Polish mixed-breed rabbits (Table 1), and to a lower extend to the results by other authors regarding rabbits other than Polish mixed-breed rabbits, the results of which studies were presented in the same units as in the present study (Table 2).

When assessing the results regarding haematological factors in these animals (Table 3), it must be stated that the values of haemoglobin concentration in them, remaining within the range from 10.23 to 12.10 mmol/l (Table 1), are slightly higher than the results obtained previously in the studies on Polish mixed-breed rabbits (Buczma et al. 1997, Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005, Niedźwiedzka-Rystwej and Deptuła 2010) and the values presented in the studies made on unspecified rabbits (Knorr 1980, Deptuła et al. 2003), and they are also similar to some results of studies on New Zealand race and unspecified mixed-breeds (Bortolotti et al. 1989, Aleman et al. 2000, Abdel-Azeem et al. 2010). As far as the value of haematocrit is concerned, it was recorded in these rabbits that the values amounting from 0.33 to 0.36 are comparable with the results of domestic studies also on Polish mixed-breed rabbits (Niedźwiedzka-Rystwej and Deptuła 2010), but also with domestic results regarding unspecified rabbits (Winnicka 2011, Szarek et al. 2013), and results of foreign studies on New Zealand and Sylvilagus Bachmani Riparus rabbits, as well as unspecified mixed-breeds (Hewitt et al. 1989, Hillyer 1994, Aleman et al. 2000, Cazabon et al. 2000, Kim et al. 2002, Black et al. 2009). It must be added that as regards the latter parameters regarding New Zealand and Sylvilagus Bachmani Riparus breeds, as well as unspecified mixed-breed rabbits, lower values were recorded (Black et al. 2009, Abdel-Azeem et al. 2010, Ragab et al. 2013), as well as higher values (Sabolovic et al. 1977, Harkness et al. 2007, Çetin et al. 2009, Abdel-Azeem et al. 2010, Özkan et al. 2012, Ragab et al. 2013) as compared to the ones obtained at present. In turn, as refers to the number of erythrocytes in the rabbits analysed, it was noted that the values of the parameter range from 4.72 to 5.73 10^{12}/l (Table 1), and conform to prior Polish studies in Polish mixed-breed rabbits (Tokarz-Deptuła and Deptuła 2005), values from Polish textbooks that do not specify the animals (Knorr 1980, Katkiewicz 1989, Brylińska and Kwiatkowska 1996, Deptuła et al. 2003, Winnicka 2011, Szarek et al. 2013), as well as some foreign studies (Burnett et al. 2006, Harkness et al. 2007, Jeklova et al. 2009, Poljicak-Milas et al. 2009) on New Zealand and unspecified mixed-breed rabbits. The number of thrombocytes in peripheral blood of Polish mixed-breed rabbits, ranging from 330.78 to 569.60 x 10^9/l (Table 3), was comparable with prior results obtained in domestic studies also for Polish mixed-breed rabbits (Niedźwiedzka-Rystwej and Deptuła 2010) and unspecified rabbits, the values of which have been presented in textbooks in Poland (Knorr 1980, Katkiewicz 1989, Brylińska and Kwiatkowska 1996, Deptuła et al. 2003, Winnicka 2011, Szarek et al. 2013), as well as results of foreign studies (Harkness et al. 2007, Black et al. 2009, Poljičak-Milas et al. 2009, Özkan et al. 2012) referring to New Zealand, Sylvialagus Bachmani Riparus and unspecified mixed-breed rabbits, although sporadically, in this respect, higher values were recorded in Polish mixed-breed and unspecified rabbits (Katkiewicz 1989, Deptuła et al. 2003, Tokarz-Deptuła and Deptuła 2005), and lower values in Sylvialagus Bachmani Riparus rabbits (Black et al. 2009). In turn, the recorded number of leucocytes in peripheral blood in these rabbits, amounting to from 4.46 to 5.90 x 10^9/l (Table 3), conforms to prior domestic studies in Polish mixed-breed and unspecified rabbits (Brylińska and Kwiatkowska 1996, Buczma et al. 1997, Deptuła et al. 2003, Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005, Szarek et al. 2013), and to foreign studies on New Zealand and Soviet Chinchilla, grey giant and albino breeds (Rohilla et al. 2000, Jeklova et al. 2009), although in the latter observations on Silvilagus Bachmani Riparus rabbits, also slightly lower values were recorded (Black et al. 2009), as well as higher values (Pintor and Grassini 1957, Kabata et al. 1991, Kim et al. 2002, Özkan et al. 2012) in New Zealand breed rabbits. As regards lymphocytes in peripheral blood in Polish mixed-breed rabbits, it can be stated that presently obtained values, ranging from 51.00 to 62.00%, and neutrophils – from 35.12 to 45.00% (Table 3),

