

Hematological reference intervals of four agamid lizard species from Turkey

(Squamata: Sauria: Agamidae)

Hämatologische Referenzwerte von vier Agamenarten aus der Türkei
(Squamata: Sauria: Agamidae)

ÇİĞDEM GÜL & MURAT TOSUNOĞLU

KURZFASSUNG

Die vorliegende Arbeit berichtet über hämatologische Untersuchungen [Erythrozyten- und Leukozytenzahl, Hämoglobingehalt, Hämatokrit, mittleres Zellvolumen, mittlere Zell-Hämoglobinkonzentration und Gesamteiweiß] an vier in der Türkei beheimateten Agamenarten, *Laudakia caucasica* (EICHWALD, 1831), *Laudakia stellio* (LINNAEUS, 1758), *Phrynocephalus horvathi* ROSTOMBEKOV, 1938 und *Trapelus lessonae* (DE FILIPPI, 1865). An Blutausstrichen der vier Arten wurden die Länge, Breite und Fläche der Erythrozyten sowie die Durchmesser der Lymphozyten, Monozyten, Eosinophilen, Heterophilen und Basophilen Leukozyten gemessen und ihre prozentuelle Verteilung berechnet. Die Erythrozytenzahlen lagen bei *L. caucasica* höher als bei *L. stellio* und *P. horvathi*. Die Größe der Erythrozyten von *L. stellio* übertraf jene von *L. caucasica*, *P. horvathi* und *T. lessonae*. Die Werte für die Hämoglobinkonzentration, den Hämatokrit und die mittlere Zell-Hämoglobinkonzentration unterschieden sich bei *L. caucasica*, *L. stellio* und *P. horvathi*.

ABSTRACT

Four agamid species, *Laudakia caucasica* (EICHWALD, 1831), *Laudakia stellio* (LINNAEUS, 1758), *Phrynocephalus horvathi* ROSTOMBEKOV, 1938 and *Trapelus lessonae* (DE FILIPPI, 1865), occurring in Turkey, were hematologically examined [erythrocyte and leukocyte count, total hemoglobin, hematocrit value, mean cell volume, mean cell hemoglobin, mean cell hemoglobin concentration and total protein values]. In addition, blood smears were prepared from the specimens and erythrocyte length, width, size and leukocyte diameters (lymphocyte, monocyte, eosinophil, heterophil, basophil) were measured and the percentage values of leukocyte types were calculated. The erythrocyte count in *L. caucasica* was found out to be higher than those of *L. stellio* and *P. horvathi*. The erythrocyte size in *L. stellio* was larger than those of *L. caucasica*, *P. horvathi* and *T. lessonae*, respectively. The hemoglobin concentration, hematocrit percentage and mean cell hemoglobin parameters are different among *L. caucasica*, *L. stellio* and *P. horvathi*.

KEY WORDS

Reptilia: Squamata: Sauria: Agamidae, *Laudakia caucasica*, *Laudakia stellio*, *Trapelus lessonae*, *Phrynocephalus horvathi*, hematological values, hematology, physiology, Turkey

INTRODUCTION

Most studies on hematology in saurian species dealt mainly with blood cell counts and cell sizes (HARTMAN & LESLER 1964; HUTCHISON & SZARSKI 1965; SZARSKI & CZOPEK 1966; DUGUY 1970; MERMER 1999; SEVINÇ et al. 2000; SEVINÇ & UĞURTAŞ 2001; ATATÜR et al. 2001; TOSUNOĞLU et al. 2004; SEVINÇ et al. 2004; SACCHI et al. 2007; PONSEN et al. 2008; TROIANO et al. 2008). Other hematological parameters, such as hematocrit value, total hemoglobin

concentration, mean cell volume, mean cell hemoglobin and mean cell hemoglobin concentration, were rarely studied (HARR et al. 2001; CUADRADO et al. 2002; PONSEN et al. 2008; TROIANO et al. 2008).

