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THE HEMATOLOGICAL PROFILE OF THE MOUNTAIN GAZELLE (*GAZELLA GAZELLA*): VARIATIONS WITH SEX, AGE, CAPTURE METHOD, SEASON, AND ANESTHESIA

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ABSTRACT: Hematological parameters were measured in 408 blood samples collected over a 30-mo period from 254 captive mountain gazelles (*Gazella gazella*) in Saudi Arabia. We evaluated the influence of sex, age, capture method, and season, on these parameters. Evaluations also were made with a small number of anesthetized animals. Males had a significantly higher mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) than females. There was no observed neutrophil : lymphocyte ratio shift for either sex during the first months of life. The effects of different capture methods generally were similar in males and females and included a significantly lower MCV and MCH after quick capture. Animals undergoing slow capture had a significantly lower mean corpuscular hemoglobin concentration (MCHC), and very pronounced stress neutrophilia. We propose that this stress neutrophilia caused the permanently high neutrophil : lymphocyte ratio (62:36 average for all gazelles tested) and the lack of a neutrophil : lymphocyte shift in young animals. Erythrocyte counts were significantly higher in summer, while packed cell volume and hemoglobin concentration were the same in summer and winter; thus there was a significantly lower MCV and MCH, and a significantly higher MCHC in summer in both sexes. Fibrinogen varied significantly by sex, age, capture method, and anesthesia.

Key words: Mountain gazelle, *Gazella gazella*, hematology, capture, mean corpuscular values, stress.

INTRODUCTION

King Khalid Wildlife Research Centre (KKWRC), located at Thumamah (25°30′N, 46°30′E), 70 km north of Riyadh in Saudi Arabia, presently holds a captive breeding herd of approximately 250 mountain gazelles (*Gazella gazella*). The species is maintained for reintroduction projects in the Kingdom of Saudi Arabia, one of which, at Hawtat Bani Tamim, has been very successful during its first 2 yr. It is unclear whether the mountain gazelle ever occurred in the Riyadh area, but the species still exists in small numbers in the northern and western parts of Saudi Arabia (Harrison and Bates, 1991). The subspecies kept at KKWRC generally is considered to be *Gazella gazella gazella*; we believe this is the subspecies occurring in the north of the country. Although the flat sand and gravel desert of Thumamah probably is not the species' preferred habitat, other environmental characteristics such as climate are similar throughout central and northern Saudi Arabia. The hematological profile of the Thumamah mountain gazelles may be a good indication for that found in their wild counterparts in this part of the world. As part of a tuberculosis testing program started in 1988, blood from the gazelles at KKWRC regularly was collected. Our objectives were to describe the effects of sex, age, capture method, anesthesia, and season on the hematological profile of what is probably the largest, actively managed, captive group of mountain gazelles in the world.

MATERIALS AND METHODS

Between January 1989 and August 1991, 395 blood samples were collected from 241 clinically healthy mountain gazelles. From 153 gazelles blood was collected only once, while 60 were bled twice, 19 three times, and 15 four times. One gazelle was bled six times. A further 13 samples were collected from 13 different gazelles which had been anesthetized by dart gun in the large enclosure with a combination of xylazine (Rompun Dry Substance, Bayer AG, Leverkusen, Germany) and ketamine (Ketaset Injection, C-Vet Ltd., Bury St. Edmunds, Suffolk, England). We attempted to give dosages of approximately 6.5 mg/kg body weight for xylazine and 5 mg/kg body weight for keta-

TABLE 1. Hematological values of mountain gazelles varying with age, Saudi Arabia, 1989 to 1991.

