Blood Cell Morphology and Plasma Biochemistry of the Captive European Pond Turtle *Emys orbicularis*

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Abstract

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The morphological characteristics of peripheral blood cells, micronucleated erythrocytes counts and plasma biochemistry profile were examined in ten healthy captive European pond turtles *Emys orbicularis.* Blood samples were obtained from the caudal vein. The Wright staining method was used for the classification of the blood cells. Mature erythrocytes of captive *Emys orbicularis* were nucleated ellipsoidal cells (21.7 ±1.27μm × 13.2 ±1.12 μm) with pink cytoplasm. The nucleus (6.9 ± 0.78 μm × 5.4 ± 0.65 μm) was centrally located and stained dark purple. Seven different types of blood cells were determined: erythrocytes, thrombocytes, monocytes, eosinophils, basophils, lymphocytes and heterophils. The micronucleated erythrocyte (MNE) values were 0.0016 and 0.003 for the males and females, respectively. The MNE results were presented as the mean frequency of micronucleated erythrocytes per 1000 cells per animal.

The mean plasma concentrations in the total of specimens were as follows: total protein (25 g/L), albumin (7.2 g/L), globulin (17.8 g/L), glucose (2.91 mmol/L), calcium (2.32 mmol/L), phosphorus (1.55 mmol/L), creatinine (46.85 μmol/L), urea (10.93 mmol/L) , triglycerides (0.44 mmol/L), cholesterol (1.48 mmol/L), sodium (125.76 mmol/L), potassium (3.98 mmol/L), chloride (93.94 mmol/L), iron (13.34 μmol/L) and activities of aspartate aminotransferase (2.14 μkat/L), alanine aminotransferase (0.15 μkat/L), gamma glutamyl transpeptidase (2.15 U/L), amylase (8.09 μkat/L), lactate dehydrogenase (19.93 μkat/L). We found sex-dependent differences only in ALT [(0.21 μkat/L and 0.10 μkat/L for the males and females, respectively) ($t = 3{,}107$; $df = 14$; $p < 0.05$)] value in the blood biochemical profile for healthy *Emys orbicularis*.

We suggest that the biochemical profile described in the present study may be used as a standard profile for healthy *Emys orbicularis* kept in captivity.

Haematology, plasma biochemistry, Reptilia, Chelonia, Emys, micronucleus

The distribution of *Emys orbicularis* (Linnaeus 1758) extends from Northwest Africa, through almost all of Central Europe, including the Iberian Peninsula and the Mediterranean islands of Corsica, Sardinia, Sicily, the Balkan Peninsula, and western Asia (Snieshkus 1995).

Various authors have described different circulating blood cells of different amphibian and reptile species (Mateo et al.1984; Canfield and Shea, 1988; Knotková et al. 2002; Azevedo et al. 2003). Blood biochemistry represents a valuable diagnostic tool for monitoring the health and condition of free-ranging wildlife. Comparative studies of clinically healthy and diseased turtles can provide insightful information for their management and conservation (Bolten and Bjorndal 1992; Hasbun et al.1998). Understanding the blood composition of turtles is very important for preventing and treating

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Table 1. Erythrocyte dimensions of the captive European pond turtle, *Emys orbicularis*

	MALE						FEMALE						OVERALL					
	N	Mean	Min.	Max.	S.D.	S.E.	N	Mean	Min.	Max.	S.D.	S.E.	N	Mean	Min.	Max.	S.D.	S.E.
EL (μm)	522	21.5	17.5	25.0	1.37	0.06	533	21.8	18.8	25.0	1.16	0.05	1055	21.7	17.5	25.0	1.27	0.04
EW (μm)	522	12.9	10.0	16.3	1.09	0.05	533	13.6	11.3	20.0	1.05	0.05	1055	13.2	10.0	20.0	1.12	0.03
NL (μm)	451	7.0	5.0	8.8	0.73	0.03	533	6.8	5.0	8.8	0.81	0.04	984	6.9	5.0	8.8	0.78	0.02
NW (μm)	451	5.4	3.8	7.5	0.61	0.03	533	5.4	3.8	6.3	0.69	0.03	984	5.4	3.8	7.5	0.65	0.02
ES (μm^2)	522	217.8	165.6	294.4	23.63	1.03	533	232.3	165.6	353.3	22.55	0.98	1055	225.1	165.6	353.3	24.18	0.74
NS (μm^2)	451	29.5	14.7	47.2	5.10	0.24	533	28.9	14.7	42.9	5.64	0.24	984	29.2	14.7	47.2	5.41	0.17
EL/EW	522	1.7	1.2	2.4	0.18	0.01	533	1.6	1.1	2.0	0.14	0.01	1055	1.6	1.1	2.4	0.16	0.01
NL/NW	451	1.3	0.9	2.0	0.18	0.01	533	1.3	1.0	2.3	0.20	0.01	984	1.3	0.9	2.3	0.19	0.01
NS/ES	451	0.1	0.1	0.2	0.02	0.00	533	0.1	0.1	0.2	0.02	0.00	984	0.1	0.1	0.2	0.02	0.00

