THE HAEMATOLOGY OF GROWING CAMELS (*Camelus dromedarius*) DURING THE FIRST YEAR OF LIFE

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Summary

The haematological profiles of camel calves of either sex were monitored at monthly intervals between 1-12 months of age. RBC, Hb and PCV increased with age for several months, with corresponding increases in MCH and MCHC, and a relative reduction in MCV. WBC and lymphocyte counts were highest at the age of 1 month, fell progressively during the following 6 months, and stabilized thereafter. Neutrophils were also highest at the age of one month and decreased slowly with advancing age. Eosinophils, monocytes and basophils fluctuated only from month to month. Age effect was significant for WBC, lymphocytes and neutrophils, and all the erythrocytic parameters, except MCV. Sex effect was significant for Hb and eosinophils.
(**Key Words**: Haematology, Camel Calves, *C. dromedarius*)

Introduction

There is a paucity of information on the normal variations in blood constituents of growing camels (*Camelus dromedarius*) during the first year of life. Elias and Yagil (1984) reported significant alterations in haematological and blood biochemical indices of suckling camels, aged 1-30 days, as compared to their dams, and concluded that profound metabolic changes occur in these animals during early calfhood. Comparing different age groups of camels, Petrelli et al. (1982) observed that many blood indices, particularly of the erythrocytic series, were affected by age; others arrived at similar conclusions from comparative studies on adult versus young camels (reviewed by Grundel, 1988).

In the present study, sequential changes in the haemograms of healthy camel calves of either sex were monitored at monthly intervals during the first year of life. The objective was to study variation with age and sex in the main haematological indices of these animals.

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Materials and Methods

Animals

Ten healthy camel calves of Najdi breed were used, five of each sex. The animals were born and reared in an experimental station near Riyadh. They were left with their dams for 3 weeks post partum, then transferred into separate pens, with access to their dams twice daily. They continued suckling until the age of 1 year, but from 4 months, they started taking concentrate (crude protein 18%) and hay in gradually increasing amounts. Water was provided *ad libitum*. The camels remained free from parasites during the study period.

Haematological methods

Jugular blood samples were collected monthly from each camel calf into heparinized vacutainer tubes. Haemoglobin (Hb) was determined by cyanomethaemoglobin method, packed cell volume (PCV) by microhaematocrit method, and total red (RBC) and white (WBC) blood cell counts by the haemocytometer. Differential WBC counts were made by the battlement technique, using thin blood films stained with leishman. Total and differential WBC counts were expressed as ab-

solute values. Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated (Schalm et al., 1975).

Statistical methods

An ANOVA model was fitted to the blood indices to test for age (in months) and sex effects. The model used was $Y_{ij} = \nu + \alpha_i + \beta_j + \varepsilon_{ij}$ where;

Y_{ij} = the observation of the ith sex of the jth month;

ν = the overall mean;

α_i = effect of the ith sex, i = 1, 2;

β_j = effect of the jth age, j = 1 ..... 12;

ε_{ij} = residual random error associated with the ijth observation.

Sex by age interaction was excluded from the model due to insignificancy. The statistical significance tests were carried out using GLM procedure in SAS (Goodnight et al., 1986).

Results

Statistical testing results for erythrocytic and leucocytic variable are summarized in tables 1 and 2, respectively. The mean plots for different indices are shown in figures 1-6; these figures were smoothened using cubic polynomials.

TABLE 1. STATISTICAL TESTING RESULTS* FOR ERYTHROCYTIC INDICES OF CAMEL CALVES

Source	RBC	Hb	PCV	MCV	MCH	MCHC
Sex	0.1140	0.0068	0.2154	0.9153	0.2959	0.0900
Age	0.0001	0.0447	0.0148	0.3283	0.0439	0.0001
MSE	1.45	3.11	1.50	4.52	2.21	3.62
R^2	0.49	0.21	0.24	0.13	0.21	0.50
C.V.	11.69	11.40	12.03	14.29	15.44	7.99

* P = Values; MSE = Mean Square Error; R^2 = R-squared; C.V. = Coefficient of Variation.

