The Role of Bole (Lake Soil) as a Mineral Supplement to Arsi-Bale Sheep Fed Natural Grass Hay and Concentrate Supplement

INTRODUCTION

In rift valley parts of Ethiopia, sheep rearing has been hampered over the years mainly due to the absence of good quality and adequate feeds which contains sufficient minerals. During the dry season when both good quality and quantity forage is low what usually occurs sheep are loss of live weight, low birth weight, lower resistance to disease and poor fertility (Sisay et al., 2007). Mineral imbalance in soil and forages were considered responsible for low productive and reproductive performance of small ruminants in the tropics (McDowell, 2003). Mineral deficiencies are considered to be one of the nutritional constraints to animal productivity. Poor body condition, slow live weight gain, low fertility and high mortality are normally observed in mineral-deficient animals (McDowell et al., 1983; Vijchulata, 1995).

Different studies were so far conducted on the role of daily bole soil supplementation to small ruminants but, they are not enough to confirm its effect on live weight and feed intake of sheep. Though, those studies conducted to underline the importance of daily mineral supplementation to small ruminants in most part of the country; to date, the amount of daily bole soil supplementation to sheep and its cost benefit analysis has not been investigated in the study area so far. Moreover, attention has not been paid to its effect on Arsi-Bale sheep. The main objective of this study was, therefore, to evaluate the effect of bole soil supplementation in comparison to salt and commercial mineral mix on feed intake, live weight change and carcass characteristics of Arsi-Bale sheep and its cost benefit analysis.

ABSTRACT

**Background:** Mineral deficiencies are considered to be one of the nutritional constraints to sheep performance. An experiment was conducted to evaluate the role of bole soil on feed intake, live weight change and carcass characteristics of Arsi-Bale sheep fed natural grass hay and concentrate supplement and its cost-benefit analysis of bole soil supplementation.

**Result:** Total DM, OM, CP, NDF, ADF intake and ADL were higher (p<0.0001) for T3 than for T1, T2 and T4. Final weight, body weight change, average daily gain and feed conversion efficiency were greater (p<0.0001) for T3 and T2 than for T1 and T4. There were no differences (p>0.05) between T3 and T2 whereas T4 was greater than T1 in these variables. Slaughter weight (SW) was heavier (p<0.0001) for treatment two and treatment three than for treatment four and treatment one, hot carcass weight, foreleg weight and dressing percentage on empty body weight basis were greater (p<0.0001) for T3 and T2 than for T1 and T4.

**Conclusion:** Bole soil supplementation had potentially highest effect on feed intake, live weight change and carcass characteristics of Arsi-Bale sheep than non-supplemented groups. The present study also revealed that supplementation of minerals improved the total weight gain of sheep over the control treatment.

**Key words:** Bole soil, Carcass characteristics, Nutrient intake, Performance, Sheep, Supplementation.

MATERIALS AND METHODS

Animals and management

The study was conducted in Alage Agricultural Technical and Vocational Training College form March 15, 2015 to June 30, 2015. Twenty four males Arsi-Bale sheep with an average initial body weight of 14.05 ± 1.12 kg (mean ± SD) were used and randomized by weight assigned to four groups of six sheep each. Prior to commencement of the experiment, animals were kept for 15 days for adaptation and to observe their health status. They were housed in individual pens (1m x 0.8m) in a well-ventilated concrete floor barn. All animals were drenched with a broad-spectrum anthelmintic and vaccinated against anthrax, pasteuriolosis and blackleg diseases. Bole soil was collected from Shalla Lake, Oromiya region. Sheep were offered ad libitum natural grass hay at 20% refusal rate adjusted every other week.
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and the supplemental minerals and concentrates throughout the experiment. Four treatment groups were randomly assigned to mineral supplementation.

T1 = Natural grass hay ad libitum + 300 g DM/d concentrate
+ no mineral supplement
T2 = Natural grass hay ad libitum + 300 g DM/d concentrate
+ 1% salt
T3 = Natural grass hay ad libitum + 300 g DM/d concentrate
+ 1% commercial mineral mix
T4 = Natural grass hay ad libitum + 300 g DM/d concentrate
+ 2% bole soil

Data of feed offered and refusals of the basal diet were recorded daily in the morning. The treatment diets were formulated on a DM basis. A randomized complete block design (RCBD) was used in the experiment.

