Novel physiological responses in phosphorus deficient beef cows

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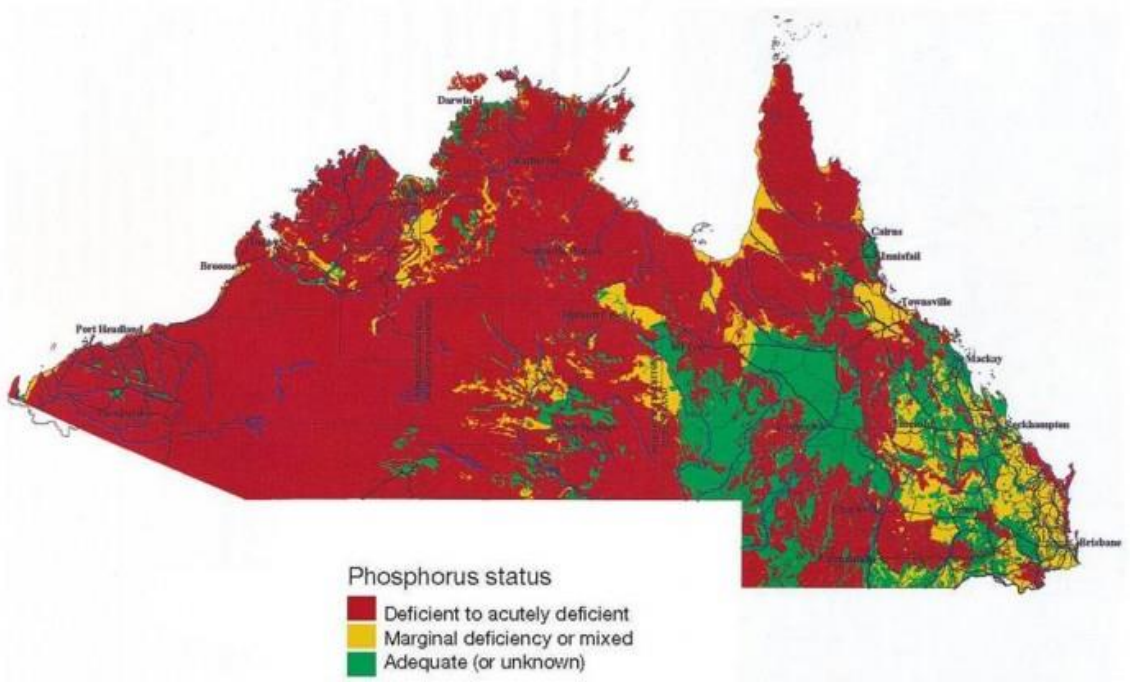
Phosphorus is a key challenge



Nutritional Phosphorus deficiency is important in cattle grazing rangelands in Northern Australia

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Our challenge

Better understand the physiological mechanisms controlling mobilization and deposition of body P reserves in breeder beef cattle

Develop diagnostic tools of P status (talk Tuesday)

Design & Methods

40 heifers calving at 3 years age, placed in pens

Balanced diet: straw, flour, sugar, oil, and urea based
+/- Calcium Phosphate **"low" P or adequate "high" P diet**

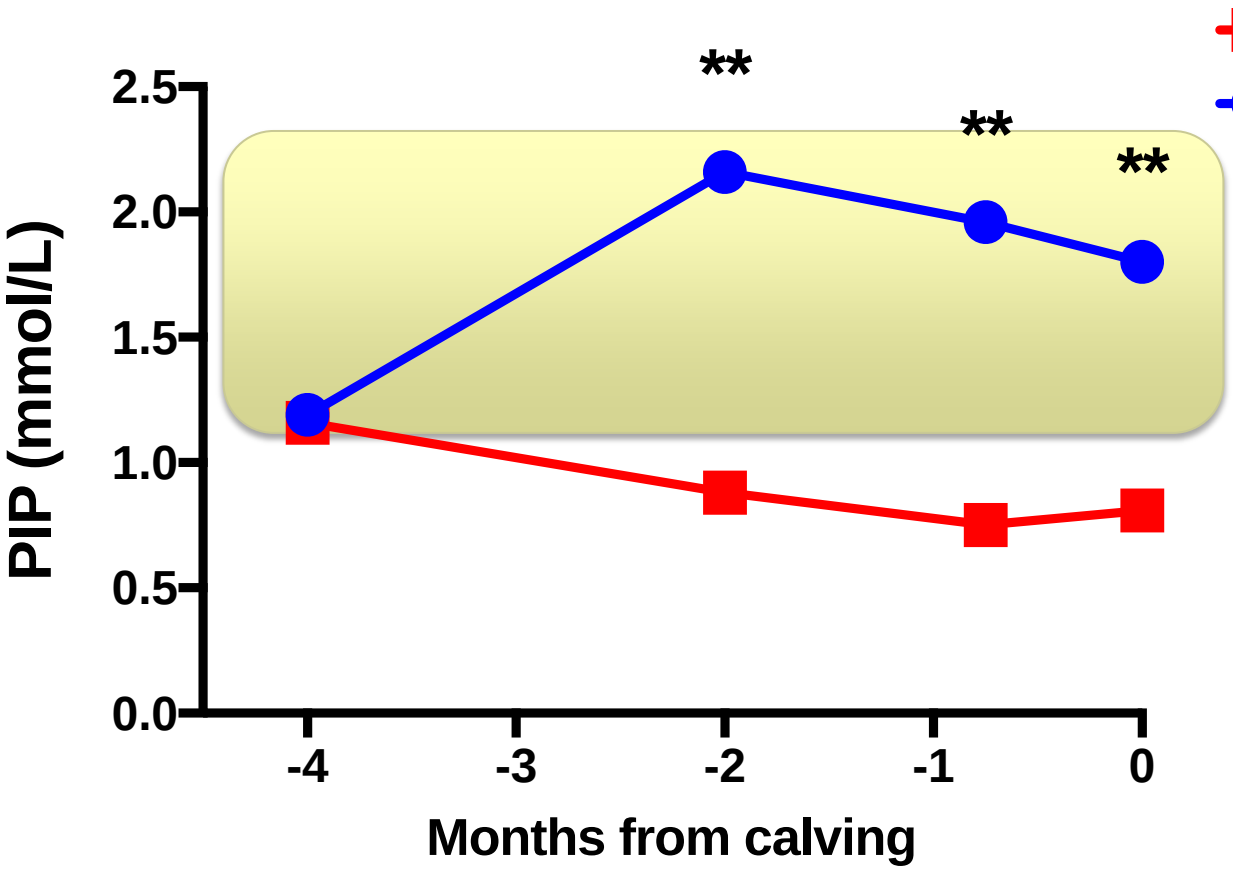
Three phases:

1. **Late pregnancy** : last 4 months
2. **Lactation** : 3 months
3. **Weaning & P repletion** : 6 weeks