TABLE 2. STATISTICAL TESTING RESULTS* FOR LEUCOCYTIC INDICES OF CAMEL CALVES

Source	WBC	Lympho	Neutro	Mono	Baso	Eosino
Sex	0.8290	0.4259	0.3192	0.2977	0.2137	0.0495
Age	0.0002	0.0048	0.0171	0.0433	0.7989	0.5430
MSE	2.68	1.90	1.80	0.33	0.11	0.27
R^2	0.32	0.32	0.28	0.25	0.11	0.17
C.V.	28.32	33.11	57.21	115.22	183.77	95.76

* P = Values; MSE = Mean Square Error; R^2 = R-squared; C.V. = Coefficient of Variation.

(a) Erythrocytic Indices:

In male camels calves, RBC varied with age from 7.5-9.5 $\times 10^{12}$/L, with an overall mean of 8.7 $\times 10^{12}$/L, while Hb varied from 9.0-13.3 g/dl, with an overall mean of 12.1 g/dl, and PCV from 24-28%, with an overall mean of 26.9%. Corresponding overall means (and ranges) for female camels were: 9.0 $\times 10^{12}$/L (7.5-9.5$\times 10^{12}$/L), 12.8 g/dl (9.5-13.9g/dl) and 27.9% (25-29%) for RBC, Hb and PCV, respectively. The lowest mean RBC was recorded at the age of one month viz. 7.5 $\times 10^{12}$/L in both sexes. This parameter increased slowly and almost linearly with advancing age in male camels. In females, a more pronounced increase occurred during the first 6 months, followed by gradual reduction during subsequent ages. By the age of 12 months, close RBC values were recorded in the two sexes (9.4 $\times 10^{12}$/L and 9.5 $\times 10^{12}$/L, respectively) (figure 1). Statistical analysis showed non-significant sex effect on RBC

whereas age effect was significant ($p < 0.05$) (table 1).

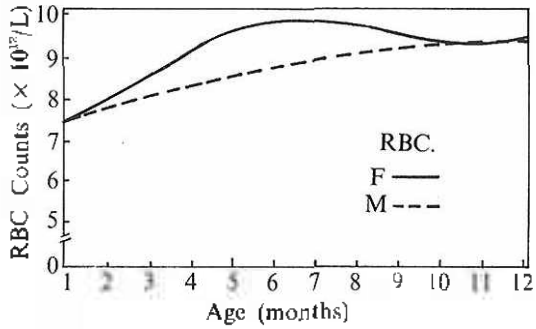

Figure 1. Mean plot for total red blood cell counts (RBC) in male and female camel calves.

Similarly, Hb increased from 9 g/dl at 1 month, to 13.3 g/dl at 8 months of age in male camels; although this was followed by a slow reduction during the following 4 months, mean Hb at 12 months was > 30% higher than that recorded at 1 month (figure 2). In females, a mean Hb of 9.5 g/dl was recorded at 1 month

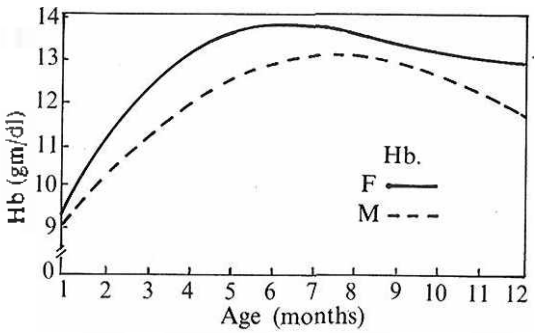

Figure 2. Mean plot for haemoglobin content (Hb) in male and female camel calves.

which also increased with age up to the 6th month, when a peak value of 14 g/dl was attained. Thereafter, Hb fluctuated slightly, giving a mean of 13.1 g/dl at 12 months i.e., 38% higher than that recorded at 1 month. The monthly Hb values in female camels consistently exceeded those recorded in males (figure 2), and the difference between the two sexes was significant ($p < 0.05$); moreover, the age effect on Hb was highly significant ($p < 0.0005$) (table 1).

The increase with age in RBC was accompanied by progressive rise in PCV from 24.2% at 1 month to > 30% at 8 months, followed by a gradual fall to a mean of 26.4% at the age of 12 months in male camels. The same trend was observed in females whose monthly PCV's rose from 25% at 1 month to 29% at 12 months of age (figure 3). Statistical analysis revealed a significant age effect on PCV ($p < 0.05$). On the other hand, although PCV values in female camels generally tended to exceed those of the males, the difference between the two sexes was statistically non-significant (table 1).