EL: Erythrocyte length; **EW:** Erythrocyte width; **NL**: Nucleus length; **NW**: Nucleus width; **ES**: Erythrocyte size; **NS**: Nucleus size.

many illnesses as well. There are many papers that characterize the blood of land tortoises (Allemann et al.1992; Garner et al. 1996; Muro et al. 1998; Knotková et al. 2002) however, little is known about the haematology and blood biochemistry of *Emys orbicularis* (Kölle et al. 1999; Ugurtas et al. 2003).

The identification of morphological characteristics of different peripheral blood cells and plasma biochemistry profile of healthy *Emys orbicularis* kept in captivity was the purpose of this study. The aim of this work was to develop reference values for the main haematological and biochemical variables of *Emys orbicularis.* We can thus have an objective method for health assessment which is essential for any conservation.

Materials and Methods

Animals

Twenty adult European pond turtles, 10 males and 10 females were studied at a private captive breeding farm in the month of July. The specimens were kept in vessels (200 × 200 × 60 cm) at the farm, and we were informed that they were fed with commercial trout food, dog food, sardines, anchovies, chopped chicken liver and sheep stomach. The mean straight carapace lengths were 10.06 ± 0.17 and 13.0 ± 0.38 cm for the males and females, respectively. The females were checked by manual examination through the cloaca for eggs in oviducts. All of them were determined as non-pregnant.

Blood sampling

A blood specimen of each turtle was taken by venepuncture from the caudal vein. Blood (1-2 ml) was collected using 21 gauge needles and 5 ml syringes. Blood specimens were transferred into Vacutainer tubes containing lithium heparin and placed on ice until processing in the laboratory 4-6 h after capture. Plasma was separated by centrifugation at 3000 rpm for 10 minutes and split in two or more vials.

Blood cell morphology

Of the 20 European pond turtles, 10 (5 ♂♂, 5♀♀), were used for blood cell morphology. Blood samples were taken from the caudal vein. Blood smears were prepared immediately and air-dried. Wright-stained blood smears were used for the measurement and assessment of blood cells. Four to five blood smears were prepared per individual. On each slide lengths (EL) and widths (EW) of randomly selected 100 mature erythrocytes and their nuclei (NL and NW), fifty thrombocytes, heterophil, eosinophil, basophil, lymphocyte and 20 monocyte were measured by an Olympus ocular micrometer at a magnification of 600 ×. Erythrocyte and nuclear sizes (ES and NS) were calculated according to formulas [(EL × EW × π) / 4] and [(NL × NW × π) / 4], respectively. In addition, micronucleated erythrocytes were counted among 1000 erythrocytes on each blood smears by the same micrometer at a magnification of 1000 ×.

Table 2. Differential leukocyte size in peripheral blood of the captive European pond turtle, *Emys orbicularis*