Feed intake

Experimental sheep were fed for consecutive 90 days and offered natural grass hay free choice for ad libitum intake at 20% refusal rate where as the concentrate supplement was offered twice a day at 8.00 and 16.00h. The amounts of daily feed offered and refused were recorded to determine daily feed intake. Chemical composition of sub-samples of feed offered and refusal were analyzed and the results were used for calculation of daily dry matter and nutrient intake.

Live weight change and feed conversion efficiency

Data on live body weight change was taken every ten days after overnight fasting starting from the first day of the last acclimatization period using a suspended spring balance. Average daily weight gain for each sheep was determined as a difference between initial and final body weights divided by the total number of actual feeding days. Feed conversion efficiency (FCE), which is the measure of feed utilization, was determined by dividing daily average live weight gain by daily total DMI of the sheep as shown by Brown et al. (2001).

Carcass analysis

All animals were deprived of feed and water for 14h to reduce variation in gut fill and were slaughtered to assess carcass characteristics of animals. Before slaughter, animals were weighed followed by slaughtering by cutting the jugular vein to drain blood. Esophagus was tied off close to head and the animals were suspended head down, over a container and blood was collected and weighed. The head was detached from the body and weighed without tongue when the main flow of blood ceased. Skin was flayed and weighed; forelegs and hind legs were trimmed off at carpal and tarsal joints and weighed. Entire gastrointestinal tract with contents were removed and weighed and then internal contents were emptied and the weight of the empty gut was recorded. After dressing and evisceration, carcass weight was immediately recorded to assess dressing percentage on slaughter weight and empty body weight bases. Empty body weight was calculated as slaughter weight without gut contents. Hot carcass weight was estimated after removing the weight of head, thoracic, abdominal and pelvic cavity contents as well as legs below the hock and knee joints. Rib-eye muscle area of each animal was determined by tracing the cross sectional areas between the 12th and 13th ribs after cutting perpendicular to the back bone (Purchas, 1978).

Partial budget analysis

It was calculated to determine profitability of all experimental feeds to sheep based on the procedure of Upton (1979). Net income (NI) was calculated by subtracting total variable cost (TVC) from total return (TR) as NI = TR-TVC. Change in net income (ΔNI) was calculated as a difference between change in total return (ΔTR) and change in total variable cost (ΔTVC), as : ΔNI = ΔTR- ΔTVC. The marginal rate of return (MRR) measures increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC). MRR = ΔNI/ΔTVC.

Chemical analysis of feeds

Samples of daily feed offered and refused were collected, weighed and separately stored for each animal in bags and kept in a room with adequate natural ventilation until the end of the experimental period. Then feed samples were thoroughly mixed, sub samples were taken to Hawassa University nutrition Laboratory. The DM content of the feed was determined by drying the samples at 105 °C overnight. Ash content of the sample was determined by combusting the samples at 550 °C for 5h in a muffle furnace. N content was determined using the Kjeldahl method and CP was calculated as N% × 6.25 (AOAC, 1995). NDF contents were analyzed using the method of Van Soest et al. (1991) whereas, ADF and ADL contents were determined according to Van Soest and Robertson (1985) using ANKOM® 200 Fiber Analyzer. All samples were analyzed in duplicates. In regard to bole soil, mineral mix and salt were sampled and taken to the Debre Zeit laboratory. Macro minerals (Ca, P, Mg, K, Na and S) and trace minerals (Mn, Cu, Fe and Zn) were analyzed using the method of Mehlich (1984) in Mehlich 3 soil test extractant.

Statistical analysis

Data on feed intake, body weight change and carcass parameters were analyzed by analysis of variance (ANOVA) using the general linear model procedure of statistical analysis system software version 9.1(SAS, 2008). The treatment mean was separated by Duncan’s multiple range test (DMRT), the model used for analysis of the data was:-
Yij = µ + ti + bj + eij, where: Y = the response variable µ = overall mean, ti = treatment effect, bj = block effect, eij=random error.

