Trop Anim Health Prod (2018) 50:205–208
DOI 10.1007/s11250-017-1402-9

SHORT COMMUNICATIONS

Bio-economic evaluation of a reduced phosphorus supplementation strategy for a cow-calf system in Brazil: a case study

Samara P. Lopes[1] · **Felipe Z. Garcia**[1] · **Vinícius C. Souza**[2] · **Diogo Fleury A. Costa**[3] · **Pedro Malafaia**[4]

Received: 24 June 2017 / Accepted: 10 September 2017 / Published online: 16 September 2017

Abstract Fertility, weight of calves at weaning, and the economic aspects of a breeding herd receiving mineral supplements containing 75 or 12.5 g of phosphorus (P)/kg were measured from 2013 to 2016. No differences in reproduction parameters or weight at weaning were found before and after the adoption of the new scheme of mineral supplementation. Before the study, the annual cost with the formula containing more P was equivalent to 29.3 weaned beef calves; after the P reduction, the annual cost was equivalent to 2.2 to 6.8 weaned calves. After 3 years of supplementation with 12.5 g P/kg no signs of P deficiency were observed. The clinical-nutritional diagnosis of the herd indicated no cause-effect of P content of mineral supplements upon fertility or performance of healthy cows, demonstranting that the adequate forage allowance was enough to meet most P required by the cows.

Keywords Cost of production · Phosphorus · Mineral supplementation

Introduction

Most livestock producers in Brazil choose mineral supplements based on price, believing that the use of commercial mineral supplements (CMS) could ensure health and productivity of their herds (Malafaia et al. 2014). That approach does not necessarily guarantee that the mineral requirements are met, and it can also lead to use in excess of particular minerals, what is not only uneconomical, but could also be detrimental to cattle performance.

Alternatively, the selective mineral supplementation (SMS) is based on a previous clinical-nutritional examination of the herd, indentification of minerals that are deficient, and the supplying adequate amounts of specific minerals, in particular P. The use of SMS allows significant economy with MS in comparison to a CMS (Costa et al. 2016).

The contribution of mineral supplements in the effective operating costs (EOC) of beef cattle production is poorly studied in Brazil. The price of phosphorus (P) is the major contributer to the cost of a MS; therefore, it is essential to seek a rational use of P, leading to significant reductions in EOC (Malafaia et al. 2014). Considering the possibility that P levels in CMS can be reduced without affecting cattle performance and health, the objective of this case study was to evaluate the effects of a reduced concentration of P in the mineral supplements of beef cows on performance parameters and on the EOC of the system.

Methods

This case study was conducted from 2013 to 2016 in a ranch located in Valença, RJ. The farm had approximately 520 ha and was formed with *Urochloa decumbens* and *U. brizantha*. Forage allowance ranged from 3 to 5 tons of dry matter per hectare. The pastures were managed based on height of the forage before and after grazing. All cattle were weighed, and the value of animal units (AU) of 450 kg was used for allocation on pastures assuring adequate forage allowance.

✉ Pedro Malafaia
malafaia_ufrrj@yahoo.com.br

[1] PPGZ, UFRRJ, Seropédica, RJ, Brazil

[2] DZO, Unesp, Jaboticabal, SP, Brazil

[3] Beef Cattle Research Center, Kansas State University, Manhattan, KS 66506, USA

[4] DNAP, UFRRJ, Seropédica, RJ, Brazil

The property conducted an extensive cow-calf system using healthy Nellore cows submitted to breeding seasons (BS) of approximately 120 days. The stocking rate ranged from 1.1 to 1.8 AU/ha. Prior to start of the BS, all cows and nulliparous were subjected to diagnosis of brucellosis, body condition score (BCS), gynecological examination to rule out females not suitable for reproduction. The BCS scale ranged from 1.0 to 6.0. Females considered not suitable had gynecological problems or a BCS below 2.0. All sires were subjected to andrological examination. The selected nulliparous were put to mate using a ratio of 30:1 cows:sire. The multiparous were firstly subjected to fixed-time artificial insemination protocol (FTAI); after 20 days, they were placed with sires using the same cows:bull ratio. Cows were culled at the end of BS if diagnosed not pregnant, had low maternal ability, not docile, and had teats or skeleton abnormalities.

Herd mineral supplements was provided during the rainy season, and a protein-energy supplement was used on the dry season.The MS in 2013 was made with a CMS containing (per kg) 150 g Ca, 75 g P, 154 g Na, 15 g S, 15 g Mg, 100 mg Co, 1500 mg Cu, 3360 mg Zn, 40 mg Se and 2511 mg Mn. From 2014 to 2016, a SMS was prepared in the farm. This SMS contained (per kg) 341 g Na, 12.5 g P, 639 mg Cu and 89 mg Co. The average daily consumption of mineral supplements were monthly measured.

