

BLOOD PARAMETERS OF GOATS IN BOTSWANA

R. C. Gray¹ and B. A. Koch²

Kansas State University^{3, 4}

Manhattan, KS 66506 USA

W. Mahabile

Department of Agricultural Research⁵

Ministry of Agriculture, Gaborone, Botswana

R. Winsor⁶, A. Holmes⁷ and C. Berg⁸

Department of Veterinary Services

Ministry of Agriculture, Gaborone, Botswana

Blood levels of P, Ca, Mg, total protein, urea and red and white blood cell counts were examined monthly for two years in Botswana goats in an attempt to establish normal values and to evaluate the effect of supplementation with mineral-mix and drought relief cubes. Overall mean levels observed for the parameters were: Ca 8.91 ± 1.61 mg/100 ml, P 5.15 ± 1.52 mg/100 ml, Mg $2.59 \pm .71$ mg/100 ml, Cu 135.39 ± 80.08 µg/100 ml, total protein 7.83

± 1.36 g/100 ml, urea 44.42 ± 17.32 mg/100 ml, RBC count 11.34 ± 2.10 millions/mm³ and WBC count 13.28 ± 3.93 thousands/mm³. Supplemented goats showed significantly higher levels of Ca. P levels were unchanged. Mineral-mix supplemented goats showed significantly lower levels of total protein, urea and white blood cells and higher levels of RBC's than did the control animals. Drought relief cube supplemented goats showed significantly lower levels of total protein and higher levels of WBC's. All observations fell within the normal ranges quoted in the literature with the exception of total protein and urea which were high. It was concluded that supplemental feeding of this kind was of minimal value under the environmental conditions imposed upon them in this study.

Keywords: Goats, Blood parameters, Minerals

Little is known of normal blood parameters in goats in Botswana. This makes it difficult to interpret findings from clinical material. At present figures obtained from Europe, South Africa and the United States are used for normal values. The study objectives were to determine (1) normal values in goat blood for the levels of phosphorus, magnesium, calcium, copper, total protein, urea, red blood cells and white blood cells, (2) if these parameters differ in animals receiving supplementary feeding of mineral-mix or drought relief cubes, and (3) effects on the performance of the animal from feeding supplemental mineral-mix or

¹Present address: P. O. Box 33414, Raleigh, NC 27636 USA.

²To whom correspondence should be addressed.

³Department of Animal Science and Industry

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⁵Agricultural Technology Improvement Project

⁶Present address: Iabvetsur, Apartado 1197, Arequipa, Peru.

⁷Present address: Hong Kong

⁸Present address: Armauer Hansensgt 11 0544 Oslo 4 Norway.

drought relief cubes.

Study area

Trial 1 was conducted from November 1984 to October 1986 in Mathangwane Village, Tutume Agricultural District, in northeast Botswana and trial 2 was conducted from July 1985 to June 1987 in Artesia Village, Kgatleng Agricultural District, in east central Botswana.

Methods

In trial 1, blood samples were taken monthly from ear-tagged animals in five goat herds receiving ad libitum supplemental mineral-mix (equal parts mixture of salt and dicalcium phosphate). Ear-tagged animals in five goat herds not receiving supplemental mineral-mix served as controls. In trial 2, blood samples were taken monthly from ear-tagged animals in five goat herds receiving supplemental feeding of 30 g/head/day of drought relief cubes. Ear-tagged animals in seven goat herds not receiving supplemental feed served as controls. The chemical analysis of drought relief cubes is given in table 1. Goats were bled on the first Tuesday of the month. A total of 50 and 55 adult goats were included in the initial bleeding in trials 1 and 2, respectively, but numbers declined during the years due to deaths, sale of animals and failure of farmers to present animals on the designated bleeding

dates. A total of 1,389 blood samples were included in the analyses, 971 and 918 from trials 1 and 2, respectively.

Whole blood and heparin blood samples were sent to the National Veterinary Laboratory, Gaborone for analyses. At the laboratory the serum was taken off and examined for phosphorus, copper, urea and total protein by spectrophotometry and for calcium and magnesium by atomic absorption spectrophotometry. Red and white blood cell counts were carried out with the heparin blood using a Coulter counter.