RESULTS AND DISCUSSION

Chemical Composition of Treatment Feeds

In agreement with a study of McDowell (2003) and McDonald et al. (2002), natural grass hay used as a basal diet in this study had low CP (6.8%) and high fiber contents (Table 1).
Table 1: Chemical composition of experimental feeds.

| Experimental Feeds          | OM  | CP  | NDF | ADF | ADL |
|-----------------------------|-----|-----|-----|-----|-----|
| Natural grass hay           | 45.4| 68.4| 77.7| 47.4| 8.4 |
| Noug seed cake              | 69.4| 67.4| 68.7| 67.4| 6.4 |
| Wheat bran                  | 56.4| 67.4| 68.7| 67.4| 6.4 |

Table 2: Macro and micro mineral composition of mineral supplements.

| Type of mineral supplement | Salt | Commercial mineral mix | Bole soil |
|----------------------------|------|------------------------|-----------|
| Macro minerals (%)         |      |                        |           |
| Ca                         | 0.2  | 3.0                    | 0.2       |
| Mg                         | 0.02 | 0.02                   | 0.02      |
| K                          | 0.02 | 0.02                   | 0.02      |
| Na                         | 0.02 | 0.02                   | 0.02      |
| S                          | 0.02 | 0.02                   | 0.02      |
| Micro minerals (ppm)       |      |                        |           |
| Cu                         | 0.2  | 9.0                    | 0.2       |
| Zn                         | 0.02 | 0.02                   | 0.02      |
| Mn                         | 0.02 | 0.02                   | 0.02      |

Table 3: Effect of supplementation of bole soil on dry matter and nutrient intake in growing Arsi-Bale sheep.

| Feed Intake( g/d) | T1   | T2   | T3   | T4   | SEM  | P value |
|-------------------|------|------|------|------|------|---------|
| Hay DMI           | 348.1| 384.3| 415.1| 355.8| 4.6  | p<0.0001|
| Concentrate DMI   | 273.9| 273.9| 273.9| 273.9| 0.00 | Ns      |
| Total DMI         | 622.4| 658.2| 689.6| 629.7| 5.1  | p<0.0001|
| Total OMI         | 568.5| 642.5| 663.5| 607.5| 4.9  | p<0.0001|
| Total CPI          | 86.3 | 92.0 | 93.5 | 89.3 | 0.4  | p<0.0001|
| Total NDFI        | 326.8| 383.3| 397.5| 355.9| 3.7  | p<0.0001|
| Total ADLI        | 204.6| 241.3| 250.5| 223.5| 2.4  | p<0.0001|
| Total ADL        | 19.4 | 21.7 | 22.3 | 20.6 | 0.2  | p<0.0001|

Means with P<0.05 values across rows are significantly different, ns= non significantly different, SEM=standard error of mean.

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Table 4: Body weight and feed conversion efficiency in growing Arsi-Bale sheep supplemented with bole soil.

| Parameters                        | Treatments | SEM | P value |
|-----------------------------------|------------|-----|---------|
| T1                                | T2         | T3  | T4      |
| Initial body weight (kg)          | 14.1       | 13.9| 13.9    | 14.2   | 0.1  | Ns     |
| Final body weight (kg)            | 16.0*      | 19.9*| 20.1*   | 18.1*  | 1.2  | p<0.0001 |
| Body weight change (kg)           | 1.9*       | 6.0*| 6.1*    | 3.9*   | 0.9  | p<0.0001 |
| Average daily gain (g)            | 21.7*      | 63.8*| 68.3*   | 45.9*  | 1.3  | p<0.0001 |
| FC E (g ADG/g TDMI)               | 0.03*      | 0.09*| 0.09*   | 0.07*  | 0.002 | p<0.0001 |

a, b, c, Means with P<0.05 values across rows are significantly different, ns= non significantly different, SEM= standard error of mean, FCE= feed conversion efficiency, TDMI = total dry matter intake, ADG = average daily gain, SEM= standard error of mean.

