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Short Communication

Reference Ranges and the Influence of Age and Sex on Haematological Values of the Endangered Catalonian Donkey

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The Catalonian donkey is a local breed found in several Pyrenean and pre-Pyrenean regions of the Catalonian area of Northeast Spain. It has contributed to the formation and improvement of several European breeds as well as the American Ass or Mammoth donkey breed (Briggs, 1971; Epstein, 1984; Parés & Vilaró, 1994). The total number of existing animals is about 100, a third of which are males, which places the breed into the critical category (<100 females) proposed by FAO (1992), implying that the breed is in danger of extinction (Bodó, 1992). The main objective of this communication is to characterize haematologically this endangered population, and to establish normal ranges.

We examined 45 adult females aged 3–17 years, 26 adult males aged 3–13 years, and 27 young donkeys (<3 years) of both sexes. All animals appeared clinically healthy. Stress was minimized by handling the animals with care before samples were collected. Data, which seemed to be normally distributed or approximate to a normal distribution after power transformation (Johnson & Wichent, 1988), were analysed by analysis of variance (ANOVA). For other data, non-parametric tests were used. Computations were performed using a statistical software program (SAS, 1989).

Reference ranges are shown in Table I. No significant differences between sexes were found for any parameter in agreement with the report of French and Patrick (1995). However, other authors have reported sexual differences for some parameters. For example, Zinkl *et al.* (1990) showed that females had higher values of mean corpuscular haemoglobin concentration (MCHC), leucocyte and neutrophil counts than males ($P<0.05$).

Age had the most influence on the haematological parameters studied in our donkey population. Nine of the 16 variables showed significant differences between young and adult animals, and there was an interaction between age and sex for eosinophil count ($P<0.05$), with a decreased trend with age in female subpopulation. Total and differential leucocyte counts showed a significant decrease with advancing age but numbers of monocytes and basophils did not seem to be so influenced. Similar results, with some exceptions, have been obtained in horses (Jain, 1986) and also in donkeys (Zinkl *et al.*, 1990). In contrast to our findings, however, Zinkl *et al.* (1990), analysing an American donkey population, reported a significant aging increase in the eosinophil count ($P<0.05$). On the other hand, Fowler and Zinkl (1989) also obtained a marked age-related increase in eosinophil counts in llamas in the Western United States, postulating that this increase may be attributable to increasing parasite burden with age. Perhaps the decrease in eosinophil count with age reflects a lower parasite burden; certainly the population of Catalonian donkeys we examined was receiving routine anthelmintic treatment.

Two red-cell parameters, mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH), and plasma protein all increased signifi-

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Table I
Haematological values of the Catalonian donkey

