Tropical Grasslands – Forrajes Tropicales (2014) Volume 2, 36−37

Copper status of free ranging cattle: what's hidden behind? A pilot study at the Gilgel Gibe catchment, Ethiopia

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Keywords: Mineral deficiency, soil, humid tropics, zebu.

Introduction

Copper (Cu) deficiency is known to be a major risk for cattle health and production and is diagnosed through low liver copper reserves and low plasma copper levels. The widespread problem is due to low Cu concentrations in the natural diet, the presence of dietary Cu antagonists, such as S, Mo and Fe, and low absorption rates in the rumen (Suttle 2010). Cattle in the tropics are even more prone to shortage of this mineral, since animals are often grazed extensively and largely dependent on natural pasture (McDowell and Arthington 2005). In Ethiopia, Cu deficiency has been described in zebu (*Bos indicus*) cattle by several authors (e.g. Dermauw et al. 2013). Similar to other minerals, Cu is part of the soil-plant-animal chain, with many factors influencing Cu concentrations at every level. In our study, the overall goal was to investigate the possible influence of certain environmental and management factors on dietary concentrations of Cu and antagonists and plasma Cu levels in free-ranging cattle.

Methods

This study was conducted in the Gilgel Gibe catchment, southwestern Ethiopia. In 3 elevation zones (1 = 1,700 −1,800 m asl, 2 = 1,800−2,000 m asl, 3 = 2,200 m asl), 19 herds (<10 to >70 animals per herd) of free-ranging zebu (*Bos indicus*) cattle were randomly selected within a radius of 35 km around the town of Jimma, and observed during one day. One lactating cow per herd was closely observed, the body condition score (BCS) was recorded and a blood sample was obtained. The soil type [Nitisols, Acrisols and Ferralsols (soil association NAF) or Planosols and Vertisols (soil association PV) according to Van Ranst et al. (2011)] was identified based upon landscape position and visual inspection of the soil. Management practices were evaluated based upon grazing strategy (communal vs. individual), supplementation with crop residues (as % of dietary observations) and the total herding distance covered (during one grazing day). The dietary plant composition was estimated through observation of ingested plant species every 10 minutes. One ingested plant per observation was equal to 1 point, several ingested species per observation were allocated 1 point divided by the number recorded. A sample of all ingested plants was collected.

To estimate the dietary mineral concentrations, the ingested proportions of each plant were multiplied by mineral content and summed. If no sample could be obtained due to small plant size, the mineral concentration of the known percentage of ingested plants was extrapolated to 100%. Finally, the number of ingested plant species (NIPS) was recorded. Plasma was obtained through centrifugation at 1,500 × G for 10 min. Plant samples were oven-dried at 65 °C for 72 h. All samples were digested using microwave destruction with 10 mL HNO_3 (plasma: open; plants: closed vessels) followed by filtration and mineral analysis through inductively coupled plasma optical emission spectrometry and mass spectrometry (ICP-OES & -MS) (Vista MPX radial, Varian, Palo Alto, CA, USA and Elan DRC-e, Perkin Elmer, Sunnyvale, CA, USA, respectively).

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Statistical analysis was performed using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA). To determine the association between categorical variables, a Fisher's Exact test was used. To determine the effect of the physical environment and management on mineral concentrations in ingested diet and status, a fixed effects model with one categorical or one continuous covariate at a time was fitted to the different response variables. Hypotheses were tested using the F-test at the 5% significance level.

Results

Of the 19 observed animals, 12 were severely Cu deficient [mean: 0.48 ± 0.19 (SD) mg/L], while estimated dietary Cu concentrations were below requirements for all herds (5.8 ± 1.4 mg/kg DM). Soil type and elevation were significantly associated ($P<0.001$), with the typical occurrence of Planosol/Vertisol associations (PV) at lower elevation. Soil type did not affect the amount of crop residues offered by the farmers ($P>0.05$), but significantly influenced herd type (more communal grazing for longer distances on PV soils). Focusing on the impact of soil type on diet, NIPS [10.7 vs. 17.2 ± 1.3 (s.e.m.)], dietary concentrations of Cu (4.7 vs. 6.4 ± 0.3 mg/kg DM) and Fe (765 vs. 1672 ± 183 mg/kg DM) were lower on PV soils, whereas concentrations of Mo (1.47 vs. 0.96 ± 0.10 mg/kg DM) were higher than on NAF soils (all $P<0.05$). Dietary concentrations of S tended to be lower on PV soils (0.15 vs. 0.19 ± 0.01 % DM, $P=0.082$). Animal Cu status, however, was not affected by soil type.

Concerning the impact of management practices on diet and status, dietary Mo concentrations were higher in communal grazing herds (1.4 vs. 1.0 ± 0.1 mg/kg DM), whereas the Cu:Mo ratio was higher in individual grazing herds (6.8 vs. 4.0 ± 1.0) (both $P<0.050$), but Cu status was not affected ($P>0.050$). The amounts of crop residues offered to grazing animals had a significant negative effect on dietary Zn concentrations ($P=0.033$) and tended to negatively affect dietary Mo and S concentrations ($P=0.064$; $P=0.063$, respectively). Animal mineral status was not affected by this, but BCS was positively affected ($P=0.010$). Herding distance tended to negatively affect Cu:Mo ratio ($P=0.082$), but did not affect Cu status or level of Cu antagonists.

Conclusion

Zebu cattle grazing in the study area were under high risk for Cu deficiency, potentially aggravated due to Fe, Mo and S overload. Lower dietary Cu concentrations were ingested on PV soils, which coincided with higher dietary Mo and lower Fe concentrations. Herd type, crop residue supplementation and herding distance had or tended to have an effect on dietary concentrations of Cu antagonists. Despite the unaffected Cu status, these results accentuate the impact of both environment and management on dietary concentrations of Cu and antagonists. The impact of these factors may encourage farmers to take informed choices, which might improve the copper status of their animals.

Acknowledgments

This study was funded by Grant SB091348 from IWT-Vlaanderen. Furthermore, we would like to thank the IUC-JU programme of VLIR-UOS for logistical support and Ria Van Hulle for performing mineral analyses.

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DOI: 10.17138/TGFT(2)36-37

This paper was presented at the 22nd International Grassland Congress, Sydney, Australia, 15−19 September 2013. Its publication in *Tropical Grasslands – Forrajes Tropicales* is the result of a co-publication agreement with the IGC Continuing Committee. Except for adjustments to the journal's style and format, the text is essentially the same as that published in: **Michalk LD; Millar GD; Badgery WB; Broadfoot KM, eds. 2013. Revitalising Grasslands to Sustain our Communities. Proceedings of the 22nd International Grassland Congress, Sydney, Australia, 2013. New South Wales Department of Primary Industries, Orange, NSW, Australia. p. 665–666.**