Erythrocytes are morphologically similar among the various lizard species. However, it was reported that red blood cell count and size displayed significant individual and interspecies variation, and that this variation was also related to body weight,

age, sex and altitudinal distribution (SAINT GIRONS 1970; SEVINÇ et al. 2000, 2004; SEVINÇ & UĞURTAŞ 2001; ATATÜR et al. 2001; PAL et al. 2008; PONSEN et al. 2008). Differences in further hematological parameters were reported by HARR et al. (2001), CUADRADO et al. (2002) and PONSEN et al. (2008).

The comparative scarcity of information on the hematology of agamid species (PIENAAR 1962; SODEINDE & OGUNJOBI 1994; ELIMAN 1997; PAL et al. 2008) does not fully correspond to the importance of the family. Agamidae are the fourth largest lizard family, comprising more than 330 species and 54 genera, among which the

morphological and ecological differences are conspicuous (RASTEGAR-POUYANI & NILSON 2002). Representatives of this genus colonized a wide range of Old World habitats such as dry, tropical and subtropical regions (MOODY 1980).

The purpose of this study was to determine reference intervals of blood cell counts and sizes and some additional hematological parameters of four agamid species from three genera found in Turkey (BAŞOĞLU & BARAN 1977; BARAN & ATATÜR 1998), viz. *Laudakia caucasia* (EICHWALD, 1831), *Laudakia stellio* (LINNAEUS, 1758), *Phrynocephalus horvathi* ROSTOMBEKOV, 1938 and *Trapelus lessonae* (DE FILIPPI, 1865).

MATERIALS AND METHODS

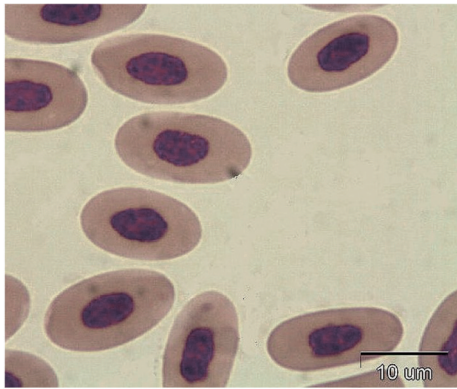
Materials.- Ten male and ten female mature *Laudakia stellio* from Muğla (36°46'N, 28°40'E, 105 m a.s.l), 2008.07.02; five male and five female mature *Laudakia caucasia* from Iğdır (39°58'N, 44°13'E; 838 m a.s.l), 2008.06.26; five male and five female mature *Phrynocephalus horvathi* from Iğdır, 2008.06.27; and two male and three female mature *Trapelus lessonae* from Mardin (37°23'N, 40°56'E; 950 m a.s.l), 2002.04.22.

Blood analysis.- Blood samples of the live specimens obtained in the laboratory within one day of their capture were taken from the postorbital sinus via heparinized hematocrit capillaries (MAC LEAN et al. 1973). After taking of the blood, specimens were released at the places from where they were collected. Red (RBC) and white blood cell counts were made utilizing a Neubauer hemocytometer. As a diluting solution, the standard Hayem's solution was used for erythrocytes, while the method of JERRETT & MAYS (1973) was utilized for leukocytes; i.e., a 1:1 mixture of (i) neutral red diluted to 1/5000 with 0.07% physiological saline and, (ii) 12% formaline prepared with 0.07% physiological saline.

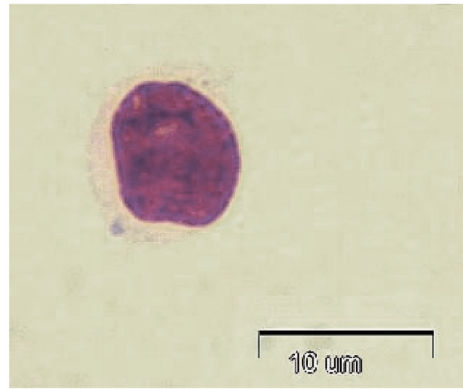
Blood smears stained with Wright's stain were used in measuring the blood cells (erythrocytes, leukocytes and thrombocytes). Cell measurements were performed under a microscope with an ocular micro-