Parameter	Neonates (n = 2[a])	Infants (n = 11)	Juveniles (n = 23)	Subadults (n = 53)	Adults (n = 306)
Erythrocyte count (10^{12}/ml)					
Mean	10.94	12.91[b]	13.40[c]	12.80[d]	11.81[b,c,d]
SD	0.36	1.36	1.59	1.29	1.35
Packed cell volume (%)					
Mean	43.50	47.36	49.65[c]	48.51	47.41[c]
SD	2.0	4.0	4.0	4.0	3.0
Hemoglobin (g/dl)					
Mean	14.90	15.85	16.70	16.25	15.97
SD	0.20	1.40	1.59	1.42	1.42
Mean corpuscular volume (fl)					
Mean	39.75	36.74[b]	37.22[c]	37.95[d]	40.45[b,c,d]
SD	0.95	1.75	2.04	2.47	3.65
Mean corpuscular hemoglobin (pg)					
Mean	13.65	12.32[b]	12.57[c]	12.75[d]	13.62[b,c,d]
SD	0.25	0.88	0.78	0.88	1.31
Mean corpuscular hemoglobin concentration (%)					
Mean	34.35	33.53	33.63	33.53	33.69
SD	1.55	1.08	0.83	1.10	1.15
Leucocyte count (10^9/ml)					
Mean	3.92	3.75[b,e]	4.68	5.18[e]	5.74[b]
SD	2.32	1.04	1.43	1.49	2.28
Neutrophils (%)					
Mean	55.50	54.64	52.52[c]	55.62[d]	64.52[c,d]
SD	17	13	16	14	15
Neutrophils (10^9/ml)[f]					
Mean	2.18	2.05	2.46	2.88	3.70
Lymphocytes (%)					
Mean	42.50	44.27	46.61[c]	43.19[d]	34.30[c,d]
SD	17	12	15	14	15
Lymphocytes (10^9/ml)[f]					
Mean	1.67	1.66	2.18	2.24	1.97
Monocytes (%)					
Mean	2	1	<1	<1	<1
SD	0	1	0	1	1
Eosinophils (%)					
Mean	<1	<1	<1	<1	<1
SD	0	0	0	0	0
Basophils (%)					
Mean	<1	<1	<1	<1	<1
SD	0	0	0	0	0
Fibrinogen (g/l)					
Mean	1.90	2.82	2.59[c]	3.09[d]	4.44[c,d]
SD	0.20	0.84	1.22	1.27	2.12

TABLE 1. Continued.

Parameter	Neonates ($n = 2^a$)	Infants ($n = 11$)	Juveniles ($n = 23$)	Subadults ($n = 53$)	Adults ($n = 306$)
Erythrocyte sedimentation rate (mm/hour)					
Mean	1	1	1	1	1
SD	0	0	0	0	2

[a] Neonate data insufficient for statistical analysis.
[b] Significant difference between infants and adults ($P < 0.01$).
[c] Significant difference between juveniles and adults ($P < 0.01$).
[d] Significant differences between subadults and adults at $P < 0.01$.
[e] Significant difference between infants and subadults ($P < 0.01$).
[f] Mean values only: standard deviations and significance levels not determined.

mine. No actual means or standard deviations were calculated for the doses administered.

Mountain gazelles at KKWRC were housed as a herd in a 400 ha enclosure, as small groups in breeding pens of approximately 0.6 ha, or singly in stables measuring 3 × 3 m. All animals were fed the same diet, consisting of fresh alfalfa, alfalfa hay, and a modified dairy cattle pellet (Gazelle Pellet, Arasco Co., Al Kharj, Saudi Arabia). Mineral salt blocks and water were always available. The age of the sampled animals varied from a few hours to >4 yr. They were divided into five age groups: neonate (≤1 mo old, $n = 2$), infant (>1 to ≤3 mo, $n = 11$), juvenile (3 to ≤6 mo, $n = 23$), subadult (6 to ≤12 mo, $n = 53$), and adult (>12 mo, $n = 306$).

Three capture methods were used at KKWRC, which differed mainly in the length of time the animals were driven and confined before being caught by hand. On this basis we considered them to represent different levels of stress for the animals. From the largest enclosure, animals were trapped in bomas, fixed or transportable structures into which the animals could be fed, whereupon the structure could be closed. The animals then were driven into a catching chute or confined behind a movable canvas screen. It was a relatively slow procedure because of the size and shape of the bomas, the relatively small size of the chute, and the sometimes large groups of animals. The animals could be subjected to >4 hr of confinement and driving. This was called slow capture, and it was considered to represent a high level of stress for the animals. The smaller groups of gazelles in the breeding pens were driven actively into a separate catching area. This was a much faster procedure, often lasting <30 min. It was called quick capture, and was considered to represent a period of short stress for the animals. In the stables the animals were caught individually by net, which usually took <1 min. The animals usually calmed down rapidly once in hand. This was called net capture, and the technique was considered to represent relatively little stress for the animals.

