Bone Alkaline Phosphatase as an indicator of phosphorus status in breeder cows

Stephen Anderson, Rob Dixon, David McNeill, Jereme Spiers, Yuri Castells, Lisa Kidd, Kerri Goodwin & Mary Fletcher

Laboratory for Animal Endocrinology
School of Biomedical Sciences
The University of Queensland
Brisbane, Australia
stephen.anderson@uq.edu.au

Phosphorus is a key challenge

In Northern Australia rangelands nutritional phosphorus deficiency is a major issue

Guidelines to producers

Animals that need phosphorus the most are growing animals, late-pregnant breeders and wet cows

There are no simple diagnostic tests for the phosphorus status of cattle.

Blood phosphorus concentration is likely to give the best indication of the P status of a growing animal, but cannot be applied to a lactating cow.

https://futurebeef.com.au

Our challenge

Better understand the physiological mechanisms controlling body Phosphorus reserves in beef breeder cows

Develop better diagnostic tests for P status

Using a bone marker for P status?

Bone specific Alkaline Phosphatase (BAP) is an enzyme synthesised solely by osteoblasts

Used as a biomarker for bone deposition. Role(s) in mineralisation.

However total Alkaline Phosphatase (ALP) is a more common standard biochemical test

ALP often used in conjunction with liver enzymes to provide differential diagnosis liver or bone disease

Design & Methods

Replenishment of P reserves post-weaning
Mature (6-11years) Bos indicus cross cows
Pregnant, immediately post-weaning
Housed in individual pens
Fed ad-libitum P deficient diets for 13 weeks
Either “low” (moderate) or “high” ME 8.6 vs9.7 MJ/kg DM
With “low” or “high” P 0.08 vs 0.28 g P/kg DM
2x2 factorial design LE-LP, LE-HP, HE-LP, HE-HP groups

Measures: feed intake, digestibility, live weight
Bone biopsies: start and end trial
Blood samples: minerals, bone markers & hormones
Results:

Prior to start of experiment
PIP 1.78 ± 0.06 mmol/L (n=40)
But range was 1.02 to 2.73 mmol/L
expectation of low to marginal P status

Results: Phosphorus

Osteocalcin  Bone Deposition Marker
No major diet effect on osteocalcin

CTX-1  Bone Resorption Marker
CTX-1 is increased in P deficiency

Results: Bone biopsies

P Supplementation post-weaning
mid-pregnancy
Increased plasma inorganic P
No effect Osteocalcin (bone deposition marker)
Decreased CTX-1 (bone resorption marker)
ie. decreased bone turnover
Increased trabecular bone volume
Bone Alkaline Phosphatase

BAP is increased on low P diets
But BAP is supposedly a marker of bone deposition?

Total Alkaline Phosphatase

High ALP concentrations in some animals
Not explained by abnormal liver enzyme result (AST)

Results: % change

Some concordance between ALP and BAP
So change in ALP likely due to change in bone isoform
But still unusual result

BAP in diary cows

Conclusions

BAP may be a candidate marker for P status in mature cows
BAP exhibits an inverse relationship to dietary P intake/plasma phosphorus
Increased ALP is observed with hypophosphatemia in humans, and is associated with osteomalacia.
Breeder cows can replenish skeletal P reserves after weaning, with adequate P supplementation & moderate ME diets

Acknowledgements

University of Queensland
David McNeill
Lisa Kidd
Rob Dixon
Mary Fletcher
Post-docs
Yuri Castells
Jereme Spiers
Marcelo Benvenutti
Students
Keanne Santos
Sam Van de Wakker
Gabrielle Penna

DAF Brian Pastures Research Station
Kerri Goodwin
Don Cherry
Bob Karfs
DAF Biosecurity Sciences Laboratory
Brian Burren
Michael Gravel

(Grateful Acknowledgments from past and current members of the research team, including funding agencies and institutions)