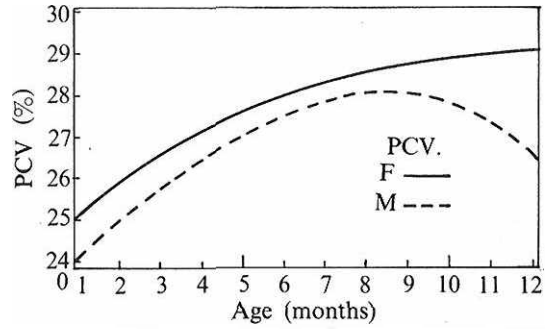

Figure 3. Mean plot for packed cell volume (PCV) in male and female camel calves.

MCV, MCH and MCHC exhibited variations commensurate with changes in RBC, Hb and PCV (figure 4). In both sexes, MCV decreased slowly during the first 8 months of age, i.e., from 34 fl to around 30-31 fl; thereafter, MCV tended to stabilize in the male camel calves, while rising gradually in females. MCH and MCHC, on the other hand, increased during the first 5-6 months of age. During this period, MCH rose from initial values of 12.5 pg and 13.2 pg to peak values of about 15.0 pg and 15.3 pg in male and female camels, respectively, while MCHC increased from around 37.5 g/dl in both sexes to about 47 g/dl in males and nearly 49 g/dl in females. MCH and MCHC then fell gradually towards more stable values from 7 months onwards in both sexes. The overall mean MCV was 31.6 fl in male and 31.7 fl in female camel calves, while the respective overall MCH and MCHC means were 14.1 pg and 44.9 g/dl in male and 14.6 pg and 46 g/dl in female camels. No significant effect due to sex was observed in these parameters; on the other hand, age effect was significant for MCH ($p < 0.05$) and highly significant for MCHC ($p < 0.0005$) (table 1).

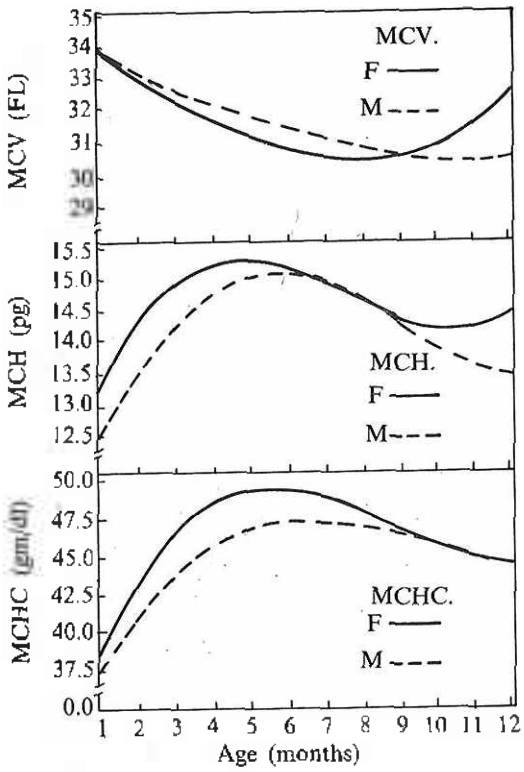

Figure 4. Mean plot for mean corpuscular volume (MCV), Mean Corpuscular Haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) in male and female camel calves.

(b) **Leucocytic series:**

WBC ranged between 8.0-14.2 × 10^9/L accor-ding to age, with an overall mean of 9.4 × 10^9/L, in male, and between 8.7-15.4 × 10^9/L, with an overall mean of 9.9 × 10^9/L in female, camel calves. The trend was closely similar in the two sexes, highest values being recorded at the age of 1 month, followed by a progressive fall during the following 6 months (figure 5). Thereafter, WBC tended to stabilize around 8-10.5 × 10^9/L. Statistical alalysis showed a highly significant age effect ($p < 0.0005$) on WBC whereas sex effect was non-significant (table 2).