Table 5: Effect of bole soil supplementation on carcass characteristics in growing Arsi-Bale sheep.

| Carcass Parameters               | Treatment | SEM | P value |
|-----------------------------------|-----------|-----|---------|
| Fore leg (kg)                     |           |     |         |
| T1                                | 1.5c      | 1.8*|         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Hind leg (kg)                     | 1.6c      | 1.9*|         |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Sternum (g)                       | 338.3c    | 435.2c| 512.4c  | 454.7c | 9.9  | p<0.0001 |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Slaughter body weight (kg)        | 16.0c     | 19.9*| 20.1*   | 18.1*  | 441.4| p<0.0001 |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Empty body weight (kg)            | 11.9c     | 14.0*| 13.9*   | 13.49c | 411.2| p<0.05   |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Hot carcass weight (kg)           | 5.0c      | 7.2*| 7.3*    | 6.1b   | 0.22 | p<0.0001 |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Dressing percentage (%)           |           |     |         |
| On empty body weight base         | 41.9c     | 51.8*| 52.4*   | 45.4b  | 0.8  | p<0.0001 |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| On slaughter body weight base     | 45.7c     | 49.9*| 51.2*   | 46.2c  | 0.72 | p<0.001  |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |
| Rib eye area (cm²)                | 5.5c      | 7.1*| 6.8ab   | 6.5c   | 0.2  | p<0.0001 |
| T1                                |           |     |         |
| T2                                |           |     |         |
| T3                                |           |     |         |
| T4                                |           |     |         |

a, b, c, Means with P<0.05 values across rows are significantly different, ns= non significantly different, SEM= standard error of mean.

Table 6: Total edible offals in growing Arsi-Bale sheep supplemented with bole soil.

| Edible offals(g)                  | Treatments | SEM | P value |
|-----------------------------------|------------|-----|---------|
| T1                                | T2         | T3  | T4      |
| Head                              | 966.1c     | 1190.3c| 1171.2c| 1052.3c| 22.3 | P<0.0001 |
| Tail                              | 381.35c    | 456.21c| 492.12c| 479.24c| 13.98| P<0.001  |
| Tongue                            | 45.3c      | 51.2  | 48.8    | 44.2  | 0.9  | P<0.001  |
| Liver                             | 215.9c     | 272.1c| 265.3c  | 252.9c| 9.5  | P<0.05   |
| Heart                             | 60.8c      | 98.5  | 105.5c  | 96.2  | 1.9  | p<0.0001 |
| Kidney with fat                   | 107.5c     | 127.8c| 131.2c  | 128.0c| 2.9  | p<0.0001 |
| Reticulo-rumen                    | 327.9c     | 435.1c| 444.4c  | 400.7c| 12.5 | p<0.0001 |
| Omasum-abomasum                   | 93.7c      | 151.5c| 158.1c  | 144.4c| 3.4  | p<0.0001 |
| Large and Small Intestine         | 449.6c     | 576.8c| 567.9c  | 532.4c| 13.4 | p<0.0001 |
| Abdominal fat                     | 30.2c      | 106.1c| 98.7c   | 90.3c | 4.7  | P<0.0001 |
| Testicle                          | 119.1c     | 138.9c| 140.8c  | 129.3c| 3.6  | P<0.05   |
| TEO                              2797.5c   3603.8c| 3624.2c| 3350.1b| 66.9  | p<0.0001 |

a, b, c, Means with P<0.05 values across rows are significantly different, ns= non significantly different, SEM= standard error of mean.

Edible offal components
The current study findings showed that the supplementation of minerals for the sheep had a significant effect on all edible offal components (Table 6).

Non edible offals
The findings of the current study showed that animals supplemented with minerals showed significant impact on weight of blood, gut content, spleen, esophagus and skin with feet, lung and total non-edible offals (Table 7).

Partial budget analysis
The high profit obtained in T2 is due to the lower cost of buying salt as compared to T3. The higher profit also obtained in T4 is due to zero cost of bole soil, which resulted in a higher selling price as compared to T1 and T3. On the
In this regards you may please reply of the reviewer comments mail.