All blood samples were collected from the jugular vein, using 18 gauge single-use Vacutainer needles (Becton Dickinson Vacutainer Systems, Rutherford, New Jersey, USA) and 5 or 7 ml. Vacutainer tubes (Becton Dickinson) containing ethylenediamine-tetra-acetic acid (EDTA). From neonates, blood was collected using disposable 10 ml syringes, and transferred to an EDTA tube. Neonates were bled <24 hr of birth. Anesthetized gazelles were bled ≤20 min after full anesthesia was attained. Most samples were collected in the morning. All blood samples were evaluated the same day. A Coulter Counter Model ZM (Coulter Electronics Ltd., Luton, Bedfordshire, United Kingdom) was used to perform erythrocyte counts (RBC) and leucocyte counts (WBC). Packed cell volume (PCV) values were determined with a microhematocrit centrifuge (Heraeus-Christ GMBH, Osterode am Harz, Germany). Hemoglobin concentrations were measured using the cyanmethemoglobin method and a spectrophotometer (Spectronic 601, Bausch and Lomb, Rochester, New York, USA). Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were calculated from measured RBC, PCV, and hemoglobin values using standard equations (Coles, 1986). Differential counts were done visually with the battlement method (Jain, 1986). Fibrinogen was determined by heat precipitation method (Millar et al., 1971), and the erythrocyte sedimentation rate (ESR) was measured with the Westergren method (Archer, 1977). All hematological values were entered in a database (R:Base, Microsoft Corporation, Redmond, Washington, USA). Statistical calculations (means and standard deviations) were made with the compute option of the same database. The ESR values of <1 were entered in the database as 1. Significance of differences was calculated

TABLE 2. Hematological parameters of adult mountain gazelles varying significantly by sex Saudi Arabia, 1989 to 1991.

Parameter	Males (n = 155) Mean (SD)	Females (n = 151) Mean (SD)	P
Packed cell volume (%)	48.21 (3.83)	46.60 (3.71)	<0.001
Hemoglobin (g/dl)	16.26 (1.42)	15.68 (1.36)	<0.001
Mean corpuscular volume (fl)	41.04 (3.98)	39.84 (3.19)	0.004
Mean corpuscular hemoglobin (pg)	13.83 (1.41)	13.41 (1.17)	0.005
Fibrinogen (g/l)	5.06 (2.14)	3.81 (1.91)	<0.001

using Student's t-test in Systat (Wilkinson, 1990). Differences were considered significant if $P < 0.01$. Unless otherwise stated, values are expressed as mean (± standard deviation).

RESULTS

Age was significantly related to most hematological parameters (Table 1). The size of the group of neonates was too small for statistical analysis. The RBC, PCV, and hemoglobin increased with age to a highest level in juveniles and then decreased to adult levels. The MCV and MCH, high in the two neonates, were lowest in infants and increased to the maximum levels in adults; MCHC had no significant changes. The WBC also increased with age >1 mo. However, in the differential count the neutrophil percentage (neutrophil %) decreased during the first 6 mo of life and then increased to the maximum level in adults. The lymphocyte percentage (lymphocyte %) had an inverse pattern, being highest in juveniles. There were no major shifts of the neutrophil : lymphocyte ratio; neutrophils always dominated. The neutrophil : lymphocyte ratio for mountain gazelles of all sexes and age groups was 62 (±15):36(±15). Fibrinogen increased with age, while ESR did not vary with age. Monocytes were not common, eosinophils were rare, and basophils were absent in all age groups.

There was a significant difference between males and females for PCV, hemoglobin, MCV, MCH, and fibrinogen; all five variables were higher in males (Table 2). The MCHC values were almost identical in the two sexes.

Significant differences were found when comparing quick capture with net capture (short stress with little stress), with MCV, MCH, and fibrinogen lower after quick capture (Table 3). Males undergoing quick capture had no significant differences in their white blood cell values, compared to other males. Animals undergoing slow capture (high stress) had significantly lower MCHC, higher WBC, higher neutrophil % and neutrophil numbers, and lower lymphocyte %; the absolute numbers of lymphocytes were the same. Hematological profiles of males and females varied in a similar fashion with the different capture techniques; although in females the differences in leucocyte values of animals exposed to slow capture were even more pronounced than in males (Table 3).

The RBC, PCV, and fibrinogen values of 13 anesthetized, adult and subadult gazelles were significantly lower than those of 139 adult and subadult gazelles caught in the stables by net; MCHC values were significantly higher and leucocyte values were not affected by the intramuscular administration of xylazine and ketamine (Table 4). The RBC and mean corpuscular values varied significantly by season (Table 5); in both sexes MCV and MCH were lower in summer than in winter, and RBC and MCHC higher.