Treatments **HH, HL, LH and LL,** cross-over at calving

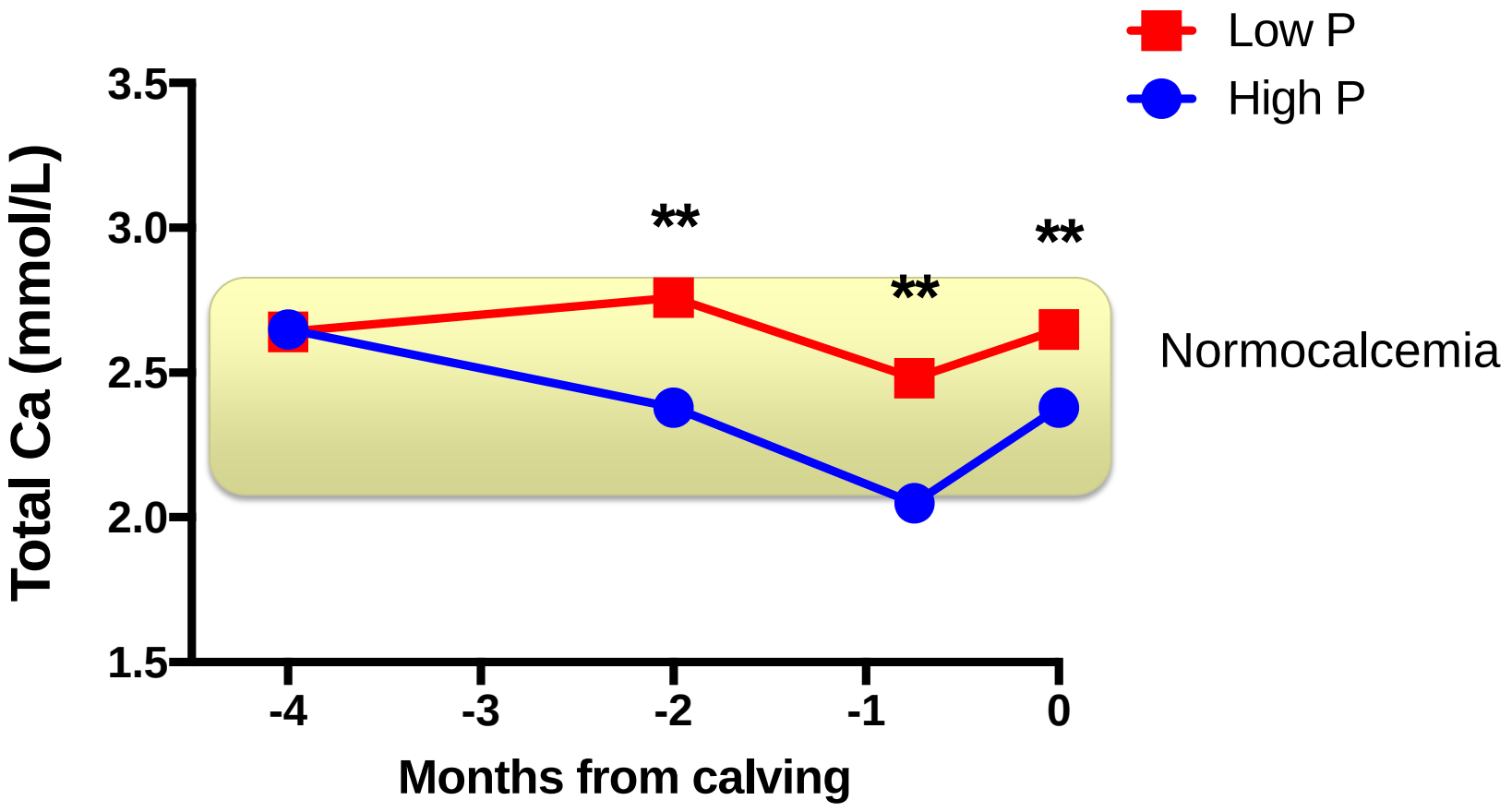
Measurements: LW, feed intake, faecal, milk,
blood samples and bone biopsies (rib & hip)

Results: Blood Phosphorus



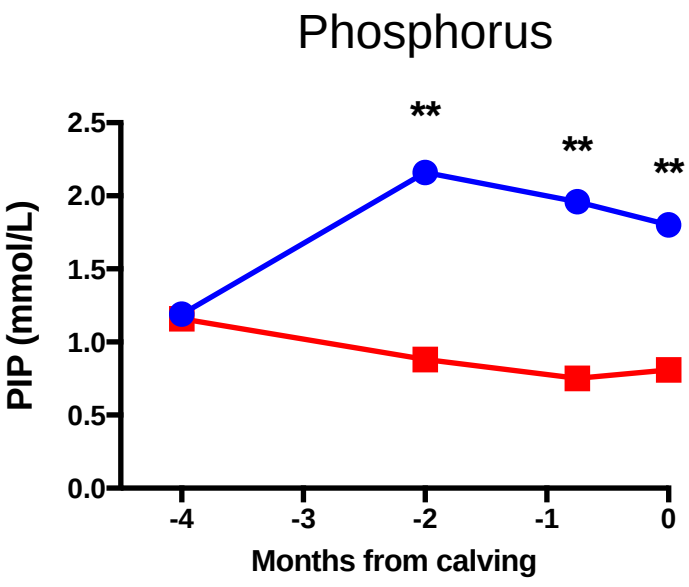
Cows placed on low P diet 2 weeks prior to start