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Table 7: Total non-edible offals in growing Arsi-Bale sheep supplemented with bole soil.

| Non edible offals (g)     | Treatments | SEM | P value |
|---------------------------|------------|-----|---------|
|                           | T1         | T2  | T3      | T4      |
| Skin with feet            | 1463.8b    | 1724.2a | 1759.5a | 1632.2a | 43.9 | P<0.05 |
| Spleen                    | 60.9b      | 68.1*  | 65.6ab  | 63.49ab | 1.6  | P<0.05 |
| Penis                     | 27.3*      | 33.9*  | 33.2a   | 34.1*   | 1.0  | P<0.001|
| Lung                      | 175.5b     | 204.6a | 207.2a  | 210.9a  | 5.5  | P<0.05 |
| Trachea                   | 43.6b      | 52.6a  | 52.2a   | 44.7b   | 1.8  | P<0.05 |
| Esophagus                 | 24.9       | 26.5   | 26.0    | 25.60   | 0.9  | Ns    |
| Gall bladder              | 8.2        | 7.9    | 7.5     | 7.2     | 0.4  | Ns    |
| Gut content               | 4055.8c    | 5942.5a | 6203.3a | 4623.2b | 144.4 | P<0.0001|
| Blood                     | 698.4c     | 873.8* | 865.0*  | 761.3b  | 18.4 | P<0.0001|
| Urinary bladder           | 32.1       | 40.1   | 34.7    | 33.6    | 2.9  | Ns    |
| TNEO                      | 6605.7c    | 8994.3* | 9274.0* | 7453.1b | 194.9 | P<0.0001|

a, b, c Means with P<0.05 values across rows are significantly different, ns= non significantly different., SEM= standard error of mean , T1=no mineral supplement , T2= 1% salt, T3= 1%mineral mix and T4= 2% bole soil, TNEO= Total non-edible offals.

Table 8: Partial budget analysis in growing Arsi-Bale sheep supplemented with bole soil.

| Parameters                          | Treatments | T1       | T2       | T3       | T4       |
|-------------------------------------|------------|----------|----------|----------|----------|
| Sheep purchase price (ETB/head)     |            | 381.7    | 383.3    | 382.5    | 378.3    |
| Hay price (ETB/head)                |            | 49.8     | 61.8     | 64.2     | 55.6     |
| Total hay offered (kg/head)         |            | 50.6     | 57.8     | 56.9     | 55.9     |
| Concentrate price (ETB/head)        |            | 148.4    | 148.4    | 148.4    | 148.4    |
| Total concentrate consumed (kg/head)|            | 27       | 27       | 27       | 27       |
| Mineral purchase price (ETB/head)   |            | -        | 3.0      | 113.4    | -        |
| Mineral consumed(kg/head)           |            | -        | 0.27     | 0.27     | 0.54     |
| Gross return (ETB/head)             |            | 288.3    | 393.3    | 399.2    | 315.5    |
| Total variable cost (ETB/head)      |            | 293      | 308.1    | 420.8    | 298.8    |
| Net return (ETB/head)               |            | -4.7     | 85.2     | -21.6    | 16.2     |
| ΔGR                                 |            | -        | 105      | 110.8    | 26.7     |
| ΔTVC                                |            | -        | 15.1     | 127.8    | 5.8      |
| ΔNR                                 |            | -        | 89.9     | -16.9    | 20.85    |
| MRR ΔNI/ΔTVC                        |            | -        | 5.9      | -0.13    | 3.58     |

ETB= Ethiopian birr, ΔGR= change in gross return, ΔTVC = change in total variable cost, ΔNR =change in net return, MRR= marginal rate of return, T1= no mineral supplement, T2= 1% salt, T3= 1%mineral mix and T4= 2% bole soil.

other hand, the values of MRR of the present study were positive for T2 and T4. The MRR showed that each additional unit of one ETB per sheep cost increment resulted in one ETB and additional of 5.9 and 3.6 ETB benefit from T2 and T4 groups respectively (Table 8).

CONCLUSION

Bole soil supplementation had potentially highest effect on feed intake, live weight change and carcass characteristics of Arsi-Bale sheep than non-supplemented groups. The present study also revealed that supplementation of minerals improved the total weight gain of sheep over the control treatment. The performance of animals supplemented with bole soil was inferior to those supplemented with common salt and commercial mineral mix. With regard to the economic benefits, sheep supplemented with bole soil and salt returned high net income in comparison to treatments. Therefore, bole soil and salt are highly recommended to farmers for their animals as a mineral supplement.

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