Tests for statistical differences were made using Student's "T" test with the Daisy Professional Program on the Apple IIe Computer, unless otherwise noted.

Results

Trial 1

Results are presented in Table 1 for control and treated (ad libitum supplementation with an equal parts mixture of salt and dicalcium phosphate).

Condition: Condition scores of control and treated animals averaged $2.61 \pm .52$ and $2.68 \pm .48$, respectively, and differed significantly ($P < .05$). Overall, the animals were in good condition.

Calcium: Mean blood plasma calcium levels of control and treated goats were 8.49 ± 1.41 and 8.80 ± 1.39 mg/100 ml, respectively,

and differed significantly ($P < .01$). The overall mean was 8.66 ± 1.40 mg/100 ml.

Phosphorus: Mean blood plasma phosphorus levels for control and treated goats were 5.03 ± 1.54 and 4.91 ± 1.39 mg/100 ml, respectively, and did not differ significantly. The overall mean was 4.96 ± 1.46 mg/100 ml.

Magnesium: Mean blood plasma magnesium levels of control and treated goats were $2.56 \pm .71$ and $2.60 \pm .70$ mg/100 ml, respectively, and did not differ significantly. The overall mean was $2.59 \pm .90$ mg/100 ml.

Copper: Mean blood plasma copper levels for control and treated goats were 121.56 ± 66.21 and 120.41 ± 65.37 μ g/100 ml, respectively, and did not differ significantly. The overall mean value was 120.91 ± 65.70 μ g/100 ml.

Total protein: Mean blood serum total protein levels for control and treated goats were 8.42 ± 1.60 and 7.90 ± 1.37 g/100 ml respectively and differed significantly ($P < .01$). A seasonal trend was not apparent. The overall mean was 8.13 ± 1.49 g/100 ml.

Urea: Mean blood serum urea levels for control and treated goats were 46.07 ± 18.01 and 43.08 ± 16.93 mg/100 ml, respectively, and differed significantly ($P < .01$). A plot of the data showed a clear seasonal trend with lower levels occurring as the dry season progressed as would be expected with decreased protein intake in the diet. The overall mean was 44.39 ± 17.47 mg/100 ml.

Red Blood Cells: Red blood cell counts of control and treated

goats were 10.87 ± 2.04 and 11.36 ± 2.32 millions/ mm^3 , respectively, and differed significantly ($P < .01$). The overall mean was 11.14 ± 2.21 millions/ mm^3 .

White Blood Cells: The white blood cell counts of control and treated goats were 14.99 ± 3.93 and 13.97 ± 4.42 thousands/ mm^3 , respectively, and differed significantly ($P < .01$). The overall mean value was 14.42 ± 4.24 thousands/ mm^3 .

Reproductive Performance: An estimate of reproductive performance of the control and treated herds was made by analyzing the herd structure in Table 3. It was assumed that females in age categories 1, 2, 3 and 4 had reached reproductive maturity. In November 1986, control herds consisted of 104 females of reproductive age and 108 kids (age category 0) or a 103.8 percent reproductive rate. Treated herds consisted of 125 females of reproductive age and 136 kids (age category 0) or a 108.8 percent reproductive rate. Reproductive rate in control herds ranged from 82.6-122.6 percent while the reproductive rate in treated herds ranged from 71.4 to 121.1 percent. The reproductive rate of the control and treated herds was not significantly different.

Herd Structure: Herd structure of control and treated herds was given in Table 3. Control and treated herds were composed of 61.4 and 66.9 percent females, 24.7 and 22.1 percent males and 13.9 and 11.0 percent castrates, in November 1985. The percentage of goats in each category of control and treated goats was tested with Chi-square and was not significantly different, again indicating that there was no difference in reproductive performance.