DISCUSSION

Little available information on the hematology of other gazelle species is detailed enough for direct comparison with these findings in mountain gazelle. The

TABLE 3. Hematological values of adult male mountain gazelles varying with capture method, Saudi Arabia, 1989 to 1991.

Parameter	Slow cpature (n = 53) Mean (SD)	Quick capture (n = 29) Mean (SD)	Net capture (n = 64) Mean (SD)
Erythrocyte count (10^{12}/ml)	11.70 (1.38)	12.45 (1.32)	11.66 (1.36)
Packed cell volume (%)	48.45 (3.81)	46.83 (2.82)	48.78 (4.21)
Hemoglobin (g/dl)	16.18 (1.33)	15.79 (1.24)	16.59 (1.53)
Mean corpuscular volume (fl)	41.75 (3.90)[a]	37.93 (3.17)[a,b]	42.11 (0.61)[b]
Mean corpuscular hemoglobin (pg)	13.97 (1.42)[a]	12.79 (1.15)[a,b]	14.28 (1.26)[b]
Mean corpuscular hemoglobin concentration (%)	33.41 (1.03)[c]	33.63 (1.00)	34.02 (1.06)[c]
Leucocyte count (10^9/ml)	6.59 (2.06)[c]	5.51 (1.80)	4.92 (2.09)[c]
Neutrophils (%)	71.57 (12.98)[a,c]	61.93 (15.20)[a]	61.59 (15.46)[c]
Neutrophils (10^9/ml)[d]	4.71	3.41	3.03
Lymphocytes (%)	27.34 (13.15)[c]	35.69 (16.15)	36.95 (15.49)[c]
Lymphocytes (10^9/ml)[d]	1.80	1.97	1.82
Monocytes (%)	0.96 (1.00)	0.79 (1.08)	1.33 (1.46)
Monocytes (10^9/ml)[d]	0.06	0.04	0.06
Fibrinogen (g/l)	5.20 (1.60)[a]	4.16 (1.67)[a,b]	5.37 (2.02)[b]

[a] Significant difference between quick and slow capture ($P < 0.01$).
[b] Significant difference between quick and net capture ($P < 0.01$).
[c] Significant difference between slow and net capture ($P < 0.01$).
[d] Mean values only: standard deviations and significance levels not determined.

baseline hematological data of healthy, adult mountain gazelles resembled those published for other gazelle species and most ruminants (Bush et al., 1981; Raphael et al., 1982; Pospisil et al., 1984; Jain, 1986; Rietkerk 1986; Roeder et al., 1991). Compared with dorcas gazelle (*Gazella dorcas*), mountain gazelles had a lower RBC but similar PCV, giving a larger MCV and MCH and an approximately similar MCHC (Bush et al., 1981). The dorcas gazelle had a higher WBC than the mountain gazelle, and had a similar lack of monocytes, eosinophils and basophils. The high neutrophil : lymphocyte ratio in mountain gazelles was found in most other gazelles and was the most obvious difference when comparing mountain gazelle with domestic livestock (Jain, 1986) and blue duiker (*Cephalus monticola bicolor*) (Roeder et al., 1991), in which lymphocytes generally outnumber neutrophils in adult animals. Sex differences were rather pronounced in mountain gazelle. The significantly higher PCV and hemoglobin in males have been reported in other species of ruminant (Bush et al., 1981; Pospisil et al., 1984; Rietkerk, 1986; Roeder et al., 1991). Interestingly,

TABLE 4. Hematological parameters of adult and subadult mountain gazelles varying significantly with xylazine and ketamine anesthesia, Saudi Arabia, 1989 to 1991.

Parameter	Hand held after net capture (n = 139) Mean (SD)	Anesthesia (n = 13) Mean (SD)	P
Erythrocyte count (10^{12}/ml)	11.89 (1.38)	10.48 (0.85)	<0.001
Packed cell volume (%)	48.27 (4.37)	44.15 (3.80)	0.001
Mean corpuscular hemoglobin concentration (%)	33.95 (1.14)	34.92 (1.21)	0.004
Fibrinogen (g/l)	4.37 (2.17)	2.44 (1.31)	0.002

TABLE 5. Hematological parameters of adult mountain gazelles varying significantly by season, Saudi Arabia, 1989 to 1991.