	MALE						FEMALE						OVERALL					
	N	Mean	Min.	Max.	S.D.	S.E.	N	Mean	Min.	Max.	S.D.	S.E.	N	Mean	Min.	Max.	S.D.	S.E.
Eosinophils (µm)	250	16.1	12.5	20.0	1.41	0.09	250	15.6	11.3	20.0	1.56	0.10	500	15.8	11.3	20.0	1.51	0.07
Basophils (µm)	250	13.5	11.3	16.3	1.02	0.06	250	13.2	11.0	16.3	1.24	0.08	500	13.3	11.0	16.3	1.15	0.05
Lymphocytes (µm)	250	8.8	6.3	12.5	1.27	0.08	226	8.7	6.3	12.5	1.26	0.08	476	8.7	6.3	12.5	1.27	0.06
Monocytes (µm)	85	14.2	11.3	18.8	2.01	0.22	93	13.2	10.0	17.5	1.28	0.13	178	13.7	10.0	18.8	1.75	0.13
Thrombocytes (µm)	234	7.7	6.3	11.3	1.09	0.07	218	7.3	5.0	10.0	1.02	0.07	452	7.5	5.0	11.3	1.08	0.05
Heterophils (µm)	250	19.2	17.5	23.8	1.15	0.07	250	20	17.5	25	1.39	0.09	500	19.6	17.5	25	1.33	0.06

Plasma biochemistry

Biochemical indices of plasma were measured spectrophotometrically (Microlab Merck 200) by means of commercial kits (Biomedical Biosystems/Spain). Na, K and Cl were measured by means of an ion selective device. Samples that appeared haemolysed were discarded. The following plasma were measured: aspartate aminotransferase (EC 2.6.1.1), alanine aminotransferase (EC 2.6.1.2), gamma glutamyl transpeptidase (EC 2.3.2.2), amylase (EC 3.2.1.1), lactate dehyrogenase (EC 1.1.1.27), total protein, albumin, glucose, creatinine, urea, triglycerides, cholesterol, calcium (Ca), phosphorus (P), sodium (Na), potassium (K), chloride (Cl) and iron (Fe). Blood chemical values are expressed in SI units.

Statistical analyses

Haematological and biochemical variables were summarized as mean, standard deviation (SD), standard error of the mean (SE) and range. We used analysis of variance (ANOVA) and the *t* test for a comparison of the sexes. Results were considered significant at $p < 0.05$. Statistical analyses were carried out by using STATISTICA version 6.0.

Results

Blood cell morphology

Mature erythrocytes of captive *Emys orbicularis* were nucleated ellipsoidal cells (21.7 ± 1.27µm × 13.2 ± 1.12 µm) with pink cytoplasm (Fig. 1A). The nucleus (6.9 ± 0.78 µm × 5.4 ± 0.65 µm) was centrally located and stained dark purple under Wright' stain. One-way ANOVA verified sexual dimorphism in terms of EL ($F = 5{,}654$; $p < 0.05$), EW ($F = 81{,}425$; $p < 0.0001$), NL ($F = 7.991$; $p < 0.05$), ES ($F = 72.870$; $p < 0.0001$) NS ($F = 3.928$; $p < 0.05$) and EL/EW ($F = 40.249$; $p < 0.0001$). Results of erythrocyte measurements are summarized in Table 1.

Five types of leucocytes were identified as heterophils, eosinophils, basophils, lymphocytes and monocytes. The descriptive statistics of the leucocytes are presented in Table 2. The mean diameter of the eosinophils was 15.8 µm ± 1.51 with blue circular or oval nucleus (Plate II, Fig. 1B). The nucleus sometimes consisted of two lobes and was positioned eccentrically. The cytoplasm was pink-red and filled with rough round granules.

Heterophils were 19.6 µm ± 1.33 in diameter and not always round in shape. The eccentrically positioned nucleus of heterophil (Fig. 1C) was round to oval and pale blue. The pale pink cytoplasm was filled with irregular spindle-shaped granules.

Basophils (Fig. 1D) were 13.3 µm ± 1.15 in diameter with a round and centrally positioned nucleus. The cytoplasm was filled with large round granules with a colour varying from dark blue to dark purple-black.

Lymphocytes (Fig. 1A) were 8.7 µm ± 1.27 in diameter with a large, dark and intense centrally positioned nucleus. Light blue cytoplasm covered a narrow area around the nucleus.