Goat Weights: Weights of control and treated goats were taken at the end of the study in November 1983 and are summarized in Table 4. The differences between weights of control and treated goats in age by sex groups were non-significant. Goats in control herds were slightly heavier than goats in treated herds in all age by sex groups except one.

Trial 2

Results of Trial 2 are presented in Table 1 for control and treated (supplementation with 30 g/head/day of drought relief cubes) goats by years and overall.

Condition: Condition scores of control and treated animals averaged $2.82 \pm .40$ and $2.77 \pm .46$, respectively, and did not differ significantly. Overall, the animals were in good condition.

Calcium: Mean blood plasma calcium levels of control and treated goats were 9.01 ± 1.58 and $9.40 \pm$ mg/100 ml, respectively, and differed significantly ($P < .01$). The overall mean was 9.19 ± 1.77 mg/100 ml.

Phosphorus: Mean blood plasma phosphorus levels for control and treated goats were 5.35 ± 1.52 and 5.36 ± 1.60 mg/100 ml, respectively, and did not differ significantly. The overall mean was 5.35 ± 1.55 mg/100 ml.

Magnesium: Mean blood plasma magnesium levels of control and treated goats were $2.58 \pm .71$ and $2.57 \pm .71$ mg/100 ml,

respectively, and did not differ significantly. The overall mean was $2.58 \pm .71$ mg/100 ml.

Copper: Mean blood plasma copper levels for control and treated goats were 150.41 ± 67.66 and 149.38 ± 75.28 µg/100 ml, respectively, and did not differ significantly. The overall mean value was 149.94 ± 71.10 .

Total Protein: Mean blood serum total protein levels for control and treated goats were 7.64 ± 1.15 and 7.31 ± 1.06 g/100 ml respectively and differed significantly ($P < .01$). The overall mean was 7.49 ± 1.12 g/100 ml.

Urea: Mean blood serum urea levels for control and treated goats were 45.03 ± 16.79 and 43.77 ± 17.36 mg/100 ml, respectively, and did not differ significantly. A plot of the data showed a clear seasonal trend with lower levels occurring as the dry season progressed as would be expected with decreased protein intake in the diet. The overall mean was 44.44 ± 17.15 mg/100 ml.

Red Blood Cells: Red blood cell counts of control and treated goats were 11.65 ± 1.98 and 11.42 ± 1.88 millions/mm³, respectively, and did not differ significantly. The overall mean was 11.54 ± 1.94 millions/mm³.

White Blood Cells: The white blood cell counts of control and treated goats were 11.77 ± 3.02 and 12.44 ± 3.25 thousands/mm³, respectively, and differed significantly ($P < .01$). The overall mean value was 12.07 ± 3.15 thousands/mm³.

Discussion

The data from trials 1 and 2 were pooled to arrive at estimates for comparison with values reported in the literature.

Calcium: The pooled mean value for blood plasma calcium level was 8.91 ± 1.61 which is above the critical level of 8 mg/100 ml for adult ruminants (McDowell et al, 1983). Rushton (1981) quotes a range of 8.02-12.02 mg/100 ml while Merck (1986) gives a range of 9.0-11.6 mg/100 ml.

Phosphorus: Mean blood plasma phosphorus level for the pooled data was 5.15 ± 1.52 and falls within the mean of normal values which are stated to be between 4-6 mg/100 ml for adult ruminant animals (Conrad, 1979). Rushton (1981) quotes a range of 4.66-7.90 mg/100 ml and Merck (1986) gives a range of 3.7-9.7 mg/100 ml.

Magnesium: Mean blood plasma magnesium level was $2.59 \pm .71$ and was well above the critical level of 1-2 mg/100 ml (McDowell et al, 1983). Rushton (1981) gives a normal range of 1.7-2.92 mg/100 ml and Merck (1986) gives a normal range of 2.10-2.90 mg/100 ml.

Copper: Mean blood plasma copper level was 135.39 ± 80.08 μ g/100 ml and was well above the level of 65 μ g/100 ml which is considered critical (McDowell et al, 1983). Rushton (1981) lists normal values of 59.69-120.65 μ g/100 ml.