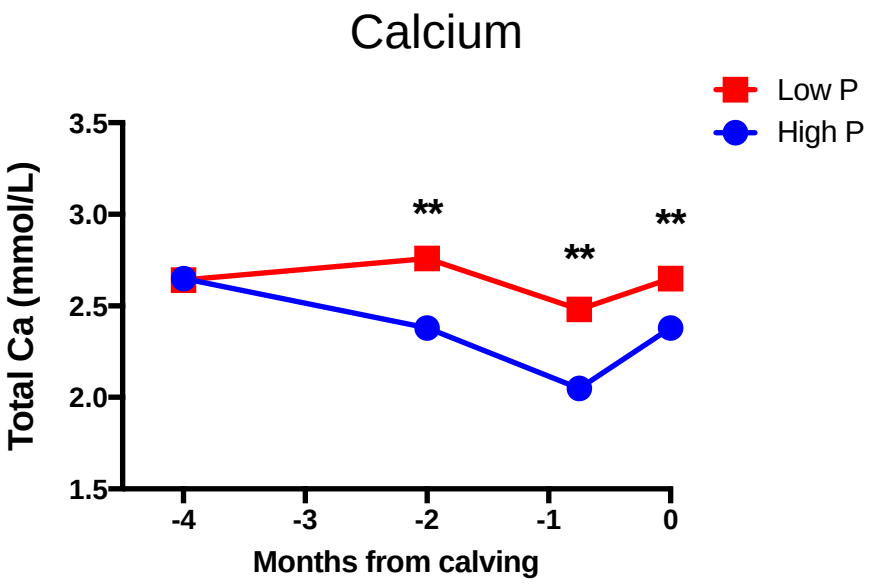
Results: Blood Calcium



Ca is increased in P deficiency

Phosphorus & Calcium





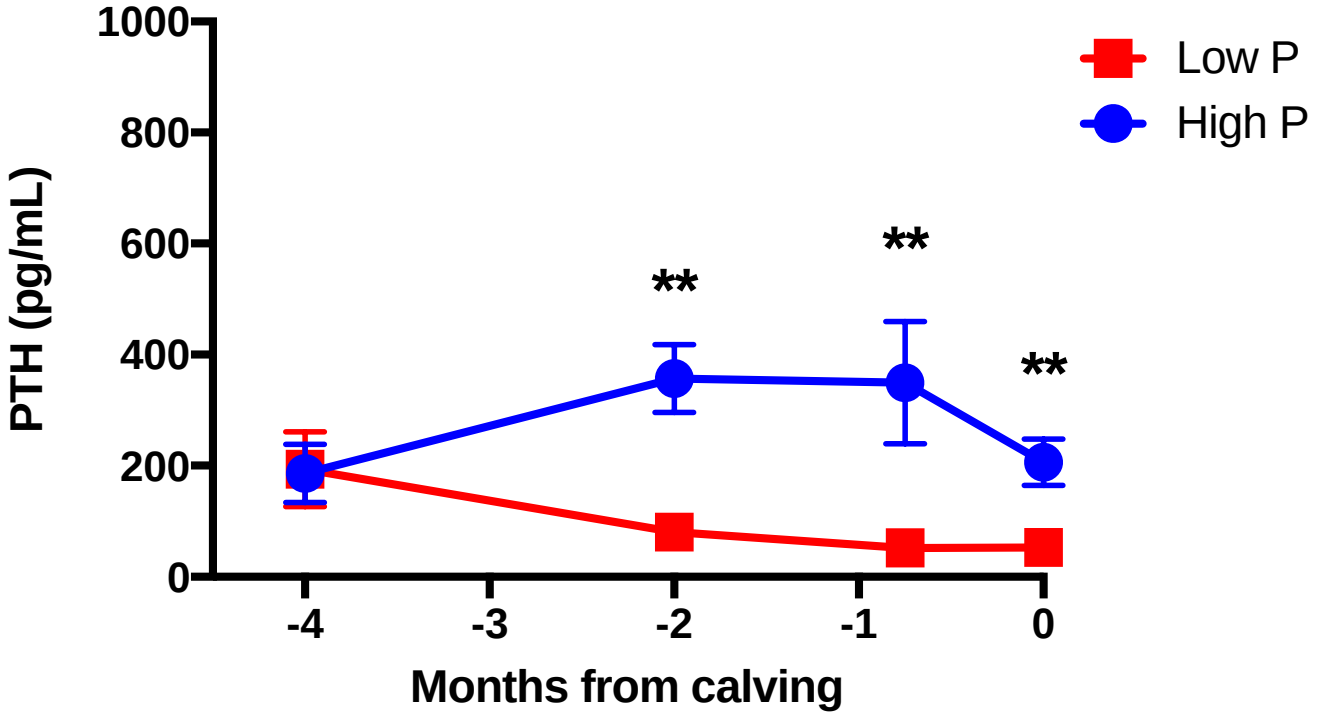
Inverse relationship between blood P and Ca (& Mg)

P deficiency towards hypercalcaemic

Adequate P diet towards hypocalcemic

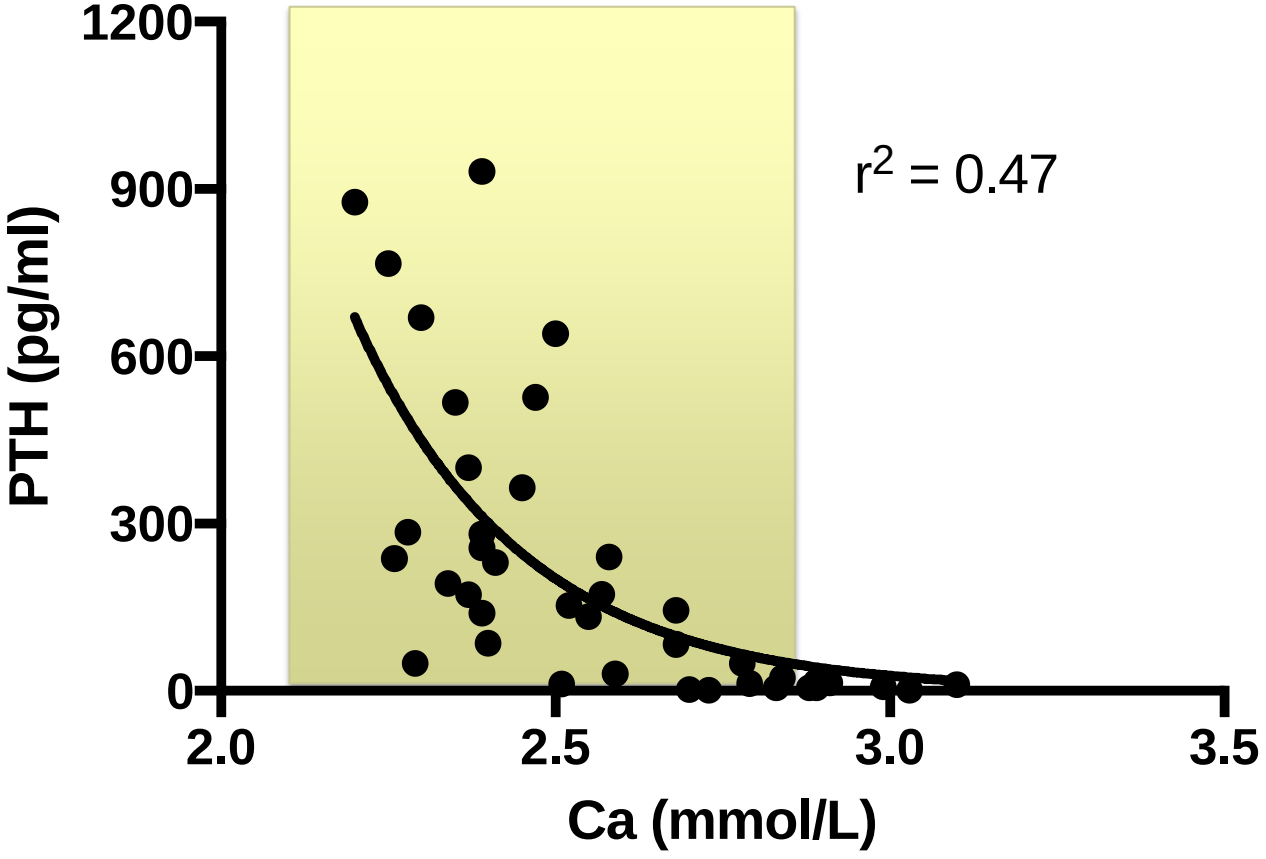
Likely due to more bone mobilisation in P deficiency

