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Erythrocyte Size in Some Wild Spanish Birds

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An analysis was made of the erythrocyte dimensions of 21 species of the following Passeriformes common to the Iberian Peninsula: Fringilidae, Silvidae, Turdidae, Prunellidae, Ploceidae, Certhiidae, Emberizidae, Paridae, Troglodytidae and Apodiformes: F. Apodidae.

The erythrocyte dimensions in Passeriformes were very uniform. Only the Silvidae presented a significant correlation ($r = 0.96$) between body size and cell area. In Apodiformes, cell area and cell length and width were significantly greater ($p < 0.01$) than red blood cell dimensions in Passeriformes.

The study of erythrocyte size in birds may be of metabolic importance where different oxygen demands and blood transport adaptation are concerned. At present it is not clear if red cell size is of functional importance in vertebrates (7), although authors (3, 10), among others, have related erythrocyte size with the carapace length and the size of the birds, respectively. However, the data available in birds thus far reveal no striking correlations between red blood cell (R B C) size and oxygen transport functions.

In a previous study (6) an analysis was made of erythrocyte dimensions in seven species of domestic and 16 wild but captive birds from the Barcelona Zoo. Since then, only a study (1) on the common Indian weaver has been found dealing with this specific subject. Neither the review (4) in *Avian Biology*, nor (8) cite references that had not already been taken into account.

In the present study, 21 species of wild birds common to the Iberian peninsula, were analyzed most of them not having been previously studied. Of the 21 species presented herein, 18 species are representatives of 8 families belonging to the order Passeriformes (Fringilidae, Silvidae, Prunellidae, Ploceidae, Certhiidae, Emberizidae, Paridae, Troglodytidae) and 3 species are of the order Apodiformes.

Materials and Methods

The Passeriformes were captured by Japanese mist nests 20 Km northwest of

Barcelona, in a wooded area 150 m above sea level. Dates of capture are indicated for each specimen in table I.

The swifts *(Apus apus)* were caught in four different locations and habitats: northern Barcelona, an urban habitat where birds were captured from nests in buildings; the village of Rubi, in an urban habitat; Garraf mountain. Birds were captured in open fields and from nests in the cliffs. In cliffs near the village of San Quirico de Safage.

Some specimens of *Apus melba* were caught using Japanese mist nest from small local population in an old house in another area of the city of Barcelona (Valle Hebron). The majority of the *A. melba*, as well as the *A. pallidus*, were captured in their natural nests in the rocky cliffs near San Quirico de Safage and Garraf (province of Barcelona). Either Japanese mist nests or bird lime was used in this case.

All the specimens were brought to the laboratory and blood samples were withdrawn by heart puncture with a heparinized needle and catheter, the end of which was introduced into a small, short glass tube. A gentle continuous vibration on the tube, produced by a small electric device, facilitated the flow of blood and prevented coagulation in these blood samples. All blood samples were obtained within 24 hours of capture.

The smears were air-dried, fixed with methanol for 5 min, stained for 3 min with May-Grünwald stain and washed with distilled water. The slides were then stained for 15 min with a 50 % solution of Giemsa stain in distilled water and, finally, rinsed with tap water.

The cells were examined under oil immersion, and their dimension estimated by means of a calibrated eyepiece. Measurements of 100 erythrocytes from each species were taken from different smears selected for excellence of staining and internal cytology. Ratios of maximum length to width were calculated as an index of the deviation of R B C's from a spherical shape.

From the erythrocyte dimensions (average length and width reported) the surface area of the elliptic red cell and nucleus for each specimen was calculated according to the following formula: $A = \pi$ a b; a and b being the longest and shortest ratios, respectively.

Results* and Discussion

The erythrocyte dimensions in Passeriformes (table I) are very uniform among the species studied ranging between 10.8-13.8 μm in length and 5.4-6.4 μm in width; the corresponding total areas ranged from 46.2 to 65.2 μm^2. The ratio L/W ranged between 1.8-2.5. The nuclear dimensions were 4.7-6.5 μm $\times$ 1.94-2.80 μm representing an average surface of 7.2 to 13.7 μm^2.

In Apodiformes the erythrocyte dimensions were very similar among the three species (cytosome 13.6-6.9 μm; ratio L/W = 1.97; nucleus: 6.21 $\times$ 2.39 μm^2; ratio L/W = 2.6). The erythrocyte area was the highest in all the species studied (73.4 μm^2). Both cell area and cell length and width of the Apodiformes differed statistically ($p < 0.01$) from the Passeriformes. The values tabulated for Passeriformes differed statistically ($p < 0.01$) from the Falconiforme species analyzed previously (6), but are close to those for other orders. However, in general the ratio L/W is obviously higher in all the groups of the present study, including the raven, the only representative of the Passeriformes order analyzed in our earlier study.