Analyte	n	*Mean±SD*	*Percentiles*			*Range*
			95%	*Median*	*5%*	
Erythrocyte count (10^{12} l^{-1})						
All donkeys	98	6·87±1·22	8·67	6·99	4·78	4·07–10·44
Young donkeys	27	7·14±1·34	8·94	6·96	5·26	4·46–10·44
Adult donkeys	71	6·77±1·17 (NS)	8·52	7·00	4·78	4·07–10·16
Haemoglobin (g l^{-1})						
All donkeys	98	122·8±22·7	155	123	93	13·6–169
Young donkeys	27	118·4±14·1	136	121	93	93·0–149
Adult donkeys	71	124·5±25·1 (NS)	158	124	96	13·6–169
Packed cell volume (l l^{-1})						
All donkeys	98	0·36±0·05	0·45	0·35	0·27	0·13–0·48
Young donkeys	27	0·34±0·03	0·40	0·34	0·27	0·26–0·41
Adult donkeys	71	0·36±0·05 (NS)	0·45	0·36	0·28	0·13–0·48
Mean corpuscular volume (Fl)						
All donkeys	98	52·6±7·5	63·8	53·5	40·3	20·4–68·8
Young donkeys	27	48·6±5·7	57·9	48·1	40·3	36·4–62·8
Adult donkeys	71	54·1±7·6 (**)	64·6	54·9	42·2	20·4–68·8
Mean corpuscular haemoglobin concentration (g l^{-1})						
All donkeys	98	347·0±12·8	366	347	326	282–384
Young donkeys	27	347·1±11·2	363	345	328	321–366
Adult donkeys	71	346·9±13·4 (NS)	368	348	326	282–384
Mean corpuscular haemoglobin (pg)						
All donkeys	98	18·4±2·2	22·4	18·4	14·7	12·3–23·6
Young donkeys	27	16·9±1·9	19·8	16·8	13·9	12·5–21·5
Adult donkeys	71	19·1±2·1 (**)	22·6	19·3	15·9	12·3–23·6
Leucocytes (10^9 l^{-1})						
All donkeys	98	10·7±2·9	16·7	9·7	7·1	6·4–21·0
Young donkeys	27	13·9±3·0	17·7	14·3	9·7	7·5–21·0
Adult donkeys	71	9·6±1·8 (**)	13·7	9·3	6·9	6·4–15·4
Lymphocytes (10^9 l^{-1})						
All donkeys	98	5·3±2·4	11·0	4·6	2·4	1·8–13·6
Young donkeys	27	8·0±2·7	12·7	7·3	4·7	3·2–13·6
Adult donkeys	71	4·2±1·2 (**)	6·4	4·3	2·4	1·8– 7·8
Monocytes (10^9 l^{-1})						
All donkeys	98	0·22±0·19	0·59	0·19	0·00	0·00–1·05
Young donkeys	27	0·27±0·26	0·81	0·25	0·00	0·00–1·05
Adult donkeys	71	0·21±0·16 (NS)	0·52	0·19	0·00	0·00–0·77
Band neutrophils (10^9 l^{-1})						
All donkeys	98	0·06±0·11	0·31	0·00	0·00	0·00–0·60
Young donkeys	27	0·09±0·14	0·34	0·00	0·00	0·00–0·60
Adult donkeys	71	0·08±0·10 (*)	0·25	0·04	0·00	0·00–0·56
Segmented neutrophils (10^9 l^1)						
All donkeys	98	4·5±1·2	6·7	4·3	2·6	2·2–9·4
Young donkeys	27	5·0±1·3	7·2	4·9	3·0	2·3–7·6
Adult donkeys	71	4·3±1·2 (**)	6·3	4·2	2·6	2·2–9·4

Table I (continued)
Haematological values of the Catalonian donkey

Analyte	n	*Mean*±*SD*	*Percentiles* 95%	*Median*	5%	*Range*
Eosinophils (10^9 l^{-1})						
All donkeys	98	0·68±0·54	1·82	0·56	0·00	0·00–3·15
Young donkeys	27	0·81±0·71	1·72	0·62	0·00	0·00–3·15
Adult donkeys	71	0·63±0·46 (*)	1·82	0·52	0·00	0·00–1·98
Basophils (10^9 l^{-1})						
All donkeys	98	0·02±0·06	0·20	0·00	0·00	0·00–0·26
Young donkeys	27	0·02±0·05	0·15	0·00	0·00	0·00–0·20
Adult donkeys	71	0·02±0·06 (NS)	0·20	0·00	0·00	0·00–0·26
Platelets (10^9 l^{-1})						
All donkeys	98	234·1±82·9	510·0	237·5	105·0	77·0–510·0
Young donkeys	27	228·9±86·5	367·0	237·0	95·0	94·0–431·0
Adult donkeys	71	236·1±82·1 (NS)	357·0	238·0	107·0	77·0–510·0
Fibrinogen (g l^{-1})						
All donkeys	98	2·08±0·59	3·04	2·07	1·23	0·00–4·45
Young donkeys	27	2·26±0·67	3·17	2·22	1·82	0·00–4·21
Adult donkeys	71	2·00±0·55 (**)	2·69	2·01	1·23	0·38–4·45
Plasma protein (g l^{-1})						
All donkeys	98	66·2±6·8	78·0	68·0	53·0	46·5–87·0
Young donkeys	27	65·9±11·6	82·0	65·0	49·0	46·5–87·0
Adult donkeys	71	68·4±12·0 (*)	83·0	69·0	53·9	48·8–87·0