meter. Forty erythrocytes were randomly chosen on each blood smear; cell lengths (EL) and widths (EW), together with the lengths (NL) and widths (NW) of their nuclei, were measured (μm). Cell (ES) and nucleus (NS) sizes (μm^2) were computed according to the formulas $(\text{EL} \cdot \text{EW} \cdot \pi) / 4$ and $(\text{NL} \cdot \text{NW} \cdot \pi) / 4$, respectively. Leukocyte diameters, thrombocyte lengths (TL) and thrombocyte widths (TW) (μm) were measured as well. Cell photomicrographs were taken with an Olympus and Hitachi photomicroscope.

Blood from each specimen was placed in a heparinized tube for determining the following hematological parameters. Hematocrit was determined using the micro-hematocrit method (TANYER 1985). The tubes were spun in a micro-hematocrit centrifuge for 5 minutes at 12000 rpm and the hematocrit [HCT (%)] was calculated from the proportion of the blood cell volume in the total blood volume. Total hemoglobin concentration [THb (g/dl)] was measured colorimetrically with a Sahli hemoglobinometer (TANYER 1985). The derived erythrocyte values 'Mean Cell Volume' ($\text{MCV} = \text{HCT} / (100 \cdot \text{RBC})$ [μm^3]), 'Mean Cell Hemoglobin' ($\text{MCH} = \text{THb} / \text{RBC}$ [pg]) and 'Mean Cell Hemoglobin Concentration' ($\text{MCHC} = (\text{THb} \cdot 100) / \text{HCT}$ [%]) were calculated mathematically from the results of the above-mentioned analyses (TANYER 1985).



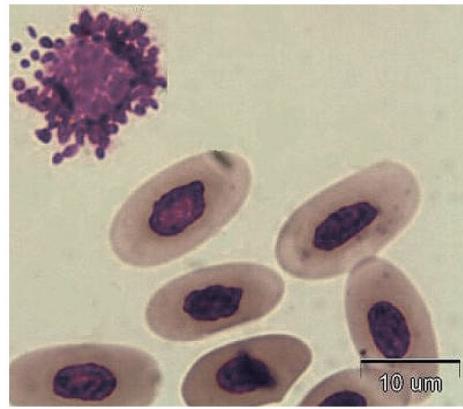
A - Erythrocytes



B - Lymphocyte



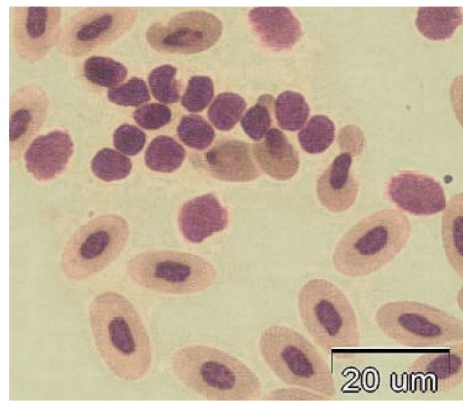
C - 1 Monocyte, 2 Basophil



D - Heterophil



E - Eosinophil



F - Thrombocytes

Fig. 1: Blood cells as observed in the four agamid species studied (Wright's stain).

Abb. 1: Blutzellen wie sie bei den vier untersuchten Agamenarten beobachtet wurden (Wright-Färbung).

Table 1: Hematological parameters in *Laudakia caucasia* (EICHWALD, 1831). *n* - Number of Specimens; SD - Standard Deviation; Min-Max: Minimum-Maximum values.

Tab. 1: Hämatologische Werte von *Laudakia caucasia* (EICHWALD, 1831). *n* - Anzahl der Exemplare; SD - Standardabweichung; Min-Max: Minimum-Maximum.