Total Protein: Mean blood serum total protein level was 7.83 ± 1.36 g/100 ml. The value appears to be on the high side of the expected range. Rushton (1981) lists normal values of 6.6-7.5 g/100 ml and Merck (1986) reports 6.0-7.5 g/100 ml.

Urea: Mean blood serum urea value was 44.42 ± 17.32 mg/100 ml and is higher than expected. A plot of the monthly data in both trials showed a clear seasonal trend with lower levels occurring as the dry season progressed as would be expected with decreased protein intake in the diet. Rushton (1981) lists values of 27.04-55.29 mg/100 ml while Merck (1986) lists values of 12.6-25.8 mg/100 ml. Howard (1986) gives a range of 13-28 mg/100 ml.

Red Blood Cells: Mean red blood cell count was 11.34 ± 2.10 millions/mm³ which was in the normal range of values. Rushton (1981) lists normal values from 5-10 millions/cu³ while Merck (1986) lists values from 8-18 millions/mm³.

White Blood Cells: The pooled mean white blood cell count was 13.28 ± 3.93 thousands/mm³ and was on the high side of values reported in the literature. Rushton (1981) quotes values of 4.0-10.0 thousands/mm³ and Merck (1986) quotes values of 4.0-13.0 thousands/mm³ in normal goats.

Conclusions

The blood parameters of goats in this study were in the normal range of values reported in the literature. Values for phosphorus and calcium were well above levels considered critical. These results present workers with a set of "normal blood values" for goats in Botswana.

Blood levels of calcium, phosphorus, total protein and urea were significantly affected by feeding mineral mix in trial 1. Blood levels of calcium and total protein were significantly

affected by supplemental feeding drought relief cubes in trial 2. Red blood cell counts were increased and white blood cells counts were decreased with mineral-mix feeding in trial 1. Red blood cell counts were not changed and white blood cell counts were increased with supplemental feeding of drought relief cubes in trial 2. The supplemental feeding did not enhance the condition or performance of the treated goats. This finding is not surprising since previous work with goats in Botswana had shown that the diet of goats under normal range conditions had a mean calcium content of .87 percent (range of monthly values from .48-1.20 percent) and a mean phosphorus content of .75 percent (range of monthly values from .63-1.10 percent (Animal Production Research Unit, 1983-84). Dietary calcium and phosphorus values above .36 percent are adequate for nutrition of ruminants, thus the goats in that study consumed approximately twice their requirements.

The high urea value is interesting with regard to the disease "pizzle or sheath rot" which is not uncommon in smallstock in Botswana. High protein diet and consequent high urea content of the urine is considered to be of etiological significance (Blood et al, 1983). The crude protein in the diet of goats in the previous study ranged from 11.2-13.8 percent. These values are far above the 7 percent level which is the critical level for adequate utilization of dietary energy (Animal Production Research Unit 1983-84). The high blood serum total protein and urea values found in this study are consistent with the dietary intake findings of that study.

Thus, it is concluded that supplementation with mineral-mix and drought relief cubes was of minimal value under the environmental conditions imposed upon them in this study.

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TABLE 1: CHEMICAL ANALYSIS OF DROUGHT RELIEF CUBES

| Compound | g/kg |
|------------|----------|
| Protein | 100 Min. |
| Fat | 25 Min. |
| Calcium | 15 Max. |
| Phosphorus | 4 Min. |
| Fibre | 120 Max. |