Results: Parathyroid Hormone



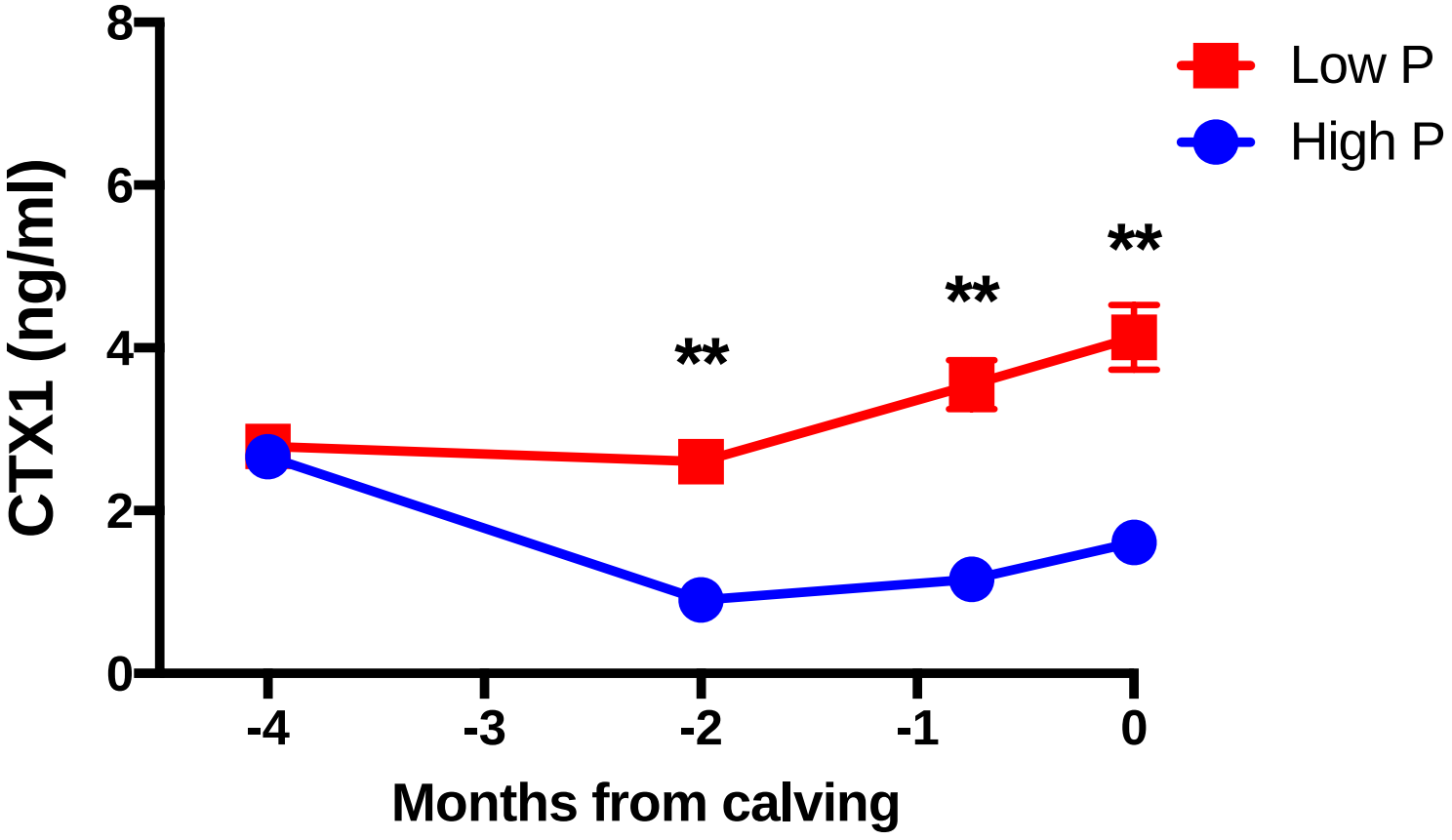
PTH is suppressed in P deficiency

Results: PTH versus Calcium



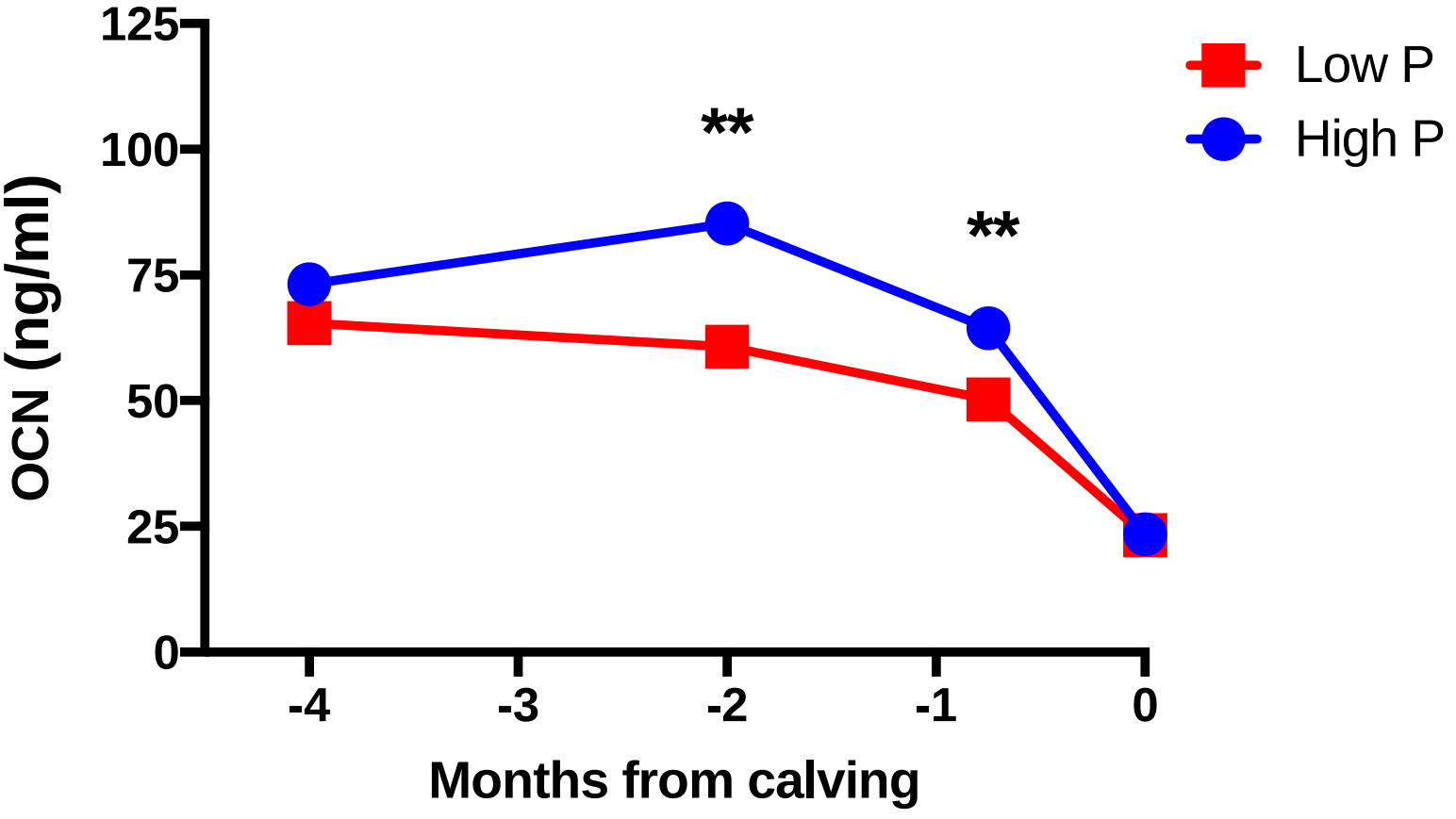
PTH levels correspond (in large part) to plasma Ca

Results: CTX-1 bone resorption



CTX-1 is increased in P deficiency
Increase in CTX-1 towards term

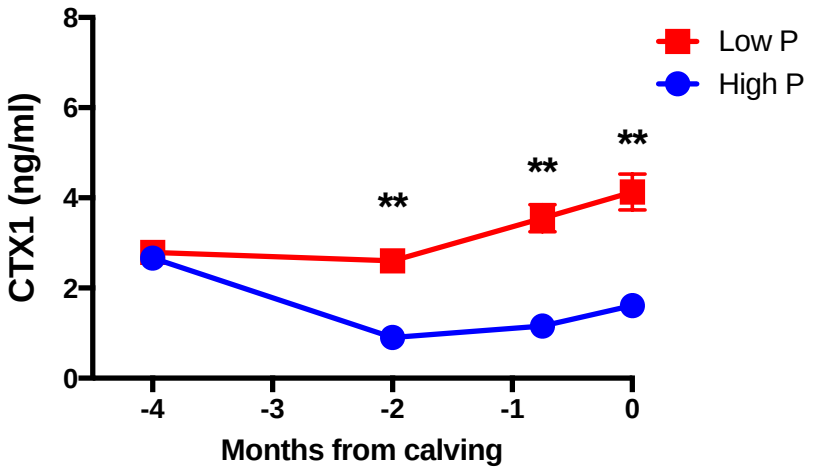
Results: Osteocalcin Bone deposition



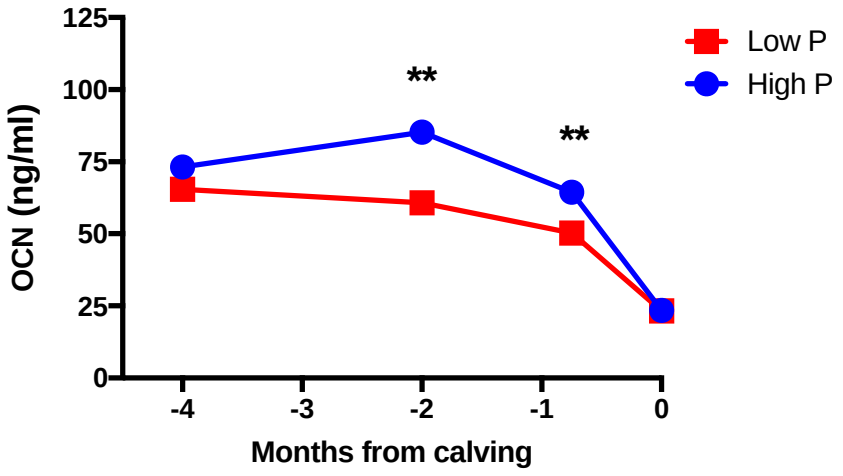
OCN is decreased in P deficiency
Marked decrease OCN at calving