Monocytes (Fig. 1E) were 13.7 µm ± 1.75 in diameter with

Table 3. Blood biochemistry values obtained from the healthy captive European pond turtle, *Emys orbicularis*

Indicators	Unit	MALE					FEMALE					OVERALL				
		N	Mean	Range	S.D.	S.E.	N	Mean	Range	S.D.	S.E.	N	Mean	Range	S.D.	S.E.
Aspartate aminotransferase (AST)	µkat/L	10	2.25	1.40-3.40	0.84	0.26	10	2.02	1.48-2.70	0.50	0.16	20	2.14	1.40-3.40	0.68	0.15
Alanine aminotransferase (ALT)	µkat/L	10	0.21	0.10-0.35	0.09	0.03	10	0.10	0.05-0.15	0.03	0.01	20	0.15	0.05-0.35	0.08	0.02
Gamma glutamyl transferase (GGT)	U/L	10	2.1	1-4	0.99	0.31	10	2.2	1-4	0.92	0.29	20	2.15	1-4	0.93	0.21
Lactate dehydrogenase (LDH)	µkat/L	8	20.86	10.10-31.97	6.86	2.42	8	19.01	9.77-27.94	6.54	2.31	16	19.93	9.77-31.97	6.54	1.64
Amylase	µkat/L	9	7.77	4.40-14.39	3.36	1.12	8	8.44	4.82-14.59	3.18	1.13	17	8.09	4.40-14.59	3.19	0.77
Total protein	g/L	10	23.90	18.40-33.60	4.70	1.50	10	26.20	14.70-33.50	6.40	2.00	20	25.00	14.70-33.60	5.60	1.30
Albumin	g/L	10	6.40	4.70-10.30	1.70	0.50	10	8.00	5.70-11.00	1.90	0.60	20	7.20	4.70-11.00	1.90	0.40
Globulin	g/L	10	17.50	11.70-23.30	3.50	1.10	10	18.20	5.20-26.40	6.90	2.20	20	17.80	5.20-26.40	5.30	1.20
Albumin /globulin rate		10	0.37	0.28-0.62	0.10	0.03	10	0.58	0.22-1.83	0.48	0.15	20	0.48	0.22-1.83	0.35	0.08
Creatinine	µmol/L	9	41.55	21.22-65.42	13.26	4.42	10	52.16	20.33-86.63	22.10	7.07	19	46.85	20.33-86.63	18.56	4.42
Urea	mmol/L	9	11.23	7.43-15.96	3.08	1.03	10	10.66	7.41-14.90	2.44	0.77	19	10.93	7.41-15.96	2.70	0.62
Triglycerides	mmol/L	9	0.46	0.16-0.79	0.22	0.07	10	0.41	0.17-0.74	0.20	0.06	19	0.44	0.16-0.79	0.21	0.05
Cholesterol	mmol/L	9	1.46	0.98-1.74	0.27	0.09	10	1.50	0.99-1.79	0.26	0.08	19	1.48	0.98-1.79	0.26	0.06
Glucose	mmol/L	10	3.22	2.28-4.15	0.53	0.17	10	2.61	1.55-4.38	0.78	0.25	20	2.91	1.55-4.38	0.72	0.16
Calcium	mmol/L	9	2.22	1.98-2.53	0.18	0.06	10	2.41	1.87-3.39	0.47	0.15	19	2.32	1.87-3.39	0.37	0.08
Phosphorus	mmol/L	9	1.64	1.13-2.03	0.31	0.10	10	1.46	1.16-1.87	0.26	0.08	19	1.55	1.13-2.03	0.30	0.07
Iron	µmol/L	9	12.82	8.96-17.91	3.32	1.11	8	13.93	9.85-18.27	2.81	0.99	17	13.34	8.96-18.27	3.05	0.74
Sodium	mmol/L	9	125.00	119-135	4.85	1.62	8	126.63	118-136	5.55	1.96	17	125.76	118-136	5.09	1.24
Potassium	mmol/L	9	3.80	3.10-5.30	0.70	0.23	8	4.19	3.50-5.60	0.72	0.26	17	3.98	3.10-5.60	0.72	0.17
Chloride	mmol/L	9	93.89	91-100	3.52	1.17	8	94.00	89-101	3.89	1.38	17	93.94	89-101	3.58	0.87

an oval and kidney-shaped nucleus, which was less intense and contained pale chromatin. The cytoplasm was grey blue and covered more area.

The nucleus of thrombocytes (Fig. 1F), which formed cell groups on blood smears, was round to oval and dark. The cytoplasm was blue-purple and positioned around the nucleus. The diameter of the thrombocytes was 7.5 µm ± 1.08.

Plasma biochemistry

We have seen sex-dependent differences only in the ALT value (t = 3.107; df = 14; $p < 0.05$) in blood biochemistry profile in healthy *Emys orbicularis*. Results of plasma biochemistry analyses are summarized in Table 3.