Parameter	<i>n</i>	Mean / Mittel	SD	Minimum - Maximum
RBC (Red Blood Cell Count) (1/mm ³)	10	1023000	118701	800000 - 1200000
WBC (White Blood Cell Count) (1/mm ³)	10	6007.00	2641.26	2000 - 9450
THb (Total Hemoglobin concentration) (g/dl)	10	10.54	1.32	08.00 - 13.00
Hematocrit (%)	10	37.70	4.83	29.00 - 44.00
Erythrocyte Mean Cell Volume (µm ³)	10	370.95	49.33	284.31 - 453.61
Erythrocyte Mean Cell Hemoglobin (pg)	10	103.69	13.21	78.43 - 124.44
Erythrocyte Mean Cell Hemoglobin Concentration (%)	10	28.17	3.44	21.36 - 33.33
Lymphocytes (%)	9	53.55	6.72	44.00 - 62.00
Monocytes (%)	9	11.00	2.00	8.00 - 14.00
Heterophils (%)	9	11.44	3.08	8.00 - 15.00
Eosinophils (%)	9	14.77	3.30	11.00 - 21.00
Basophils (%)	9	9.44	3.46	4.00 - 15.00
Total Protein (g/dl)	10	4.52	0.41	4.00 - 5.25
Erythrocyte Length (EL) (µm)	10	17.02	0.39	16.43 - 17.53
Erythrocyte Width (EW) (µm)	10	9.54	0.27	9.07 - 9.90
Erythrocyte Size (ES) (µm ²)	10	127.64	5.37	121.45 - 135.90
EL/EW	10	1.78	0.05	1.73 - 1.88
Erythrocyte Nucleus Length (NL) (µm)	10	7.57	0.71	6.80 - 9.45
Erythrocyte Nucleus Width (NW) (µm)	10	3.85	0.26	3.52 - 4.31
Erythrocyte Nucleus Size (NS) (µm ²)	10	22.87	2.20	20.33 - 28.29
NL/NW	10	1.98	0.25	1.63 - 2.48
NS/ES	10	0.18	0.02	0.16 - 0.24
Thrombocyte Length (µm)	10	6.75	0.21	6.45 - 7.10
Thrombocyte Width (µm)	10	4.57	0.28	3.90 - 4.87
Lymphocyte Size (µm ²)	10	8.99	0.59	8.20 - 10.05
Monocyte Size (µm ²)	10	14.83	0.73	13.70 - 15.70
Heterophil Size (µm ²)	10	12.71	0.64	11.96 - 13.66
Eosinophil Size (µm ²)	10	12.69	0.52	12.10 - 13.32
Basophil Size (µm ²)	10	9.11	0.66	8.00 - 10.00

Data analysis.- Non-parametric tests (Kruskal Wallis) and descriptive statistics were conducted using SPSS (v10.0). Kruskal Wallis test was applied to test for

differences between males and females. The confidence interval was set at 95% for all tests.

RESULTS

Blood cell morphology

Erythrocytes - oval-shaped cells with centrally located oval nuclei in all species studied (Fig. 1 A).

Lymphocytes - cells of spherical shape. Using Wright's stain, their cytoplasm were stained in pale blue and their nuclei in violet-blue; the most abundant leukocytes in all species studied (Fig. 1 B).

Monocytes - the largest among the leukocytes in all species studied. Their cytoplasm were stained in light pink and the nuclei in violet (Fig. 1 C1).

Basophils - the smallest leukocytes in all species studied. Their cytoplasm appeared light blue, with dark purplish-to-bluish granules partly obscuring the dark blue nucleus (Fig. 1 C2).

Heterophils - cells characterized by a reniform to lobulated nucleus, often in

Table 2: Hematological parameters in *Laudakia stellio* (LINNAEUS, 1758). *n* - Number of Specimens; SD - Standard Deviation; Min-Max: Minimum-Maximum values.Tab. 2: Hämatologische Werte von *Laudakia stellio* (LINNAEUS, 1758). *n* - Anzahl der Exemplare; SD - Standardabweichung; Min-Max: Minimum-Maximum.