Differential counts showed that changes in WBC were largely a reflection of changes in lymphocyte and neutrophil counts (figure 5). The former cells were the most predominant leucocyte type in camel's blood, constituting about 65% of their total circulating WBC s (range 45-57%) and giving overall means of 5.5 × 10^9/L in male

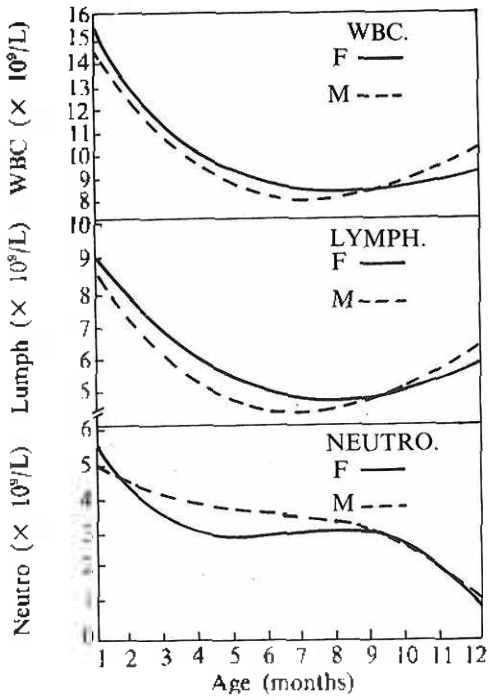

Figure 5. Mean plot for total leucocyte (WBC), lymphocyte and neutrophil counts in male and female camel calves.

and 6.2 × 10^9/L in female camels, respectively. The highest lymphocyte counts, viz. 8.6 × 10^9/L in male and 9.0 × 10^9/L in female camels, were recorded at the age of 1 month, then decreased in the same manner as WBC. Neutrophils were the second commonest leucocytes, forming about 26% of total WBC (range 18-40%), and giving overall means of 3.3 × 10^9/L and 3.1 × 10^9/L in male and female camels, respectively; these cells also gave highest values (5.0 × 10^9/L in males and 5.5 × 10^9/L in females) during the first month of age, then decreased slowly as the camels grew older. Statistical analysis showed significant age effects on lymphocytes and neutrophils ($p < 0.005$ and $p < 0.05$, respectively). However, neither of these cell counts was affected significantly by sex (table 2). In both sexes, lymphocyte/neutrophil ratio (L/N) averaged 1.5:1.0 during the first 6 months of age, then increased to 2.5:1 from 7 months onward.

Means for eosinophils, monocytes and basophils are plotted in figure 6. The overall means for monocytes and basophils wer 0.26 × 10^9/L and 0.05 × 10^9/L in male, and 0.34 × 10^9/L and 0.36 × 10^9/L in female camels, respectively.

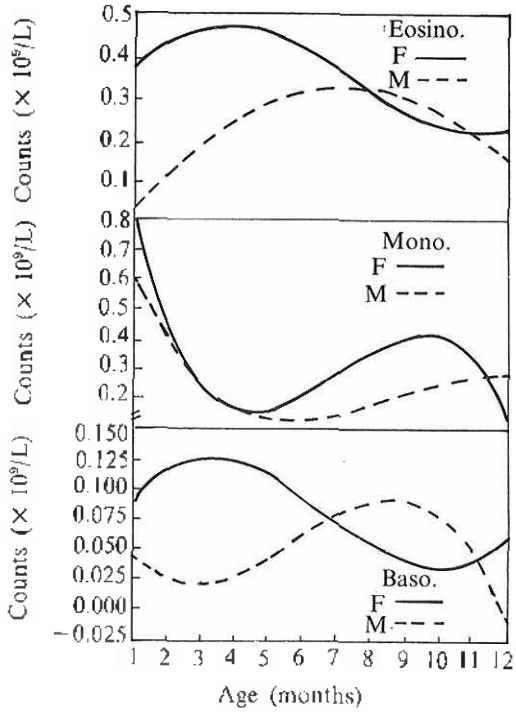

Figure 6. Mean plot for eosinophils, monocytes and basophils in male and female camel calves.

Eosinophil counts, on the other hand, had overall means of 0.23×10^9/L in male and 0.36×10^9/L in female camels. No significant age effects were observed on these indices, and there was also no significant sex effect except on eosinophils ($p < 0.05$) (table 2).

Discussion

Previous studies on the blood picture of camels were mainly concerned with adult animals, and the values cited by different workers show a wide range of variation (Grundel, 1988). It is not surprising, therefore, that although some workers had recorded differences in the blood indices of young versus adult camels (Eissa and Abdel Fattah, 1974; Petrelli et al., 1982), others were unable to show them (Ghodsian et al., 1978; Hussein et al., 1983).