Micronucleated erythrocytes (MN)

The micronucleated erythrocyte (MNE) values were 0.0016 and 0.003 for the males and females, respectively. The micronucleated erythrocyte counts and values in 1000 erythrocytes of 10 captive (5 ♂, 5 ♀) *Emys orbicularis* are given in Table 4.

Discussion

According to a detailed survey of Saint Girons (1970), the largest erythrocytes in reptiles belong to the member of an ancient group, the tua-

Table 4. Micronucleated peripheral erythrocytes in ten captive European pond turtles, *Emys orbicularis*

Gender	N	Individual animal counts/1000 erythrocytes	Micronucleated erythrocyte/1000
Male	5	1 / 4 / 2 / 1 / 0	0.0016
Female	5	2 / 1 / 1 / 10 / 1	0.003

tara (*Sphenedon punctatus*), followed by those of turtles and crocodilians. Erythrocytes are morphologically similar among various species of reptiles (Saint Girons 1970). The erythrocytes of Russian tortoises, *Agrionemys horsfieldi*, were reported to be long or irregular in shape (Knotková et al. 2002). Mature erythrocytes of the captive European pond turtle (*Emys orbicularis*) were nucleated ellipsoidal cells with a pink stained cytoplasm. The nucleus was positioned centrally, and stained dark purple under Wright' stain. The nucleus in a mature erythrocyte is round in desert tortoises (*Gopherus agassizii*) (Allleman et al. 1992; Garner et al. 1996) as well in green turtles (*Chelonia mydas*) (Samour et al. 1998; Work et al. 1998). The only blood cell values, which were comparable with those of the natural *Emys orbicularis helenica* from Turkey, were EL, EW, ES, EL/EW and NS/ES reported by Ugurtas et al. (2003). When the means of our blood cell values were tested with one sample *t* test against the natural *Emys orbicularis* population mean; the EW, ES EL/EW and NS/ES values differed significantly ($p < 0.0001$) from those of the captive population.

The classification of reptilian leucocytes poses many problems since these cells show morphological variation within the class, and several different nomenclatures have been used to describe those (Knotková et al. 2002). For example, Saint Girons (1970) reported the presence of eosinophils, azurophils, neutrophils and plasma cells in reptiles, Sypek and Borysenko (1988) described eosinophils and heterophils in the reptilian blood. According to Canfield (1998), the mammalian neutrophil is equivalent to the non-mammalian heterophil. The heterophil, except in mammals, has coarse, red to brown, spiculated to irregular granules of variable size, and either a bilobed (birds and some lizards) or unlobed nucleus (most reptiles and amphibians). Azevedo et al. (2003) observed that 2 types of eosinophilic granulocytes are present in the blood of *Chrysemys dorbignih.* The eosinophils in the present study had a blue circular or oval nucleus (Fig. 1B). The nucleus sometimes consisted of two lobes and was eccentrically positioned. The cytoplasm was pink-red and filled with rough round granules.

In our study we identified heterophils with eccentrically positioned nuclei, pale blue in colour and round to oval in shape. The pale pink cytoplasm was filled with irregular spindle-shaped granules.

Basophils were round with a centrally positioned nucleus. The cytoplasm was filled with large rounded granules, whose colour varied from dark blue to dark purple-black. Rounded, basophilic granules filled the cytoplasm and often partially masked the nucleus, as previously found by Canfield (1998).

Lymphocytes may be small, medium or large (Canfield 1998). Canfield (1998) stated that cytoplasm may contain small vacuoles and azurophilic granules. In the present study, the lymphocytes almost filled the cytoplasm of the cell and had a blue stained nucleus. The amount of cytoplasm was lower and stained in light blue.

Monocytes are large cells with unlobed or lobed nuclei and a large amount of lightly basophilic cytoplasm. Monocytes in the captive *Emys orbicularis* are irregular with oval and kidney-shaped nuclei, which were less intense and contained pale chromatin. The cytoplasm was grey-blue and expanded over a larger area. They contained a higher amount of lightly basophilic cytoplasm in comparison to lymphocytes.