Parameter	<i>n</i>	Mean / Mittel	SD	Minimum - Maximum
RBC (Red Blood Cell Count) (1/mm ³)	20	883166.55	1.27	660000 - 1173333
WBC (White Blood Cell Count) (1/mm ³)	20	5326.65	2329.56	1666 - 9800
THb (Total Hemoglobin concentration) (g/dl)	20	9.00	1.42	5.80 - 12.00
Hematocrit (%)	20	34.55	4.08	27.00 - 41.00
Erythrocyte Mean Cell Volume (µm ³)	20	395.76	54.24	325.65 - 550.72
Erythrocyte Mean Cell Hemoglobin (pg)	20	102.60	13.81	79.12 - 127.90
Erythrocyte Mean Cell Hemoglobin Concentration (%)	20	26.24	4.31	18.12 - 36.66
Lymphocytes (%)	9	43.30	7.02	32.00 - 52.00
Monocytes (%)	9	13.10	5.27	6.00 - 23.00
Heterophils (%)	9	16.80	4.34	13.00 - 27.00
Eosinophils (%)	9	16.15	2.02	12.50 - 19.00
Basophils (%)	9	10.00	3.16	6.00 - 15.00
Total Protein (g/dl)	20	4.25	0.65	3.50 - 5.35
Erythrocyte Length (EL) (µm)	10	17.91	0.73	16.60 - 19.41
Erythrocyte Width (EW) (µm)	10	9.89	0.16	9.66 - 10.22
Erythrocyte Size (ES) (µm ²)	10	139.32	7.61	125.94 - 155.89
EL/EW	10	1.81	0.05	1.72 - 1.90
Erythrocyte Nucleus Length (NL) (µm)	10	7.23	0.43	6.40 - 8.01
Erythrocyte Nucleus Width (NW) (µm)	10	3.98	0.30	3.18 - 4.28
Erythrocyte Nucleus Size (NS) (µm ²)	10	22.70	2.67	17.45 - 26.94
NL/NW	10	1.82	0.14	1.63 - 2.19
NS/ES	10	0.16	0.01	0.13 - 0.19
Thrombocyte Length (µm)	10	7.01	0.39	6.37 - 7.60
Thrombocyte Width (µm)	10	4.68	0.31	4.30 - 5.17
Lymphocyte Size (µm ²)	10	8.52	0.68	7.50 - 9.60
Monocyte Size (µm ²)	10	14.73	0.66	13.90 - 16.10
Heterophil Size (µm ²)	10	12.85	0.77	11.90 - 14.10
Eosinophil Size (µm ²)	10	13.53	0.85	12.00 - 15.00
Basophil Size (µm ²)	10	9.13	0.68	8.45 - 10.60

excentric position. The cytoplasm contained numerous stick-shaped granules, which were stained in bright pink to orange by Wright stain (Fig. 1 D).

Eosinophils - cells containing a usually bilobed nucleus stained in dark blue. The cytoplasm, characterized by large, roundish and bright reddish granules, was stained in light blue (Fig. 1 E).

Thrombocytes - spindle-shaped cells harboring a darkly stained large oval nucleus which leaves a narrow, irregular cytoplasmic area. Thrombocytes tended to clump together in blood smears (Fig. 1 F).

In the blood smears of four agamid species examined, lymphocytes were the most numerous blood cells whereas basophils and monocytes were the rarest. Among leukocytes, in all specimens, mono-

cytes had the largest diameter whereas basophils were the smallest cells.

Further hematological parameters

There were significant hematological differences between males and females in *L. stellio* and *L. caucasia*. Such differences found in *L. stellio* refer to (i) total hemoglobin concentration (Kruskal Wallis test, $\chi^2 = 7.18$, $df = 1$, $P < 0.05$), (ii) Mean Cell Hemoglobin (Kruskal Wallis test, $\chi^2 = 11.07$, $df = 1$, $P < 0.05$) and, (iii) Mean Cell Hemoglobin Concentration (Kruskal Wallis test, $\chi^2 = 5.14$, $df = 1$, $P < 0.05$). In *L. caucasia*, the sexes were different in terms of their total hemoglobin values (Kruskal Wallis test, $\chi^2 = 4.84$, $df = 1$, $P < 0.05$). For hematological reference intervals of four agamid species studied see Tables 1-4.