The present study elucidates the normal pattern of variation in the haematological profiles of healthy camels of the indigenous Najdi breed of Saudi Arabia during the first year of life. Our data indicate significant age and sex effects on some of the blood indices of these growing camels, which should be taken into consideration when interpreting their haemograms. The present data support parthy the observations of Petrelli et al. (1982) and Elias and Yagil (1984) on the haematological picture of young camels. The data presented by the former authors showed that RBC, PCV and Hb increased, while MCV, MCH and MCHC decreased, with age in Somali camels up to the age one year. Our results also showed that trend, except that gradual increases in MCH and MCHC were recorded up to the age of 5 months in the present study. Elias and Yagil (1984), on the other hand, reported that total WBC, neutrophil and platelet counts were consistently higher in camel neonates in comparison to their dams, whereas their total serum proteins were generally lower; these authors concluded that the early life of a newborn camel was "marked by metabolic changes reflected in the concentrations of many blood and serum constituents", and that such changes could be attributed to the stress of parturition. Our results showed that age associated changes in the blood picture of newborn camels actually extended for several months post-partum.

It is evident from the present results that although WBC, lymphocytes and neutrophils were relatively high at the age of 1 month, the general trend was for these indices to decrease towards lower, more stable values with advancing age. In this respect, our results differe form those of Petrelli et al. (1982) who reported a tendency for leucocytes to increase with age in the camel up to the age of 2 years. On the other hand, Elias and Yagil (1984) reported high leucocytosis, due to neutrophilia, in juvenile camels on the day of birth, which subsided gradually during the following 2 weeks, yet still accounted for a relatively high WBC at the age of 30 days. We have also observed high WBC counts, in which neutrophilia formed more than 40% of the blood leucocytes, in some of the present calves on the day of birth. A similar phenomenon is known to occur in bovine neonates, and it has been suggested that the underlying cause might be the acquisition by the foetus of adrenocortical hormones released by its dam in response to the stress of parturition (Schalm et al., 1975).

The present study showed that male and female camel calves differed significantly in their

overall mean Hb values; however, no significant differences were observed between the two sexes in RBC, PCV, MCV, MCH and MCHC, nor in total and differential WBC counts, apart from eosinophils. Differences due to sex in the blood indices of adult camels, on the other hand, had not been observed by Tartour (1971), and Hussein *et al.* (1983), whereas Majeed et al. (1980) reported that lymphocytes, eosinophils, and erythrocyte sedimentation rates, of adult camels differed significantly between the two sexes. In a similar study on the blood constituents of adult camels in Kuwait, Barakart and Abdel Fattah (1971) reported that although Hb was not affected by sex, several other blood biochemical indices differed significantly between male and female camels. There is also evidence that some of the haematological indices of cattle (Fraser, 1930; Scarborough, cited by Schalm et al., 1975) and other animals (Holman and Dew, 1964; Vaidya et al., 1970) vary significantly with sex.

From a comparative standpoint, it appears that the haematological profile of growing camels is broadly similar to that reported in young ruminants of other species. Hence, the data compiled by Schalm et al. (1975) on the blood indices of cattle indicated that their RBC, Hb and PCV increased with age during the first year of life. Moreover, MCV was shown to fall gradually in bovine calves up to the age of 4 months, followed by a rise to normal levels in older calves (Holman, 1956). Similar findings were reported in lambs; for instance, Fraser (1930) reported higher RBC at 4-6 months than at 7 days of age, while Littleton et al. (1968) reported increasing RBC from 7.8 million/μl at 1 week to 14.2 million/μl at 8 weeks of age, with correspondingly decreasing MCV, from 37 fl to 29 fl. Overas (1969) reported that RBC, Hb and PCV were higher in lambs at 5 months than at 3.5 month of age. In goats, progressive increases in RBC and PCV, coupled with decrease in MCV, were reported during the first 3 months of age (Holman and Dew, 1964), and a similar trend was also evident in the data compiled by De Shaw et al. (1969). With respect to erythrocytic indices, therefore, camel calves seem to resemble closely the young stock of other ruminant species. Camels also resemble cattle and other ruminants in that their lymphocytes normally constituted the largest proportion of circulating WBC's; however, the present results show that growing camels tend to have lower WBC than that reported in adult camels (see Grundel, 1988), thus contrasting with those ruminant species whose WBC counts tend to be higher in the younger stock in comparison to adult animals (Schalm et al., 1975).

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