Parameter	Summer[a] (n = 58) Mean (SD)	Winter[a] (n = 67) Mean (SD)	P
Erythrocyte count (10^{12}/ml)	12.38 (1.39)	11.21 (1.18)	<0.001
Mean corpuscular volume (fl)	38.49 (3.31)	43.09 (2.97)	<0.001
Mean corpuscular hemoglobin (pg)	13.04 (1.16)	14.31 (1.09)	<0.001
Mean corpuscular hemoglobin concentration (%)	33.87 (0.92)	33.23 (0.88)	<0.001

[a] Summer: June, July, and August; winter: December, January, and February.

male mountain gazelles did not have a significantly higher RBC: they had larger erythrocytes with a higher hemoglobin content than females. This finding has not been described in domestic livestock, nor in other gazelle species. The higher fibrinogen in males also was found in blackbuck (*Antilope cervicapra*) (Rietkerk, 1986). Age related changes in the hematological profile have been well described in livestock (Jain, 1986) and a few non-domestic ungulates such as dorcas gazelle (Bush et al., 1981), scimitar-horned oryx (*Oryx dammah*) (Bush et al., 1983; Hawkey and Hart, 1984), and blue duiker (Roeder et al., 1991). The age-specific variation in mountain gazelles followed the general pattern for these species, except for the lack of a neutrophil : lymphocyte ratio shift, which can probably be attributed to stress neutrophilia. We found that the hematological profile of mountain gazelles varied considerably with the method of capture to which they had been subjected. Quick capture, which could be seen as a model for short stress, led to an increase in circulating erythrocytes probably due to splenic contraction (Hawkey et al., 1980; Jain, 1986), but we also found that with the increase in number of erythrocytes, their size and hemoglobin content decreased significantly. This might indicate that, when relaxed, the spleen showed a preference for sequestering small erythrocytes. After a slow capture, during which the animals were subjected to a long period of stress, most of these smaller erythrocytes had disappeared again from circulation, but the remaining erythrocytes had a significantly lower MCHC, indicating that the erythrocytes' hemoglobin carrying capacity was impaired.

Interestingly, a significant increase in neutrophils occurred only after slow capture. This stress neutrophilia has been described in other species (Jain, 1986). Females were often more difficult to catch and restrain than males, and young animals were more difficult to catch and restrain than adults. Perhaps females and young animals were more easily stressed, and this may have accentuated sex and age differences. Drevemo and Karstad (1974) and Hawkey et al. (1980) found that adrenolytic anesthetics such as xylazine led to a reduction in RBC, PCV, and hemoglobin during anesthesia, without effect on the mean corpuscular values or the leucocytes. This is what we found in mountain gazelles, with the exception of a significantly higher MCHC during anesthesia. During anesthesia the smaller erythrocytes carrying a reduced amount of hemoglobin may have been the first to be sequestered in the spleen, leaving only larger erythrocytes with an optimum hemoglobin carrying capacity.

Season has not been described as a consistent, clear cause for hematological changes in livestock (Jain, 1986) and it has not been described as an influence on hematological values in non-domestic animals. In mountain gazelles of both sexes, the RBC was significantly higher in summer, but the erythrocytes in circulation had lower MCV and MCH values. It is likely that the very high ambient temperatures in summer (often >40 C) potentiated the hematological effects of capture on the animals: possibly the summer values could be seen as an indication of heat stress. This does not explain, however, why MCHC was significantly higher in summer. In general, mountain gazelles had a remarkable variability of the mean corpuscular values, which are usually considered to be rather stable. This variability would appear to be a physiological adaptation, but further work would need to be done to determine the precise reasons and mechanisms. Jain (1986) stated that fibrinogen levels are not affected by age, sex, or exercise. We found that fibrinogen was significantly influenced by sex, by age, by capture method, and by xylazine and ketamine anesthesia. The reason for these highly variable fibrinogen levels was not clear, but did not appear to be the result of inflammation or trauma.

Much of the hematological variation with age, sex, capture method, anesthesia, and season was small, even if it was significant. With the exception of the high number of neutrophils after slow capture and some of the age-specific differences, the clinical importance of this variation may be limited. It was clearly illustrated, however, that blood values, and in the case of the mountain gazelle even the mean corpuscular values, were not static and maybe influenced by many factors.

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