confirm prior domestic results also regarding Polish mixed-breed rabbits and unspecified rabbits (Table 1), as well as results obtained in foreign studies in New Zealand, Agora, Czech and Sylvilagus Bachmani Riparius, cottontail, Soviet Chinchilla, grey giant, albino, and unspecified mixed-breed rabbits (Table 2). Similarly, ranges for basophils correspond to prior Polish and foreign studies, amounting to from 0.00 to 2.00%, eosinophils from 0.00 to 1.00%, and monocytes from 0.00 to 3.00%. To recapitulate, when comparing the obtained values of red and white blood cell parameters in Polish mixed-breed rabbits to prior results both in mixed-breed rabbits (Table 1), and pure blood rabbits (Table 2), it can be stated that, in a vast majority, the values obtained presently are similar to the ones presented for mixed-breed rabbits and unspecified rabbits in Polish literature (Table 1), and pure blood rabbits in foreign literature (Table 2), although it must be stated that as regards haematocrit value, the number of thrombocytes and leucocytes, in New Zealand and Sylvilagus Bachmani Riparius rabbits and mixed-breed Polish rabbits, slightly lower values were recorded (Black et al. 2009, Niedźwiedzka-Rystwej and Deptuła 2010, Ragab et al. 2013), as well as higher ones (Pintor and Grassini 1957, Sabolovic et al. 1977, Kabata et al. 1991, Kim et al. 2002, Tokarz-Deptuła and Deptuła 2005, Harkness et al. 2007, Çetin et al. 2009, Abdel-Azeem et al. 2010, Özkan et al. 2012, Ragab et al. 2013).

As regards the image of changes regarding the impact of the seasons on the analysed haematological parameters in Polish mixed-breed rabbits, without differentiating between sexes, it can be stated that the season of the year has a rather small impact on the values of analysed haematological parameters, as the changes refer just to three out of ten analysed haematological factors, yet the impact is the strongest within the number of monocytes (two statistically significant changes), while slightly fewer in the number of lymphocytes and haemoglobin concentration (one statistically significant change each) (Table 3). The results are not confirmed by prior Polish studies on Polish mixed-breed rabbits (Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005), where the impact of the season was recorded exclusively for the number of neutrophil granulocytes. Similarly, foreign studies also do not confirm present results, as the changes were recorded for other parameters, or they fell in different seasons. And so, Pintor and Grassini (1957) recorded the impact of the season of the year in unspecified rabbits on the number of reticulocytes, manifested with increase in autumn and decrease in spring. In turn, in the study by Abel-Azeem et al. (2010) in unspecified mixed-breed rabbits, the highest values were recorded for the number of erythrocytes, haemoglobin concentration and haematocrit in January, which is not confirmed by the present study as regards haemoglobin concentration, as in our own study the ratio was the highest in summer, namely in the period when Abel-Azeem et al. (2010) recoded the lowest values of the parameter. In Angora rabbits, however, Çetin et al. (2009) pointed out that as regards the number of erythrocytes and haemoglobin concentration, the lowest values were recorded in July, which is also different from the present own results for haemoglobin concentration, which yielded the highest values in summer, while the highest haematocrit values also fell in July. The authors (Çetin et al. 2009) also evidenced that the number of leucocytes and lymphocytes was the lowest in July and October, while in own study, the highest number of lymphocytes was recorded in spring. In turn, Black et al. (2009), while assessing the impact of the season on blood parameters in Sylvilagus Bachmanii Riparius and rabbits, and Yaqub et al. (2013) in unspecified rabbits, did not reveal the impact of this factor on haematological parameters in such animals. To conclude, therefore, on the changes regarding the impact of the seasons on the haematological parameters analysed in Polish mixed-breed rabbits, it must be stated that both in the present study (Table 3), and prior studies (Pintor and Grassini 1957, Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005, Black et al. 2009, Çetin et al. 2009, Abdel-Azeem et al. 2010, Yaqub et al. 2013), the season seems to be of little importance for shaping haematological parameters of peripheral blood, as increase referred to three analysed blood parameters (monocytes, lymphocytes and haemoglobin concentration), while in experiences of other authors (Pintor and Grassini 1957, Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005, Black et al. 2009, Çetin et al. 2009, Abdel-Azeem et al. 2010, Yaqub et al. 2013) – to six parameters (reticulocytes, erythrocytes, leucocytes, lymphocytes, haemoglobin concentration, and haematocrit value). It must also be pointed out that in own study, the values of the parameters fall in spring and summer, while in prior studies (Pintor and Grassini 1957, Nowaczyk et al. 2005, Tokarz-Deptuła and Deptuła 2005, Black et al. 2009, Çetin et al. 2009, Abdel-Azeem et al. 2010, Yaqub et al. 2013) – in autumn and winter.