Knotková et al. (2002) identified two types of thrombocytes in Russian tortoises, *Agrionemys horsfieldi*: an oval one with a good visible membrane, a faintly stained cytoplasm, and a rectangular one with small projections of lightly basophilic cytoplasm.

They attributed this variability to ageing, function and artifact. The similarity of thrombocytes and lymphocytes in reptiles is known (Frye 1991). Although this similarity was determined in the captive *Emys orbicularis,* thrombocytes mostly formed cell groups.

Of the studied blood biochemical variables, sex-dependent differences were recorded only in the ALT value, with females having lower ALT in the healthy *Emys orbicularis*. Kölle et al. (1999) recorded 16 variables as statistically different between the sexes in *Emys orbicularis*. Only 11 variables were available for a comparison with those of Kölle et al. (1999). They were Ca, P, ALT, AST, LDH, amylase, glucose, albumin, creatinine, cholesterol and triglycerides. All of the variables, except albumin, showed statistically significant differences ($p < 0.0001$) from our values. These differences may result from seasonal changes in blood parameters, feeding type and age. Pagés et al. (1992) studied the seasonal changes in blood biochemistry of *Mauremys caspica leprosa* and found that glucose, calcium and magnesium were lower in summer, whereas phosphorus was higher. Only 10 variables were available for a comparison with those of Pagés et al. (1992). They were glucose, urea, Na, K, Ca, P, total protein, albumin, globulin and albumin/globulin. All of the variables except urea and albumin/globulin showed statistically significant differences from our values ($p < 0.0001$). Total protein level was lower than in *M.c. leprosa*. Urea and albumin/globulin levels were within the range reported for *M.c. leprosa*. Na, K, Ca levels were higher than in *M.c. leprosa,* whereas glucose and phosphorus levels were lower.

The micronucleus count is an indicator of a genetic damage in mature animals. An elevated number of micronucleated cells indicate poor health. However, Zúñiga-González et al. (2000) suggested that in new-born animals, the presence of MNE could be increased, as the reticuloendothelial system might be immature in the young of some species. They also noted that the reticuloendothelial system matures with age. In some species of reptiles such as *Crocodylus acutus*, *Pituophis depei* and *Macroclemys temminckii*, the MNE counts were found very low, or no MNE was recorded (Zúñiga-González et al. 2000).

We suggest that the biochemical profile described in the present study may be used as a standard profile for the healthy *Emys orbicularis* kept in captivity. Nevertheless, some differences may be expected, especially for young turtles with rapid growth and/or for adult females during the reproductive season.

Morfologie krevních buněk a biochemie plasmy želvy *Emys orbicularis*

U deseti zdravých želv *Emys orbicularis* byly zjišťovány: morfologická charakteristika buněk periferní krve, počty mikronukleárních erytrocytů a biochemický profil plasmy. Vzorky krve byly získávány z v. caudalis. Pro klasifikaci krevních buněk bylo použito Wrightovo barvení. Zralé erytrocyty želvy *Emys orbicularis* byly jaderné elipsoidní buňky (21,7 ± 1,27μm × 13,2 ± 1,12 μm) s růžovou cytoplasmou. Jádro tmavě fialové barvy (purpurové) (6,9 ± 0,78 μm × 5,4 ± 0,65 μm) bylo lokalizováno centrálně. Bylo identifikováno 7 různých typů krevních buněk: erytrocyty, trombocyty, monocyty, eozinofily, bazofily, lymfocyty a heterofily. Počty mikronukleárních erytrocytů (MNE) byly u samců 0,0016 a u samic 0,003. Hodnoty MNE udávají průměrný počet mikronukleárních erytrocytů na 1000 krevních buněk zvířete.

Průměrné plazmatické koncentrace sledovaných ukazatelů vzorků byly následující: celková bílkovina (25 $g \cdot l^{-1}$), albumin (7,2 $g \cdot l^{-1}$), globulin (17,8 $g \cdot l^{-1}$), glukóza (2,91 $mmol \cdot l^{-1}$), Ca (2,32 $mmol \cdot l^{-1}$), P (1,55 $mmol \cdot l^{-1}$), kreatinin (46,85 $\mu mol \cdot l^{-1}$), urea (10,93 $mmol \cdot l^{-1}$), triglyceridy (0,44 $mmol \cdot l^{-1}$), cholesterol (1,48 $mmol \cdot l^{-1}$), Na (125,76 $mmol \cdot l^{-1}$), K (3,98 $mmol \cdot l^{-1}$), Cl (93,94 $mmol \cdot l^{-1}$), Fe (13,34 $\mu mol \cdot l^{-1}$) a aktivity AST (2,14 $\mu kat \cdot l^{-1}$), ALT (0,15 _$kat \cdot l^{-1}$), (GMT) (2,15 $U \cdot l^{-1}$), amylázy (8,09 $\mu kat \cdot l^{-1}$),LDH (19,93 $\mu kat \cdot l^{-1}$). Na pohlaví závislé rozdíly biochemického profilu zdravých želv *Emys orbicularis* jsme pozorovali