(*) $P<0·05$; (**) $P<0·01$; (***) $P<0·001$; (NS) Not significant.

cantly with age ($P<0·05$, $P<0·01$ and $P<0·05$, respectively). The increases in the former variables are associated with increases in packed cell volume (PCV) and haemoglobin values, and the decrease in erythrocyte count with age (Allen & Archer, 1973). The age-related increase in plasma protein concentration would be primarily caused by increased γ-globulin concentration (Jain, 1986). A general tendency for increasing plasma protein values with increasing age has been observed in donkeys (Zinkl *et al.*, 1990), horses (Jain, 1986), and llamas (Fowler & Zinkl, 1989). MCV and MCH also significantly increased with age in previous donkey studies (Zinkl *et al.*, 1990) as well as in other species such as the horse (Jain, 1986).

Significant age-related differences were not observed with the other parameters. Brown and Cross (1969) and Zinkl *et al.* (1990) found a significant decrease with age of erythrocyte counts in donkey populations, suggesting that the smaller sized erythrocytes of young donkeys could be attributable to iron deficiency. French and Patrick (1995), analysing similar haematological parameters in a large population of donkeys (*ca.* 4000 individuals), did not find significant differences for sex and age factors for any analyte. They suggested that the differences obtained by other authors could be explained by inappropriate statistics on a small non-normal sample.

Comparison of our results with previously published values for donkeys (Table II) does not reveal any large discrepancies (Zinkl *et al.*, 1990; French & Patrick, 1995) and any slight differences may be ascribed to differences in techniques. Nevertheless, it is worth mentioning that the lymphocyte count in Catalonian donkeys was slightly higher than for other breeds and populations (namely, the Mammoth donkey breed, USA donkeys, and UK donkeys). On the other hand, comparison of donkey results with reference ranges (Jain, 1986) for horses (*Equus caballus*) indicated that most values are similar. Only the erythrocyte count was slightly lower for donkeys (reference range 4·7–9·0) than horses (6·8–12·9). The platelet count was slightly higher for donkeys (105–584) than for horses (100–350), although the means were approximately similar.

Table II
Comparison of haematological values of Catalonian donkeys with other donkey breeds and horses