Results: Bone turnover

CTX-1 (resorption)



Osteocalcin (deposition)

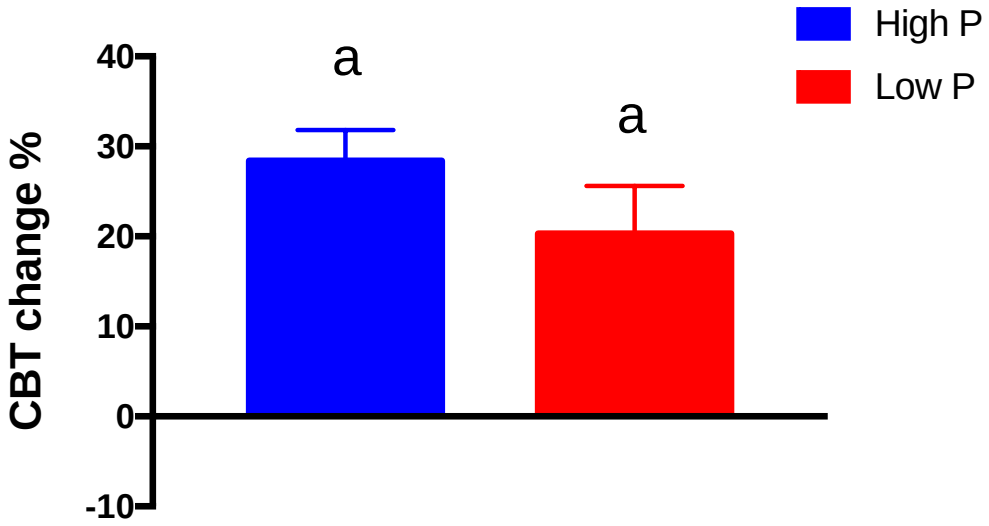


P deficiency characterised by increased bone turnover

Adequate diet P decreased bone turnover

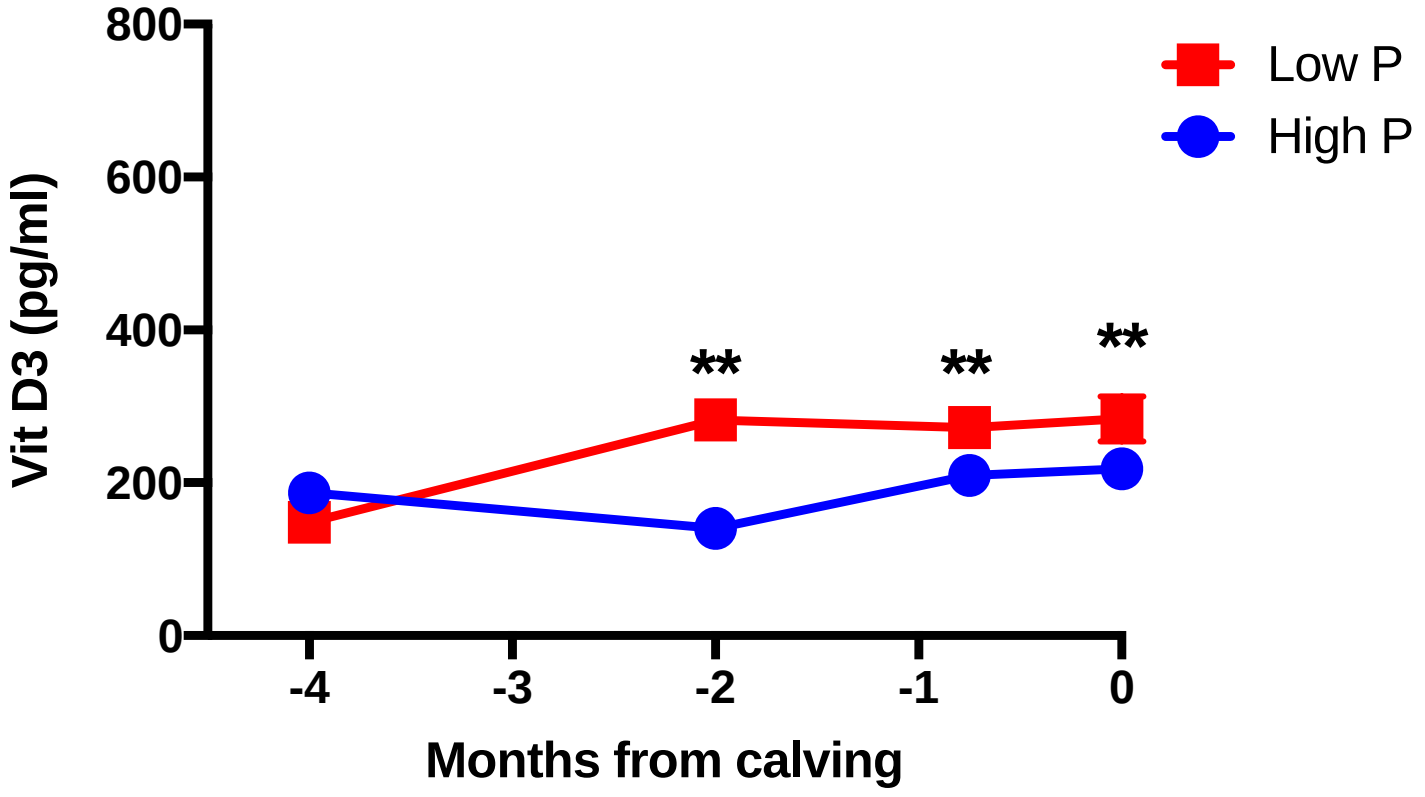
Cortical (rib) bone Thickness

Biopsy at start diets versus at calving



On both diets there was a substantial increase in rib cortical bone (growing)

Results: 1,25 Dihydroxy Vitamin D3



Vitamin D3 is increased by P deficiency

Also Vit D3 increased last weeks pregnancy in adequate (high) P diet

Results: production responses

	Change Maternal LW (kg)	Feed Intake (kg DM /day)	Calf Birth Weight (kg)
High P diet	+37	7.0	32.5
Low P Diet	-12	5.4	31.4
s.e.d	6.3	0.21	1.37
P value	<0.05	<0.05	n.s.