The extensive survey (5) using specimens from Panama and the United States (Florida and Ohio), showed values for

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species from several families (Fringillidae, Turdidae, Troglodytidae, etc.), that fit well with those of the European species; the small differences noted could be attributed to individual differences in measuring techniques. However, all the genus are different and it is not possible to make a comparison among closely related species of the same genus. Also, BARTSCH *et al.* (2) studied fifty North American species and reported erythrocyte sizes ranging from 10-14 $\mu m \times 5.5$-7.5 μm; the species with the smallest red cells was *Regulus satrapa* (9.75×5.04 μm) (2), which was similar to the European species *R. ignicapillus* (10.8×5.4 μm) of the present study.

From the different studies carried out on erythrocyte size in birds, a great uniformity in birds emerges and only the Falconiformes presented significantly larger dimensons ($p < 0.01$) than the Passeriformes and the other orders, but there were no significant differences with regard to the Apodiformes. Likewise, the Falconiformes (Catharthidae, Accipitridae, Falconidae), studied (5) had the biggest erythrocyte size among the 90 species studied. Similarly, BARTSCH *et al.* (2) who measured 3 Falconiformes *(Buteo b. borealis, Pandion haliaetus* and *Tyto alba)*, found the size to be the biggest of the 50 species analyzed. In a previous paper (6), the erythrocyte size of the 6 Falconiformes species were also found to possess the greatest dimensions.

Table II summarizes the results and observations of this study along with the data of the other researchers. The Falconiformes showed a statistically greater erythrocyte size than other birds, and there was no significant difference between Passeriformes and the general group of birds. However, a peculiar characteristic of some families was evident and they deviated from the overall mean. There were some species in several families with erythrocyte dimensions bigger than the average values in the non-falconiforme birds; however, they are few in number and there is no uniformity within the families. Likewise, the Ardeidae, Anhigidae and some Rallidae species (5), the woodpecker (2) as well as the Apodiformes (this study) show similar deviations.

There were significant but small correlations between cell width and cell area versus body mass ($r = 0.42$ and $r = 0.40$ respectively), which had already been suggested (5); on the other hand there was no significant correlation between cell length and body mass. The relation of body weight to cell size among families which had at least 4 specimens was then examined. Only the Silvidae and Fringilidae families could therefore be studied. In the Silvidae family there was a significant correlation ($r = 0.96$) between body size and cell area. In the Fringilidae, *Fringilla coelebs* presented the gratest erythrocyte dimension (13.3×5.9 μm and surface area 61.05 μm^2) and the body weight was the average of the group (18 g). The Silvidae and Turdidae families presented the extreme values for body weight; the lowest corresponding to *Regulus* and *Phylloscopus* (4-5.5 g), and the highest to *Turdus merula* (86 g). The surface area of the red blood cells ranged from 46.4-51.7 μm^2 in *Regulus* and *Phylloscopus* versus 62.09 μm^2 in *Turdus*.

With regard to other families, the Paridae and Troglodytidae deserve mention, whose representatives have a very small body size (6.7-9.7 g). Only *Parus caeroleus* had small erythrocytes with a surface area 53.3 μm^2, but in Aegithalos and especially in Troglodytes the surface area was greater (59.4-61.0 μm^2).

In comparative rheologic and ultrastructural studies between birds and mammals (9) showed that erythrocytes, in certain physiological conditions, could also adopt an elliptical shape. This could be due to a different cellular structure of the membrane. We believe that this greater rigidity makes deformation more difficult thereby minimizing possible errors due to

Table I. *Measurements of erythrocytes of wild birds (Mean ± S.E.).* All birds were captured between January and July 1978.

Species	N	Sex	Body weight (g)	Cytosome			Nucleus			Surface		
				Length (μm)	Width (μm)	Ratio L/W	Length (μm)	Width (μm)	Ratio L/W	Total μ²	Nucleus μ²	Difference μ²
Fringilidae												
Carduelis carduelis Goldfinch	3	♂ ♀	12.7	11.72 ±0.15	6.08 ±0.08	1.93	5.22 ±0.12	2.22 ±0.07	2.35	55.97	9.10	46.9
Carduelis chloris Greenfinch	2	♂	20.5	12.38 ±0.20	5.68 ±0.06	2.18	6.08 ±0.14	2.39 ±0.06	2.54	55.23	11.41	43.8
Carduelis spinus Siskin	4	♂ ♀	10.6	11.67 ±0.14	5.51 ±0.06	2.12	5.51 ±0.09	2.33 ±0.06	2.36	50.5	10.08	40.4
Fringilla coellebs Chafinch	8	♂ ♀	18.5	13.13 ±0.18	5.92 ±0.08	2.22	6.29 ±0.14	2.35 ±0.06	2.68	61.05	11.61	49.4
Serinus serinus Serin	1	♂	9.0	12.38 ±0.18	5.92 ±0.09	2.09	5.59 ±0.14	2.34 ±0.06	2.39	57.56	10.27	47.3
Turdus merula Blackbird	3	♂ ♀	86	12.47 ±0.15	6.34 ±0.06	1.97	5.75 ±0.09	2.42 ±0.06	2.38	62.09	10.93	51.2
Silvidae												
Regulus ignicapillus Firecrest	1	♂	4.0	10.83 ±0.12	5.43 ±0.10	1.99	4.75 ±0.13	1.94 ±0.10	2.45	46.19	7.24	39.0
Erithacus rubecula Robin	5	♂ ♀	14.6	12.84 ±0.19	6.33 ±0.08	2.03	6.03 ±0.10	2.55 ±0.07	2.36	63.83	12.08	56.6
Phylloscopus collybita Chiffchaff	2	♀	5.5	11.98 ±0.23	5.50 ±0.09	2.18	5.51 ±0.12	2.05 ±0.06	2.69	51.75	8.87	39.7
Cettia cetti Cetti's warbler	1	♂	9.0	13.54 ±0.16	5.39 ±0.11	2.51	6.36 ±0.11	2.29 ±0.07	2.78	57.32	11.44	45.9