Table 3: Hematological parameters in *Phrynocephalus horvathi* ROSTOMBEKOV, 1938. *n* - Number of Specimens; SD - Standard Deviation; Min-Max: Minimum-Maximum values.

Tab. 3: Hämatologische Werte von *Phrynocephalus horvathi* ROSTOMBEKOV, 1938. *n* - Anzahl der Exemplare; SD - Standardabweichung; Min-Max: Minimum-Maximum.

Parameter	<i>n</i>	Mean / Mittel	SD	Minimum - Maximum
RBC (Red Blood Cell Count) (1/mm ³)	10	729400	183198.3	447000 - 1000000
WBC (White Blood Cell Count) (1/mm ³)	9	5155.55	864.74	3800 - 6600
THb (Total Hemoglobin concentration) (g/dl)	8	8.03	1.02	5.70 - 8.80
Hematocrit (%)	10	25.10	4.50	20.00 - 35.00
Erythrocyte Mean Cell Volume (µm ³)	10	358.01	78.82	250.00 - 466.67
Erythrocyte Mean Cell Hemoglobin (pg)	8	106.92	14.49	84.00 - 126.67
Erythrocyte Mean Cell Hemoglobin Concentration (%)	8	30.84	4.83	24.29 - 38.26
Lymphocytes (%)	9	35.00	4.87	29.00 - 43.00
Monocytes (%)	9	12.22	4.26	8.00 - 18.00
Heterophils (%)	9	25.33	5.93	18.00 - 35.00
Eosinophils (%)	9	15.22	5.86	9.00 - 27.00
Basophils (%)	9	12.22	2.22	8.00 - 15.00
Total Protein (g/dl)	9	3.27	0.42	2.50 - 4.00
Erythrocyte Length (EL) (µm)	10	16.12	0.45	15.38 - 16.92
Erythrocyte Width (EW) (µm)	10	8.89	0.32	8.26 - 9.25
Erythrocyte Size (ES) (µm ²)	10	112.77	5.75	103.86 - 122.94
EL/EW	10	1.81	0.74	1.68 - 1.95
Erythrocyte Nucleus Length (NL) (µm)	10	6.77	0.26	6.26 - 7.11
Erythrocyte Nucleus Width (NW) (µm)	10	4.11	0.43	3.78 - 5.31
Erythrocyte Nucleus Size (NS) (µm ²)	10	22.01	3.07	19.26 - 30.19
NL/NW	10	1.70	0.08	1.60 - 1.89
NS/ES	10	0.18	0.01	0.17 - 0.21
Thrombocyte Length (µm)	9	8.80	0.73	7.57 - 9.62
Thrombocyte Width (µm)	9	5.18	0.58	4.56 - 6.12
Lymphocyte Size (µm ²)	9	9.48	0.53	9.00 - 10.29
Monocyte Size (µm ²)	9	14.80	0.61	14.00 - 15.87
Heterophil Size (µm ²)	9	13.32	0.56	12.25 - 14.00
Eosinophil Size (µm ²)	9	13.39	0.79	12.43 - 14.87
Basophil Size (µm ²)	9	10.59	0.65	9.75 - 12.00

DISCUSSION

Several authors (SAINT GIRONS 1970; SEVINÇ et al. 2000; SEVINÇ & UĞURTAŞ 2001; ATATÜR et al. 2001; PONSEN et al. 2008), who studied the blood of lizards, reported species-specific variations concerning both erythrocyte and leukocyte counts. SEVINÇ et al. (2004) and MERMER (1999) reported no sexual dimorphism in blood cell counts in the gecko and scincid species studied. Our results did not show any sexual differences in terms of erythrocyte counts; however, the erythrocyte count in *L. caucasia* was higher than those of *L. stellio* and *P. horvathi* (Table 5).