Summary: Late Pregnancy

P Deficiency

Hypophosphatemia
Normocalcemia, but significant increase

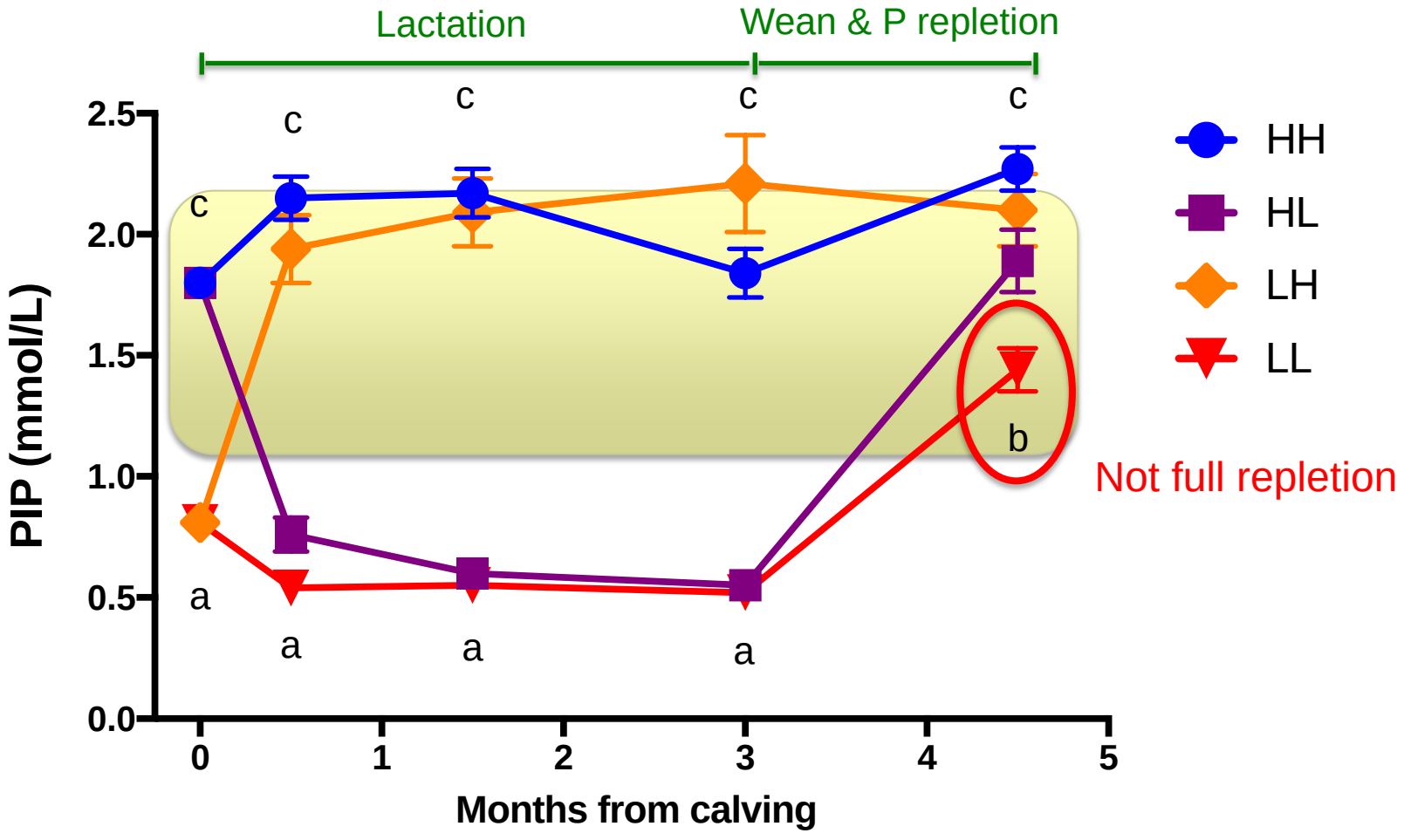
Increased CTX-1 (bone resorption)
Decreased Osteocalcin (bone deposition)

Suppressed PTH
Increased 1,25 diOH Vitamin D3

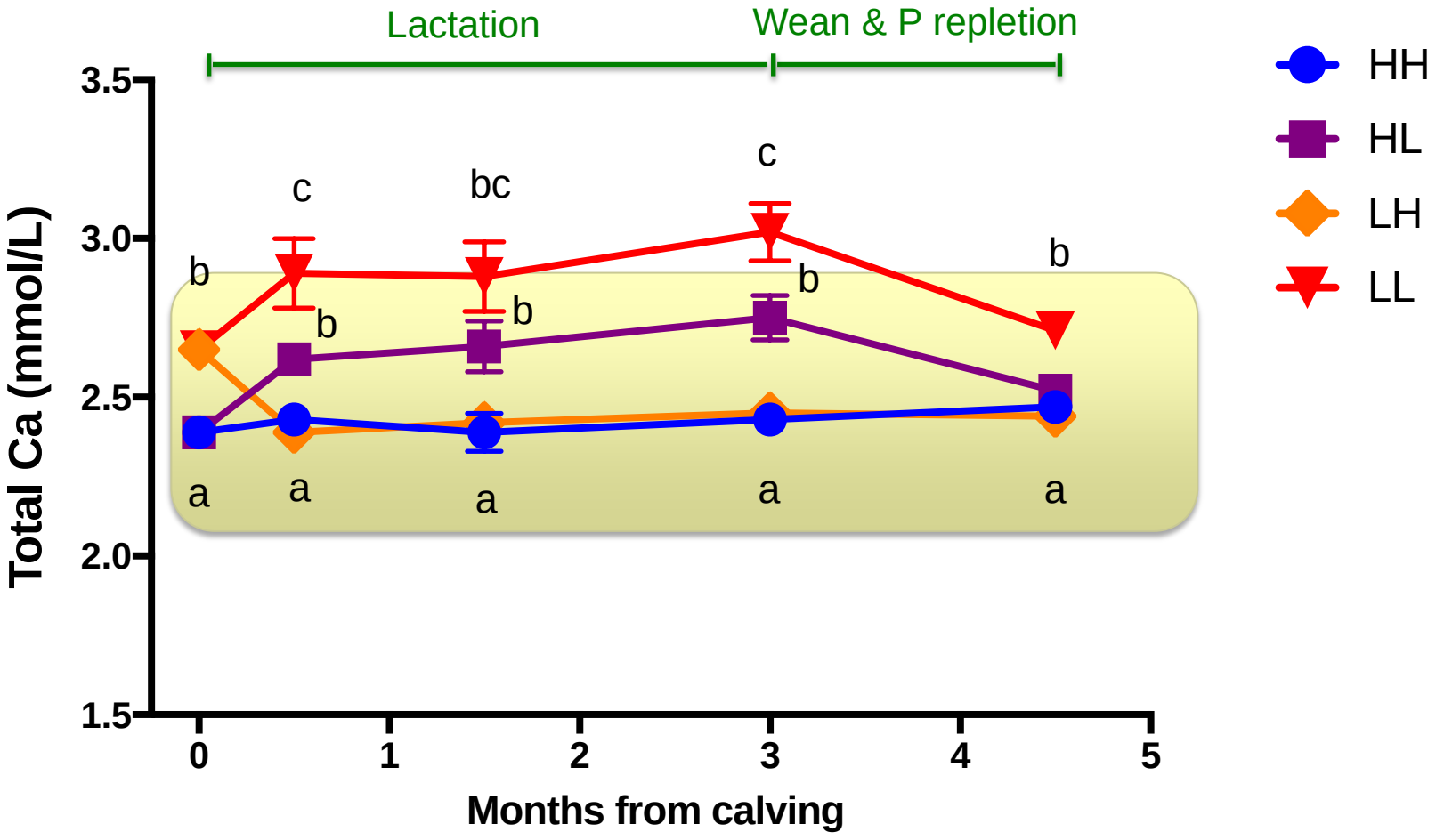
So to maintain P homeostasis pregnant heifers