Analyte	*Catalonian donkeys*	*USA donkeys**		*Mammoth donkeys**	*UK donkeys†*	*Horses‡*
Erythrocyte count (10^{12} l^{-1})						
Mean±SD	6·87±1·22 (98)	6·6±0·7 (166)		6·7±0·7 (12)	—	9·0±1·2 (147)
5% to 95%	4·78–8·67 (98)		4·7–9·0		4·0–7·3 (8995)	6·8–12·9 (147)
Haemoglobin (g l^{-1})						
Mean±SD	122·8±22·7 (98)	131±17 (166)		132±18 (12)	—	144±17 (147)
5% to 95%	93–155 (98)		95–165		90–153 (4210)	11–19 (147)
Packed cell volume (l l^{-1})						
Mean±SD	0·36±0·05 (98)	0·38±0·05 (166)		0·38±0·05 (12)	—	0·41±0·04 (147)
5% to 95%	0·27–0·45 (98)		0·28–0·47		0·25–0·38 (4215)	0·32–0·53 (147)
Mean corpuscular volume (F1)						
Mean±SD	52·6±7·5 (98)	57·9±5·5 (166)		56·3±4·9 (12)	—	45·5±4·3 (147)
5% to 95%	40·3–63·8 (98)		46·3–67·0		57·0–79·0 (4235)	37·0–58·5 (147)
Mean corpuscular haemoglobin (pg)						
Mean±SD	18·4±2·2 (98)	19·9±1·9 (166)		19·5±1·8 (12)	—	15·9±1·5 (147)
5% to 95%	14·7–22·4 (98)		16·0–23·0		18·9–28·6 (4238)	12·3–19·7 (147)
Mean corpuscular haemoglobin concentration (g l^{-1})						
Mean±SD	347±12·8 (98)	343±11 (166)		348±7 (12)	—	352±14 (147)
5% to 95%	326–366 (98)		320–362		314–391 (4239)	310–384 (147)
Leucocytes (10^9 l^{-1})						
Mean±SD	10·7±2·9 (98)	10·0±20·0 (165)		10±1·7 (12)	—	9·0±1·8 (147)
5% to 95%	7·1–16·7 (98)		5·4–15·5		6·1–16·1 (4239)	5·4–14·3 (147)
Lymphocytes (10^9 l^{-1})						
Mean±SD	5·3±2·4 (98)	4·4±1·7 (165)		3·6±1·3 (12)	—	3·5±1·1 (147)
5% to 95%	2·4–11·0 (98)		1·1–7·4		1·8–7·8 (4212)	1·5–7·7 (147)
Monocytes (10^9 l^{-1})						
Mean±SD	0·22±0·19 (98)	0·5±0·2 (165)		0·3±0·2 (12)	—	0·3±0·2 (147)
5% to 95%	0·00–0·59 (98)		0·07–1·2		0·0–0·8 (4167)	0·0–1·0 (147)
Neutrophils (10^9 l^{-1})						
Mean±SD	4·5±1·2 (98)	4·7±1·7 (165)		5·1±1·5 (12)	—	4·7±1·2 (147)
5% to 95%	2·6–6·7 (98)		2·2–10·1		2·2–13·3 (4213)	2·2–8·5 (147)

Table II (continued)
Comparison of haematological values of Catalonian donkeys with other donkey breeds and horses

Analyte	*Catalonian donkeys*	*USA donkeys**		*Mammoth donkeys**	*UK donkeys†*	*Horses‡*
Eosinophils (10^9 l^{-1})						
Mean±SD	0·68±0·54 (98)	0·58±0·53 (165)		0·8±0·5 (12)	—	0·3±0·2 (147
5% to 95%	0·00–1·82 (98)		0·00–1·71		0·09–1·15 (4158)	0·0–1·0 (147)
Basophils (10^9 l^{-1})						
Mean±SD	0·02±0·06 (98)	0·04±0·05 (165)		0·04±0·05 (12)	—	0·04±0·06 (147)
5% to 95%	0·00–0·02 (98)		0·00–0·19		0·0–0·5 (3581)	0·0–0·2 (147)
Platelets (10^9 l^{-1})						
Mean±SD	234·1±82·9 (98)	330±110 (89)		270±60 (12)	—	225·0 (147)
5% to 95%	105–510 (98)		160–584		—	100–350 (147)
Fibrinogen (g l^{-1})						
Mean±SD	2·08±0·59 (98)	3·00±1·00 (166)		2·00±1·00 (12)	—	2·60±0·80 (147)
5% to 95%	1·23–3·04 (98)		1·00–5·00		—	1·00–4·00 (147)
Plasma protein (g l^{-1})						
Mean±SD	66·2±6·8 (98)	73±6 (166)		72±7 (12)	—	69±6 (147)
5% to 95%	53–78 (98)		60–84		58–82 (4218)	58–87 (147)

*Zinkl *et al.* (1990); †French & Patrick (1995); ‡Jain (1986).
Within parentheses analysed sample size.

Haematological values for donkeys may vary according to geographical and nutritional factors (Fowler & Zinkl, 1989). Further studies in other locations are now required.

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