Generally, lymphocytes and heterophils are the most common leukocytes in the blood, while basophils and monocytes are the rarest (SAINT GIRONS 1970; FRYE

1991; CAMPBELL 1996; MADER 2000). Lymphocytes were found to be the most numerous leukocytes, basophils and monocytes the fewest in four agamid species. These results are in agreement with previous studies.

According to some authors (HUTCHINSON & SZARSKI 1965; SZARSKI & CZOPEK 1966; SAINT GIRONS 1970; SEVINÇ et al. 2000; SEVINÇ & UĞURTAŞ 2001; ATATÜR et al. 2001), erythrocyte sizes vary among lizard families, sometimes even between species within a family. Our results demonstrate the presence of some differences in erythrocyte sizes among four agamid species from Turkey. The erythrocyte size in *L. stellio* was larger than that of *L. caucasia*, *P. horvathi* and *T. lessonae*, respectively

Table 4: Hematological parameters in *Trapelus lessonae* (DE FILIPPI, 1865). *n* - Number of Specimens; SD - Standard Deviation; Min-Max: Minimum-Maximum values.Tab. 4: Hämatologische Werte von *Trapelus lessonae* (DE FILIPPI, 1865). *n* - Anzahl der Exemplare; SD - Standardabweichung; Min-Max: Minimum-Maximum.

Parameter	<i>n</i>	Mean / Mittel	SD	Minimum - Maximum
RBC (Red Blood Cell Count) (1/mm ³)	}	Not analyzed due to insufficient sample size. Wegen zu geringer Probenmenge nicht untersucht.		
WBC (White Blood Cell Count) (1/mm ³)				
THb (Total Hemoglobin concentration) (g/dl)				
Hematocrit (%)				
Erythrocyte Mean Cell Volume (μm ³)				
Erythrocyte Mean Cell Hemoglobin (pg)				
Erythrocyte Mean Cell Hemoglobin Concentration (%)				
Lymphocytes (%)	5	43.00	3.46	40.00 - 48.00
Monocytes (%)	5	12.60	1.81	10.00 - 15.00
Heterophils (%)	5	13.00	2.64	10.00 - 17.00
Eosinophils (%)	5	16.20	1.64	14.00 - 18.00
Basophils (%)	5	16.60	2.60	13.00 - 20.00
Total Protein (g/dl)	-	-	-	-
Erythrocyte Length (EL) (μm)	5	15.89	1.01	15.08 - 17.04
Erythrocyte Width (EW) (μm)	5	8.33	0.23	8.02 - 8.60
Erythrocyte Size (ES) (μm ²)	5	104.16	9.46	94.97 - 114.93
EL/EW	5	1.91	0.07	1.84 - 1.99
Erythrocyte Nucleus Length (NL) (μm)	5	7.03	0.28	6.78 - 7.34
Erythrocyte Nucleus Width (NW) (μm)	5	3.40	0.13	3.14 - 3.54
Erythrocyte Nucleus Size (NS) (μm ²)	5	18.72	1.16	16.81 - 19.83
NL/NW	5	2.09	0.11	1.93 - 2.19
NS/ES	5	0.18	0.01	0.17 - 0.19
Thrombocyte Length (μm)	5	6.77	0.18	6.58 - 7.00
Thrombocyte Width (μm)	5	4.48	0.26	4.20 - 4.60
Lymphocyte Size (μm ²)	5	9.47	0.27	9.20 - 9.80
Monocyte Size (μm ²)	5	14.50	0.39	14.20 - 15.10
Heterophil Size (μm ²)	5	11.50	0.25	11.20 - 11.90
Eosinophil Size (μm ²)	5	13.74	0.66	12.90 - 14.60
Basophil Size (μm ²)	5	8.50	0.30	8.20 - 8.80

(Table 5). Erythrocytes play an important role in oxygen and carbon dioxide transport. The erythrocytes' surface-area-to-volume ratio is a determining factor in their capacity of oxygen and carbon dioxide exchange in the tissues in that a small erythrocyte is relatively more efficient in gas exchange than a larger one (HARTMAN & LESSLER 1964; SEVINÇ et al. 2000). Our results are not in agreement with HARTMAN & LESSLER 1964, SEVINÇ et al. 2000 and PAL et al. 2008.