On the day of pregnancy diagnosis, foetal age was estimated to distinguish whether the pregnancy was a result of the FTAI or natural mating. The maternal ability was evaluated by the weight of calves at weaning adjusted for 210 days (WW_{210}).

The rainfall was recorded within 4 months of the BS. Data about fertility rate was described on percentage. For analyses of WW_{210} and BCS, each animal was considereded an experimental unit, and all means were described together with a confidence interval (CI) of 95%.

Costs of labor, mineral supplements, medication, reproduction, fuel, equipments, and fertilizers used on pastures were recorded and utilized to calculate the effective operating costs (EOC). The EOC consisted of all the items of variable costs and the fixed costs that represent expenses in cash associated with production. The interpretation of economic data was made through comparison of annual costs, considering the use of both types of MS. The annual costs of the two mineral supplements schemes were also transformed into equivalent numbers of weaned calves, using the annual average price described by the CEPEA, 2014.

Results

Pregnancy rate by FTAI were the lowest in the year that CMS was used (Table 1). After the utilization of SMS (2014 and 2015), the average of herd fertility was 75%, being greater in 2016, whereas pregnancy rates by FTAI were always higher for SMS (Table 1).

The greater daily intake and price per kilogram of CMS resulted in greater costs with MS in 2013 (Table 1). When compared to the CMS, the SMS had a price, on average 45% cheaper than CMS (Table 1). Replacement of CMS for SMS decreased the mineral supplements costs over the EOC, especially when compared to labor, pastures, medication, fuel and reproduction (Table 1). During 2013, the daily intake of CMS was 50.1 g/AU (Table 1); on the following years, the daily intake of SMS went from 35 up to 41 g/AU (Table 1). During the 3 years of SMS, no animals showed clinical signs of P deficiency. Also, the reduction in P content in SMS did not affect the WW_{210} or BCS of cows (Table 1). Labor costs were the highest amongst all variable costs (Table 1). During 2013 the annual cost for CMS was equivalent to a price paid for approximately 29 weaners; from 2014 onwards, with the use of SMS, the expenses with mineral supplements fell from 6.8 to 2.2 weaned calves/year (Table 1).

Discussion

This case study did not test a response to a zero P supplementation, but rather tested a reduction in P concentration. Similar results were found in Brazil by Peixoto et al. (2003) that evaluated the reproductive performance of about 1200 breeders, for 5 years, and found no differences in FR when cows were fed SMS or a CMS. Costa et al. (2016) supplemented Nellore cows with CMS (40 g P/kg) or a SMS (18 g P/kg) and obtained similar results on FR.

In Brazil, the reproductive success of cow-calf systems is directly linked to the health of cows, sires and the assurance of an adequate forage allowance (Malafaia et al. 2014; Costa et al.2016). In 2014, due to a prolonged drought, about 200 animals were sold. This was not a selective culling, but an attempt to fit forage allowance to 1.1 AU/ha. Other studies showed no response on FR to P supplementation when forage mass offer was not sufficient to meet cows requirements (Van Niekerk & Jacobs, 1985; Jackson et al. 2012). Unfortunately, in Brazil, there is a widespread belief that P supplementation results in increased cattle FR. This belief leads to paradoxes such as (a) P supplementation without previous control or diagnosis of the reproductive diseases, which are much common in Brazilian beef herds, (b) the sale of mineral supplements so called “specific for cattle reproduction” and (c) the use of P supplements regardless of forage allowance for both rainy and dry seasons (Malafaia et al. 2014). These popular beliefs may cause enormous economic losses to the cattle production systems across the country.

If the P ingested from pastures and from SMS were not able to meet cows requirements, the WW_{210} in this

Table 1 Data concerning reproduction parameters, mineral supplementation and economic aspects of beef cows supplemented with commercial mineral supplement (CMS) or selective mineral supplement (SMS) between 2013 and 2016