Sylvia atricapilla Blackcap	8	♂ ♀	13.8	13.24 ±0.20	6.27 ±0.14	2.11	6.20 ±0.09	2.81 ±0.07	2.21	65.20	13.68	51.5
Prunellidae *Prunella modularis* Dunnock	3	♂ ♀	19.4	11.75 ±0.20	6.44 ±0.01	1.82	6.18 ±0.01	2.49 ±0.09	2.48	59.43	12.09	47.3
Ploceidae *Passer domesticus* House sparrow	1	♀	28.0	13.00 ±0.11	6.19 ±0.06	2.10	5.50 ±0.10	2.05 ±0.05	2.68	63.20	8.86	54.3
Certhiidae *Certhia brachydactyla* Short-toed tree creeper	1	♂	7.0	12.04 ±0.15	5.96 ±0.09	2.02	5.57 ±0.11	2.28 ±0.05	2.44	56.36	9.97	46.4
Emberizidae Emberiza cirlus Cirl bunting	1	♀	20.0	13.87 ±0.17	5.81 ±0.05	2.39	6.09 ±0.09	2.36 ±0.04	2.58	63.29	11.29	52.0
Paridae *Parus caeroleus* Blue tit	1	♀	9.7	11.86 ±0.14	5.72 ±0.07	2.07	5.65 ±0.09	2.39 ±0.04	2.36	53.28	10.61	47.2
Aegithalos caudatus Long-tailed tit	1	♂	6.7	12.66 ±0.17	5.97 ±0.06	2.12	6.07 ±0.09	2.20 ±0.04	2.76	59.36	10.49	48.9
Troglodytiae *Troglodytes troglodytes* Wren	1	♀	8.4	12.65 ±0.20	6.14 ±0.07	2.06	6.54 ±0.17	2.55 ±0.06	2.56	61.00	13.10	47.9
Apodidae *Apus apus* Swift	8	♂ ?	37.2	13.57 ±0.17	6.91 ±0.10	1.96	6.18 ±0.10	2.24 ±0.05	2.76	73.65	10.87	62.8
Apus melba Alpine swift	8	♂ ♀	86.8	13.81 ±0.23	6.98 ±0.10	1.98	6.26 ±0.13	2.39 ±0.05	2.62	75.71	11.75	64.0
Apus pallidus Pallid swift	2	♂ ♀	35.3	13.45 ±0.18	6.83 ±0.08	1.97	6.19 ±0.13	2.55 ±0.06	2.43	72.15	12.40	59.8

Table II. *Measurements of erythrocytes of birds (Mean ± S.E.).*

Avian groups	N°	Cytosome			Nucleus		References
		Length (μm)	Width (μm)	Ratio L/W	Length (μm)	Width (μm)	
Passeriformes (A)	123	11.64±0.07	6.28±0.05	1.85	5.48±0.04	2.36±0.03	Present study and (2, 5, 6)
Falconiformes (B)	18	13.97±0.18	7.70±0.11	1.81	6.39±0.12	2.66±0.06	(2, 5, 6)
All birds except Falconiformes (C)	231	12.19±0.08	6.73±0.05	1.81	5.61±0.04	2.49±0.20	Present study and (1, 2, 3)

Statistical significance: A-C = N.S.; A-B = $p < 0.01$; B-C = $p < 0.01$.

the chemical treatment of the erythrocytes by the fixing agents and stains.

Resumen

Se analizan las dimensiones de los eritrocitos pertenecientes a 21 especies de Paseriformes, frecuentes en la Península Ibérica: Fringilidae, Silvidae Turdidae, Prunellidae, Ploceidae, Certhiidae, Emberizidae, Paridae, Troglodytidae, y Apodiformes: F. Apodidae.

Las dimensiones de los eritrocitos en los Paseriformes fueron muy uniformes. Unicamente los Silvidos presentaron una correlación significativa ($r = 0,96$) entre el tamaño corporal y el área celular. En los Apodiformes, el área celular y la longitud y anchura celular fueron significativamente mayores ($p < 0,01$) que en los glóbulos rojos de los Paseriformes.

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