TABLE 2: BLOOD PARAMETERS OF BOTSWANA GOATS

| VARIABLE CONDITION | CONTROL | | | TREATED | | | OVERALL | | |
|--|---------|-------------------|-------|---------|--------|-------|---------|--------|-------|
| | NO. | MEAN ^a | S.D. | NO. | MEAN | S.D. | NO. | MEAN | S.D. |
| Trial 1 | 352 | 2.61s | .53 | 451 | 2.68t | .48 | 803 | 2.65 | .49 |
| Trial 2 | 375 | 2.82 | .50 | 306 | 2.77 | .46 | 681 | 2.80 | .43 |
| Pooled | | | | | | | 1484 | 2.72 | .47 |
| Calcium (mg/100 ml) | | | | | | | | | |
| Trial 1 | 415 | 8.49x | 1.41 | 530 | 8.80y | 1.39 | 945 | 8.66 | 1.40 |
| Trial 2 | 452 | 9.01x | 1.58 | 379 | 9.40y | 1.95 | 831 | 9.19 | 1.77 |
| Pooled | | | | | | | 1776 | 8.91 | 1.61 |
| Phosphorus (mg/100 ml) | | | | | | | | | |
| Trial 1 | 388 | 5.03 | 1.54 | 500 | 4.91 | 1.39 | 888 | 4.96 | 1.46 |
| Trial 2 | 490 | 5.15 | 1.52 | 397 | 5.36 | 1.60 | 887 | 5.35 | 1.55 |
| Pooled | | | | | | | 1775 | 5.15 | 1.52 |
| Magnesium (mg/100 ml) | | | | | | | | | |
| Trial 1 | 415 | 2.56 | .71 | 531 | 2.60 | .70 | 946 | 2.59 | .71 |
| Trial 2 | 455 | 2.58 | .71 | 378 | 2.57 | .71 | 833 | 2.58 | .71 |
| Pooled | | | | | | | 1779 | 2.59 | .71 |
| CaPper (mg/100 ml) | | | | | | | | | |
| Trial 1 | 372 | 121.56 | 66.21 | 435 | 120.41 | 65.37 | 857 | 120.91 | 65.70 |
| Trial 2 | 470 | 150.41 | 67.66 | 383 | 149.38 | 75.28 | 853 | 149.94 | 71.14 |
| Pooled | | | | | | | 1710 | 135.39 | 80.08 |
| Total Protein (g/100 ml) | | | | | | | | | |
| Trial 1 | 418 | 8.42x | 1.60 | 541 | 7.90y | 1.37 | 959 | 8.13 | 1.49 |
| Trial 2 | 469 | 7.64x | 1.15 | 386 | 7.30y | 1.06 | 855 | 7.49 | .12 |
| Pooled | | | | | | | 1814 | 7.83 | 1.36 |
| Urea (mg/100 ml) | | | | | | | | | |
| Trial 1 | 420 | 46.07x | 18.01 | 541 | 43.08y | 16.93 | 961 | 44.39 | 17.47 |
| Trial 2 | 438 | 45.03 | 16.97 | 377 | 43.77 | 17.36 | 815 | 44.45 | 17.15 |
| Pooled | | | | | | | 1776 | 44.42 | 17.32 |
| Red Blood Cells (millions/mm ³) | | | | | | | | | |
| Trial 1 | 416 | 10.87x | 2.04 | 540 | 11.36y | 2.32 | 956 | 11.14 | 2.21 |
| Trial 2 | 480 | 11.65 | 1.98 | 388 | 11.42 | 1.88 | 868 | 11.55 | 1.94 |
| Pooled | | | | | | | 1824 | 11.34 | 2.10 |
| White Blood Cells (thousands/mm ³) | | | | | | | | | |
| Trial 1 | 416 | 14.99x | 3.93 | 526 | 13.97y | 4.42 | 942 | 14.42 | 4.24 |
| Trial 2 | 485 | 11.77x | 3.02 | 397 | 12.44y | 3.25 | 882 | 12.07 | 3.15 |
| Pooled | | | | | | | 1824 | 13.28 | 3.93 |

^a Means in the same row followed by different letters (x and y) differ significantly (P < .01) while those followed by other different letters (s and t) differ significantly (P < .05).