According to our observations, and not yet described in detail, physiological activity was much higher in *L. stellio* and *L. caucasica*, which have larger erythrocyte sizes than *P. horvathi* and *T. lessonae* which appeared less energized.

SZARSKI & CZOPEK (1984) found no differences in the total hemoglobin between male and female lizards. However, the re-

sults of the present study showed that total hemoglobin, Mean Cell Hemoglobin and Mean Cell Hemoglobin Concentration were different between males and females of *L. stellio*. In *L. caucasica* a difference between males and females was detected only in the total hemoglobin value. In terms of other hematological parameters, there were some clear differences between *L. caucasica*, *L. stellio* and *P. persicus*. The total hemoglobin concentration, hematocrit percentage and erythrocyte mean cell volume in *L. caucasica* and *L. stellio* were higher than of *P. horvathi*. On the contrary, the mean cell hemoglobin concentration value in *P. horvathi* was higher than of *L. caucasica* and *L. stellio*. We think that these differences are sufficiently explained by the extremely high activity of *L. stellio* and *L. caucasica* during the day.

Table 5: Some hematological values in different agamid species, according to several authors. M - Males, F - Females.
 Tab. 5: Einige hämatologische Werte verschiedener Agamenarten, nach mehreren Autoren. M - Männchen, F - Weibchen.

Reference Quelle	Species	Erythrocytes (1/mm ³)	Leukocytes (1/mm ³)	ES (µm ²)	NS (µm ²)	Total Hemo- globin (g/dl)	Hematocrit (%)
Present study /diese Arbeit	<i>Laudakia caucasia</i>	1023000	-	127.6	22.9	10.5	37.7
Present study /diese Arbeit	<i>Laudakia stellio</i>	883167	5327	139.3	22.7	9.0	34.6
Present study /diese Arbeit	<i>Phrynocephalus horvathi</i>	729400	5156	112.8	22.0	8.0	25.1
Present study /diese Arbeit	<i>Trapelus lessoniae</i>	-	-	104.2	18.7	-	-
PINEAR (1962)	<i>Agama atra</i>	1250	-	-	-	-	-
SAINT-GIRONS (1970)	<i>Agama impatlearis</i>	-	-	96.1	14.3	-	-
SAINT-GIRONS (1970)	<i>Diporiphora bilineata</i>	-	-	124.6	18.4	-	-
SAINT-GIRONS (1970)	<i>Amphibolurus reticulatus</i>	-	-	92.4	12.8	-	-
ELIMAN (1997)	<i>Pogona vitticeps</i>	-	12053	-	-	-	27.0
PAL et al. (2008)	<i>Sitana ponticeriana</i>	826825 M	14796 M	119.9 M	26.2 M	5.2 M	-
PAL et al. (2008)	<i>Sitana ponticeriana</i>	634600 F	11595 F	115.1 F	41.3 F	5.0 F	-
PONSEN et al. (2008)	<i>Leiolepis belliana rubritaeniata</i>	860000	7300	-	-	8.1	24.4

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Corresponding editor: Heinz Grillitsch

AUTHORS: Çiğdem GÜL (corresponding author) < gulcigdem@comu.edu.tr > < gulcigdem17@hotmail.com.tr >, Çanakkale Onsekiz Mart University, Faculty of Sciences and Arts, Department of Biology, 17100 Çanakkale-Turkey; Murat TOSUNOĞLU < mtosun@comu.edu.tr > Çanakkale Onsekiz Mart University, Faculty of Sciences and Arts, Department of Biology, 17100 Çanakkale-Turkey