1. mobilise bone
2. activate 1,25diOH Vitamin D3

Results: Phosphorus

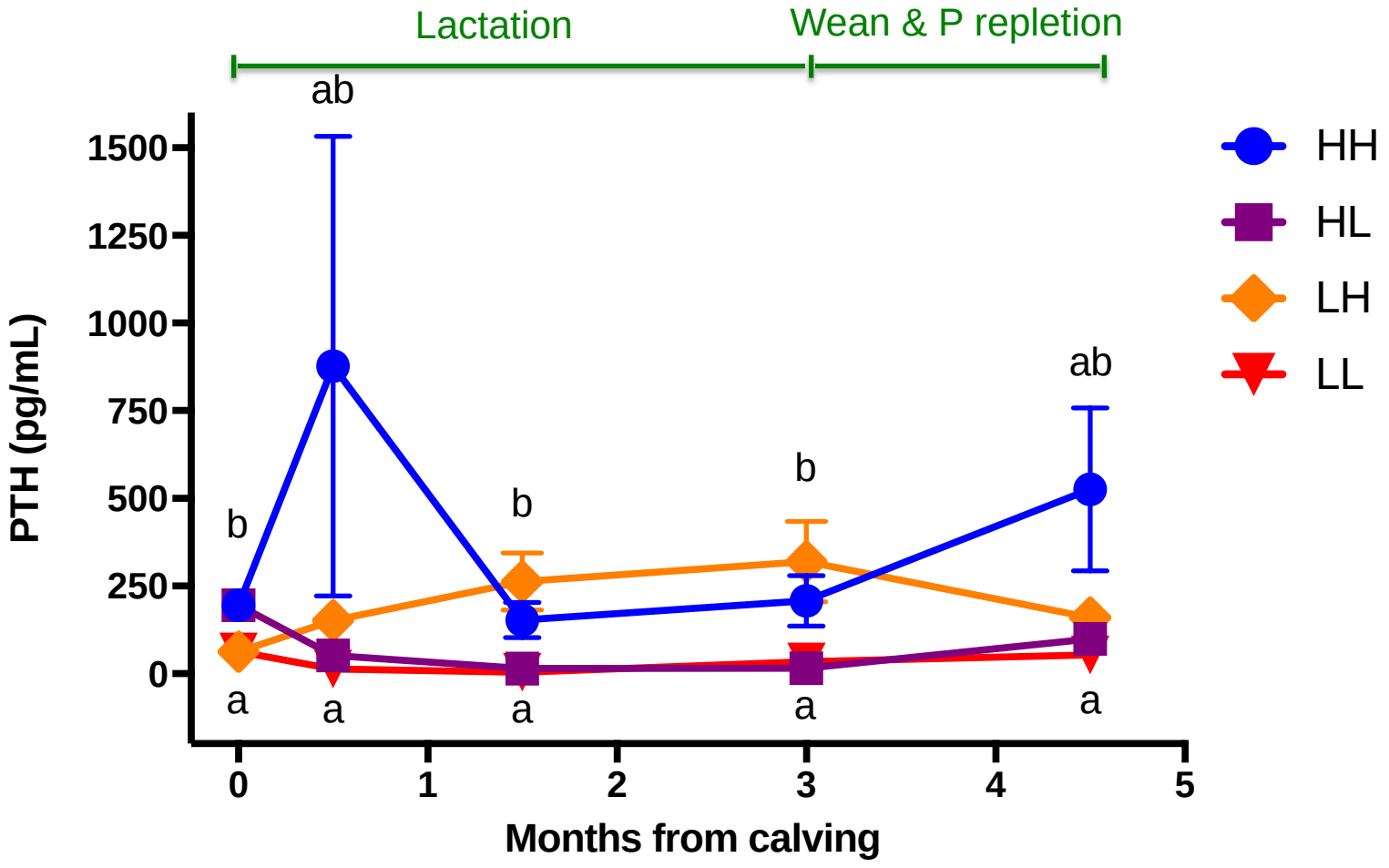


Results: Calcium



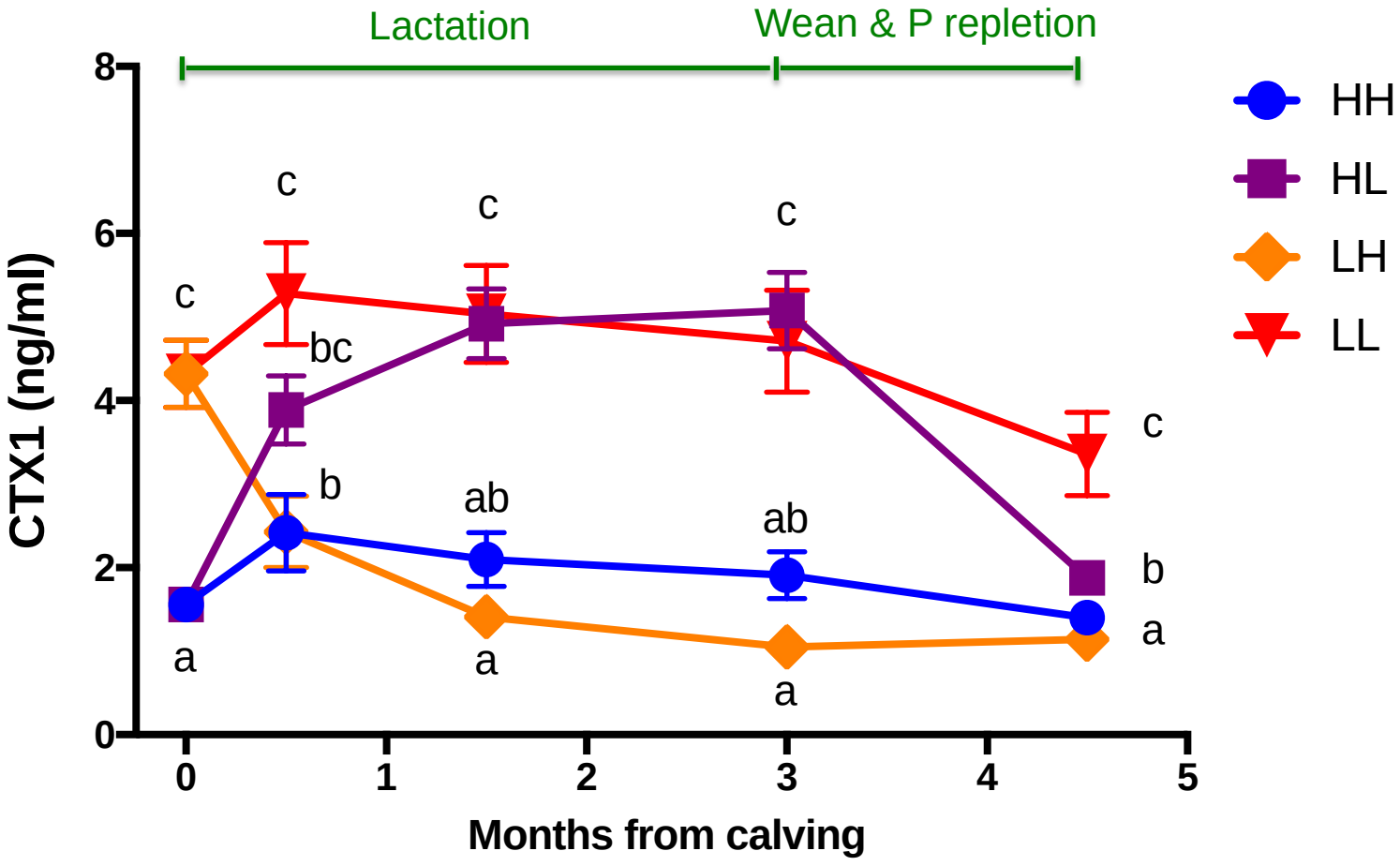
Ca is increased in P deficiency (LL and HL)