Years	2013	2014	2015	2016
Type of mineral supplementation	CMS	SMS	SMS	SMS
Total of nulliparous and multiparous submitted to BS[a]	677	646	402	447
Total pregnant	517	507	290	380
Fertility ratio (%)	76.4	78.5	72.1	85.0
Multiparous submitted to FTAI[b] protocol	388	463	223	198
Multiparous pregnant by FTAI	147	277	97	109
FTAI efficiency (%)	38	49	43	55
Days of mineral supplementation	313	258	222	201
Total of mineral supplement (kg/year)	14,400	8400	5200	3600
Price of mineral supplement (US$/kg)	0.76	0.31	0.24	0.25
Animal unity (AU)	917	928	567	563
Stocking rate (AU/ha)	1.7	1.8	1.1	1.1
Intake of mineral supplement (g/AU/day)	50.1	35.0	41.1	32.0
WW_{210} (female)	163 (3.9)	167 (3.1)	167 (2.8)	172 (4.3)
WW_{210} (male)	166 (7.4)	175 (3.9)	176 (3.8)	181 (4.5)
Body condition score	3.9 (0.21)	4.2 (0.12)	3.7 (0.1)	3.9 (0.1)
Rainfall (mm^3) within the months of BS	766	583	702	779
Effective operating cost (EOC, in US$)	177,600	150,850	111,650	77,450
Expenses with mineral supplementation (US$/year)	10,900	2550	1250	900
Price of a weaned beef calf (US$)	372	377	368	401
Expenses with mineral supplementation (calves/year)	29.3	6.8	3.4	2.2
Expenses with labor (as % of EOC)	24.1	28.4	32.8	36.8
Expenses with pastures (as % of EOC)	15.2	10.0	7.8	11.4
Expenses with the medication (as % of EOC)	6.4	5.5	7.0	7.2
Expenses with reproduction (as % of EOC)	5.6	4.4	3.3	4.0
Expenses with equipments (as % of EOC)	5.3	6.5	3.8	2.6
Expenses with fuel (as % of EOC)	3.4	3.1	3.1	1.6
Expenses with mineral supplementation (as % of EOC)	6.1	1.7	1.1	1.2

Values between brackets are 95% CI

[a] Breeding season

[b] Fixed-time artificial insemination

experiment would have decreased over time, what did not happen over 3 years of SMS use. The higher price of CMS is because of its composition, packaging, transportation, taxes, marketing and salesman commission. Alternatively, the SMS is formulated based on clinical and nutritional diagnosis of the cattle; therefore, it almost always use less mineral elements, an ideal P concentration and, being prepared on site, it ends up cheaper.

The lowest P concentration in SMS was the main reason for reduced costs. In this study, CMS was the fourth item of EOC and after starting the utilization of SMS, the expenses with MS fell into the last position over the EOC. There was a reduction of 3.8–8.4 times in the costs with SMS, with no deleterious effects in reproductive parameters or WW_{210}. The greatest savings obtained with SMS could be used for other investments within the property, such as fertilization and the subdivision of pastures.

Conclusion

The mineral supplementation, made on the farm with lower P concentration, was more economical and resulted in no negative impacts on the health and performance of the herd. These findings indicate that the levels of P in commercial mineral supplements, as stated by the Brazilian regulatory agency, needs to be further revised and producers and professionals ought to seek a more rational use of P.

Compliance with ethical standard

Ethical approval All procedureswere approved by the ethics committee on the use of human and animal subjects in teaching and research of the UFRRJ.

Competing interests The authors declare that they have no competing interest.

Informed consent Informed consent was obtained from all individual participants included in this study.

References

CEPEA, 2014. Média ponderada do boi gordo no estado de São Paulo. Available at Accessed on 30 march 2015.

Costa, R.M., Ponsano, E.H.G., Souza, V.C. and Malafaia, P., 2016. Reduction of phosphorus concentration in mineral supplement on fertility rate, maternal ability and costs of beef cows reared in pastures of *Urochloa decumbens*. Tropical Animal Health and Production, 48,417–422.

Jackson, D., Rolfe, J., English, B., Holmes, B., Matthews, R., Dixon, R., Smith, P. and Macdonald, N., 2012. Phosphorus management of beef cattle in northern Australia. Ed. Ian Partridge. Published by: Meat & Livestock Australia Limited.

Malafaia, P., Magnoli Costa, R., Brito, M.F., Peixoto, P.V., Barbosa, J.D., Tokarnia, C.H. and Döbereiner, J. 2014. Erroneous interpretations regarding mineral deficiencies and supplementation of cattle in Brazil. Pesquisa Veterinária Brasileira, 34,244–249.

Peixoto, P.V., Malafaia, P., Miranda, L.V., Canella, C.F.C., Canella Filho, C.F.C. and Vilas Boas, F.V. 2003. Reproduction performance of beef cattle cows given three different types of mineral supplements. Pesquisa Veterinária Brasileira, 23, 125–130.

Van Niekerk, B.D.H. and Jacobs, G.A. 1985. Protein, energy and phosphorus supplementation of cattle fed low-quality forage. South African Journal of Animal Science 15, 133–13