pouze u ALT [(0,21 μkat·l^{-1} u samců a 0,10 μkat·l^{-1} u samic) ($t = 3{,}107$; $df = 14$; $p < 0.05$)]. Navrhujeme používat biochemický profil, popsaný v této studii jako standard pro zdravé želvy *Emys orbicularis* chované v zajetí.

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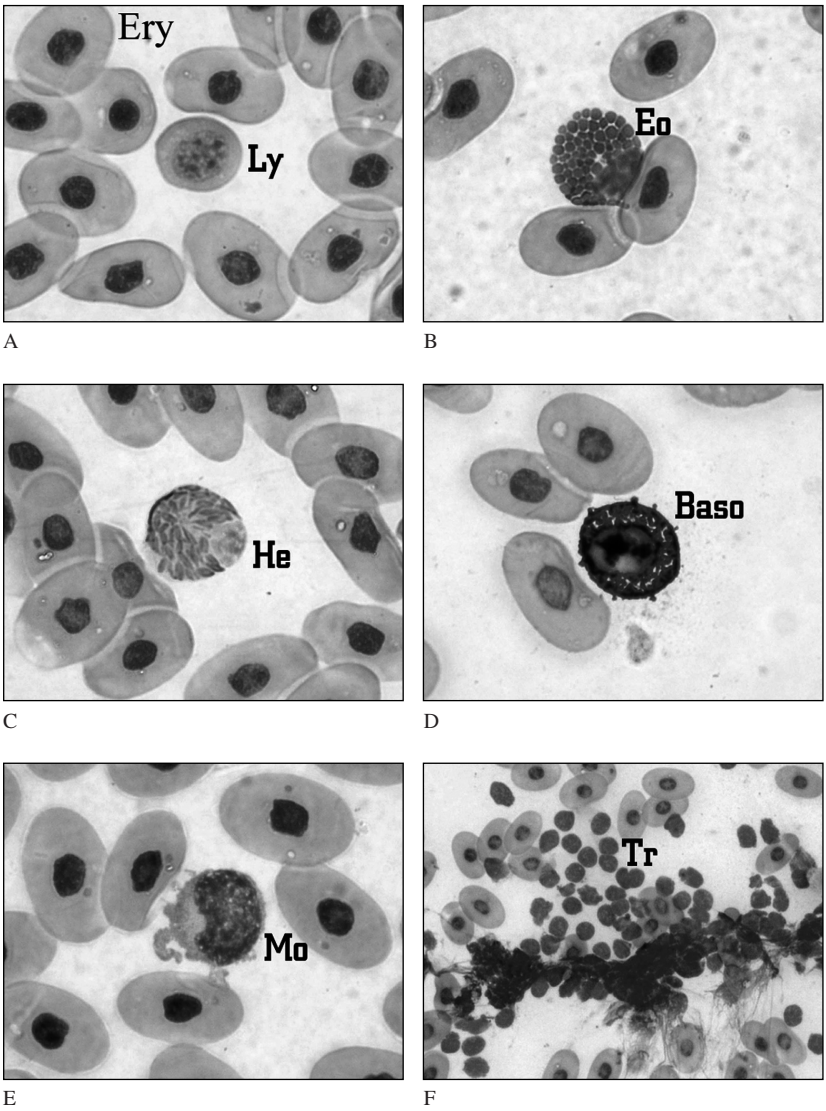

Fig. 1. Blood cells of the captive European pond turtle *Emys orbicularis*. A: Erythrocytes and Lymphocytes B: Eosinophils C: Heterophils D: Basophils E: Monocytes F: Thrombocytes