^b 1 = Poor 2 = Fair 3 = Good

TABLE 3: GOAT HERD STRUCTURE, TRIAL 1

| TREAT- MENT SEX ^b | AGE ^a | | | | | | | | TOTAL | |
|---------------------------------|------------------|------|-----|------|-----|-----|-----|-----|-------|------|
| | 0 | | 1 | | 2 | | 3 | | 4 | |
| | NO. | % | NO. | % | NO. | % | NO. | % | NO. | % |
| CONTROL | | | | | | | | | | |
| F | 50 | 19.9 | 17 | 6.8 | 13 | 5.2 | 14 | 5.6 | 60 | 23.9 |
| M | 58 | 23.1 | 3 | 1.2 | 1 | .4 | 1 | .4 | 62 | 24.7 |
| C | 1 | .4 | 16 | 6.3 | 2 | .8 | 10 | 4.0 | 7 | 2.8 |
| TOTAL | 108 | 43.0 | 36 | 14.3 | 15 | 6.0 | 24 | 9.6 | 68 | 27.1 |
| TREATED | | | | | | | | | | |
| F | 75 | 25.1 | 19 | 6.4 | 17 | 5.7 | 11 | 3.7 | 78 | 26.0 |
| M | 60 | 20.1 | 2 | .7 | 3 | 1.0 | 1 | .3 | 66 | 22.1 |
| C | 1 | .3 | 10 | 3.4 | 4 | 1.3 | 11 | 3.7 | 7 | 2.3 |
| TOTAL | 136 | 45.5 | 31 | 10.5 | 24 | 8.0 | 22 | 7.4 | 86 | 28.6 |

^a Age: 0 = no permanent incisor teeth (birth to approximately 1 year of age).
 1 = 1 set permanent incisor teeth (approximately 1 to 2 years of age).
 2 = 2 sets permanent incisor teeth (approximately 2 to 3 years of age).
 3 = 3 sets permanent incisor teeth (approximately 3 to 4 years of age).
 4 = 3 sets permanent incisor and 1 set permanent canine teeth (approximately 4 years to broken mouthed).

^b Sex: F = female M = male C = castrated male

TABLE 4: GOAT WEIGHTS (KG), TRIAL 1

| TREAT- MENT | SEX ^b | AGE ^a | | | | | | | | | | | | | | |
|----------------|------------------|------------------|------|------|-----|------|------|-----|------|------|-----|------|------|-----|------|------|
| | | 0 | | | 1 | | | 2 | | | 3 | | | 4 | | |
| | | NO. | MEAN | S.D. | NO. | MEAN | S.D. | NO. | MEAN | S.D. | NO. | MEAN | S.D. | NO. | MEAN | S.D. |
| CONTROL | F | 50 | 12.4 | 5.7 | 17 | 23.4 | 3.6 | 13 | 30.9 | 4.0 | 14 | 32.0 | 3.5 | 60 | 35.2 | 3.6 |
| | M | 58 | 13.2 | 5.0 | 3 | 29.7 | .6 | -- | ---- | --- | -- | ---- | --- | 1 | 56.0 | --- |
| | C | -- | ---- | --- | 16 | 32.2 | 3.5 | 2 | 38.0 | 2.8 | 10 | 43.6 | 6.3 | 7 | 47.3 | 8.9 |
| TREATED | F | 75 | 10.5 | 5.4 | 19 | 25.1 | 4.2 | 17 | 28.8 | 4.0 | 11 | 28.7 | 3.4 | 78 | 34.2 | 4.1 |
| | M | 60 | 11.7 | 5.8 | 2 | 30.5 | 6.4 | 3 | 34.3 | .6 | -- | ---- | --- | 1 | 35.0 | --- |
| | C | 1 | 29.0 | --- | 10 | 30.6 | 3.4 | 4 | 34.8 | 3.0 | 11 | 40.4 | 2.8 | 7 | 45.9 | 8.9 |

^a Age: 0 = no permanent incisor teeth (birth to approximately 1 year of age).
 1 = 1 set permanent incisor teeth (approximately 1 to 2 years of age).
 2 = 2 sets permanent incisor teeth (approximately 2 to 3 years of age).
 3 = 3 sets permanent incisor teeth (approximately 3 to 4 years of age).
 4 = 3 sets permanent incisor and 1 set permanent canine teeth
 (approximately 4 years to broken mouthed).

^b Sex: F = female M = male C = castrated male

9'