When assessing the impact of the seasons on the analysed parameters considering sex of the animals (Table 3), it was evidenced that the season has similar impact, also small, on shaping the analysed parameters in males and females, and in both significant values were only recorded in autumn and winter, whereas in males as regards lymphocytes and thrombocytes, while in females – exclusively monocytes (Table 3). The results are hardly comparable to prior

Polish studies (Niedźwiedzka-Rystwej and Deptuła 2010), which only involved recording the values both in males and females of Polish mixed-breed rabbits. Similarly, hard to interpret and compare are foreign studies on New Zealand and Angora breeds (Fox and Laird 1970, Kabata et al. 1991, Aleman et al. 2000, Kim et al. 2002, Burnett et al. 2006, Chineke et al. 2006, Black et al. 2009, Çetin et al. 2009, Poljičak-Milas et al. 2009, Abdel-Azeem et al. 2010, Özkan et al. 2012, Yaqub et al. 2013). And so, Kabata et al. (1991) recorded statistically significant lower values of haemoglobin concentration and haematocrit in females of New Zealand breed, and higher values in the number of leucocytes and lymphocytes, while as regards other values, such as the number of reticulocytes and thrombocytes, no statistically significant values were noted. Such observations confirm the present results exclusively in the area of lymphocytes in males. In turn, Özkan et al. (2012) showed differences between the values obtained in males and females of New Zealand breed exclusively as regards haemoglobin concentration, haematocrit value, and the number of granulocytes, which is not confirmed by the present results. However, the research by Burnett et al. (2006) revealed that males of New Zealand breed have higher values of haemoglobin concentration, number of thrombocytes and erythrocytes, which is confirmed by our present study for thrombocytes. In turn, the study by Çetin et al. (2009) indicated that in females of Angora breed, lower values are recorded for the number of erythrocytes and haemoglobin concentration, which was not observed in the present study. Furthermore, the results obtained by Poljičak-Milas et al. (2009) pointed to the number of erythrocytes as the only element differentiating the haematological image in males and females of New Zealand breed, which was not confirmed by the present study. Moreover, several studies (Fox and Laird 1970, Aleman et al. 2000, Kim et al. 2002, Chineke et al. 2006, Black et al. 2009, Abdel-Azeem et al. 2010), despite the assessment of the impact of sex on red and white blood cell image parameters in rabbits, did not record the impact of this factor on the parameters analysed. To conclude on the impact of sex among Polish mixed-breed rabbits on shaping haematological parameters of blood, it is hard to clearly determine the impact of the factor on the analysed blood parameters, as the recorded changes in the present study referred to the number of lymphocytes, thrombocytes and monocytes, principally in autumn and winter, while changes recorded by other authors – to haemoglobin concentration, haematocrit value, number of lymphocytes, granulocytes, thrombocytes and erythrocytes.

Therefore it may be concluded as follows:

1. It must be stated that the values obtained on a large and equal animal sample, can constitute reference values for Polish mixed-breed rabbits, having the following values: for haemoglobin concentration from 10.23 to 12.10 mmol/l; haematocrit from 0.33 to 0.36; erythrocytes from 4.72 to 5.73 x 10^{12}/l; thrombocytes from 330.78 to 569.60 x 10^{9}/l; leucocytes from 4.46 to 5.90 x 10^{9}/l; lymphocytes from 51.00 to 62.00%; neutrophils from 35.12 to 45.00%; basophils from 0.00 to 2.00%; eosinophils from 0.00 to 1.00%, and monocytes from 0.00 to 3.00% (Table 3).

2. The season of the year in Polish mixed-breed rabbits had a small impact on the analysed parameters, referring only to spring and summer. The results are different from the results obtained by other authors, where the changes were mostly recorded in autumn and winter. It must be added that both in own studies and studies by other authors (Pintor and Grassini 1957, Black et al. 2009, Çetin et al. 2009, Abdel-Azeem et al. 2010, Yaqub et al. 2013), the impact of the season was always recorded in the area of the number of lymphocytes and haemoglobin concentration.

3. It was also noted that in these rabbits, sex has average impact on the values of haematological parameters, as it affects three parameters analysed (number of lymphocytes, thrombocytes and monocytes) in autumn and winter.

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