Results: Parathyroid Hormone



PTH is suppressed in P deficiency (LL and HL groups)

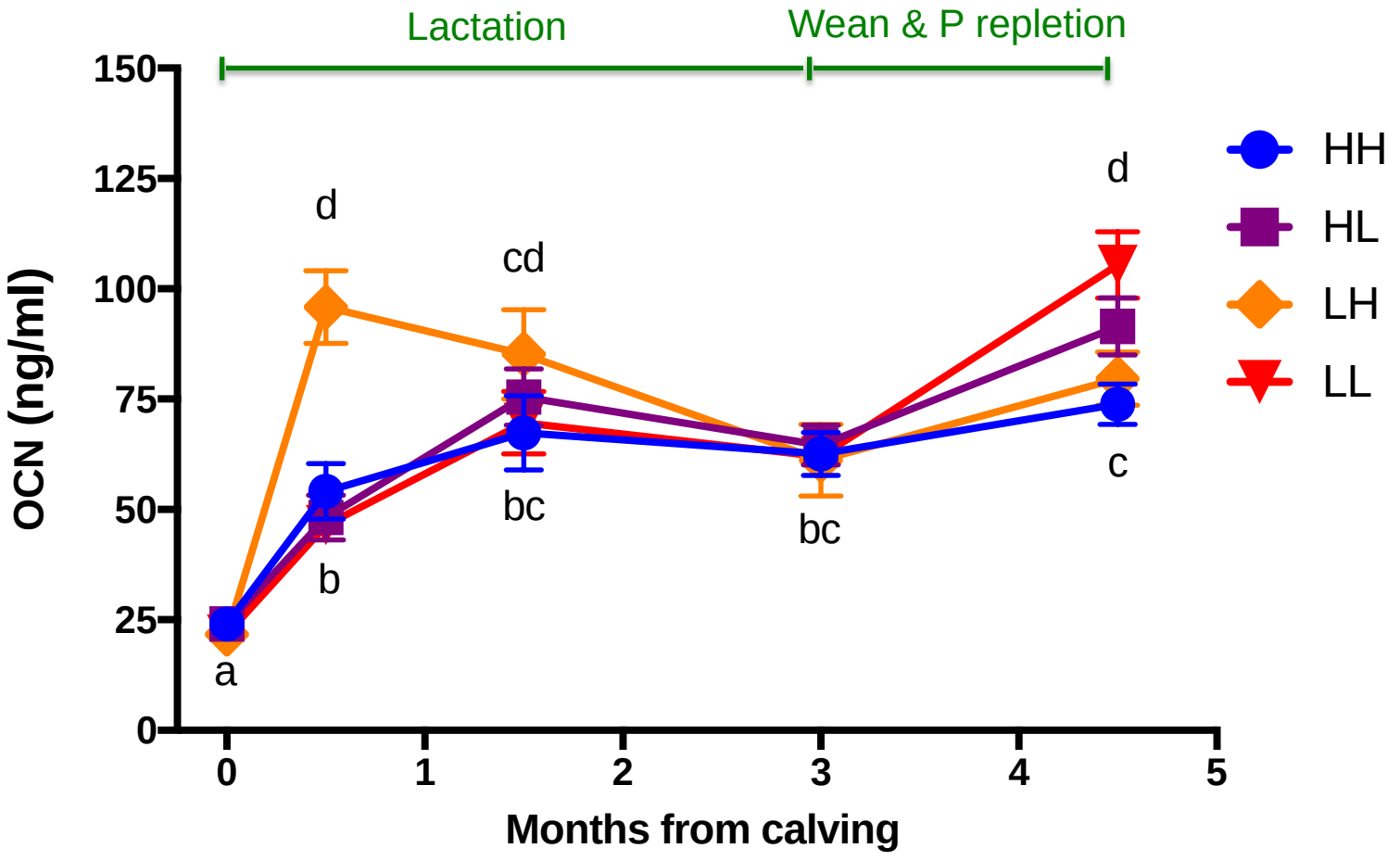
Results: CTX-1 Bone resorption



CTX-1 is increased in P deficiency

Major increase in CTX-1 early lactation

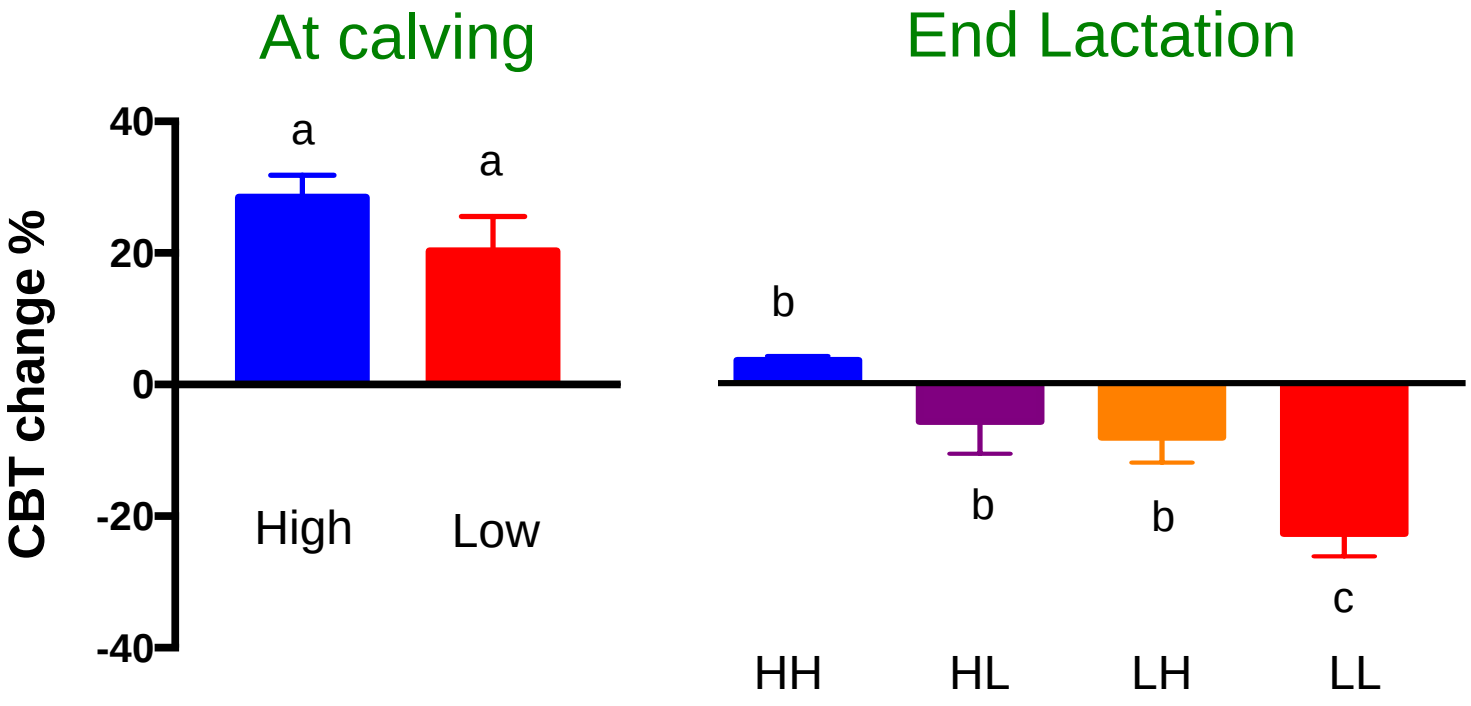
Results: Osteocalcin Bone deposition



OCN is increased in lactation

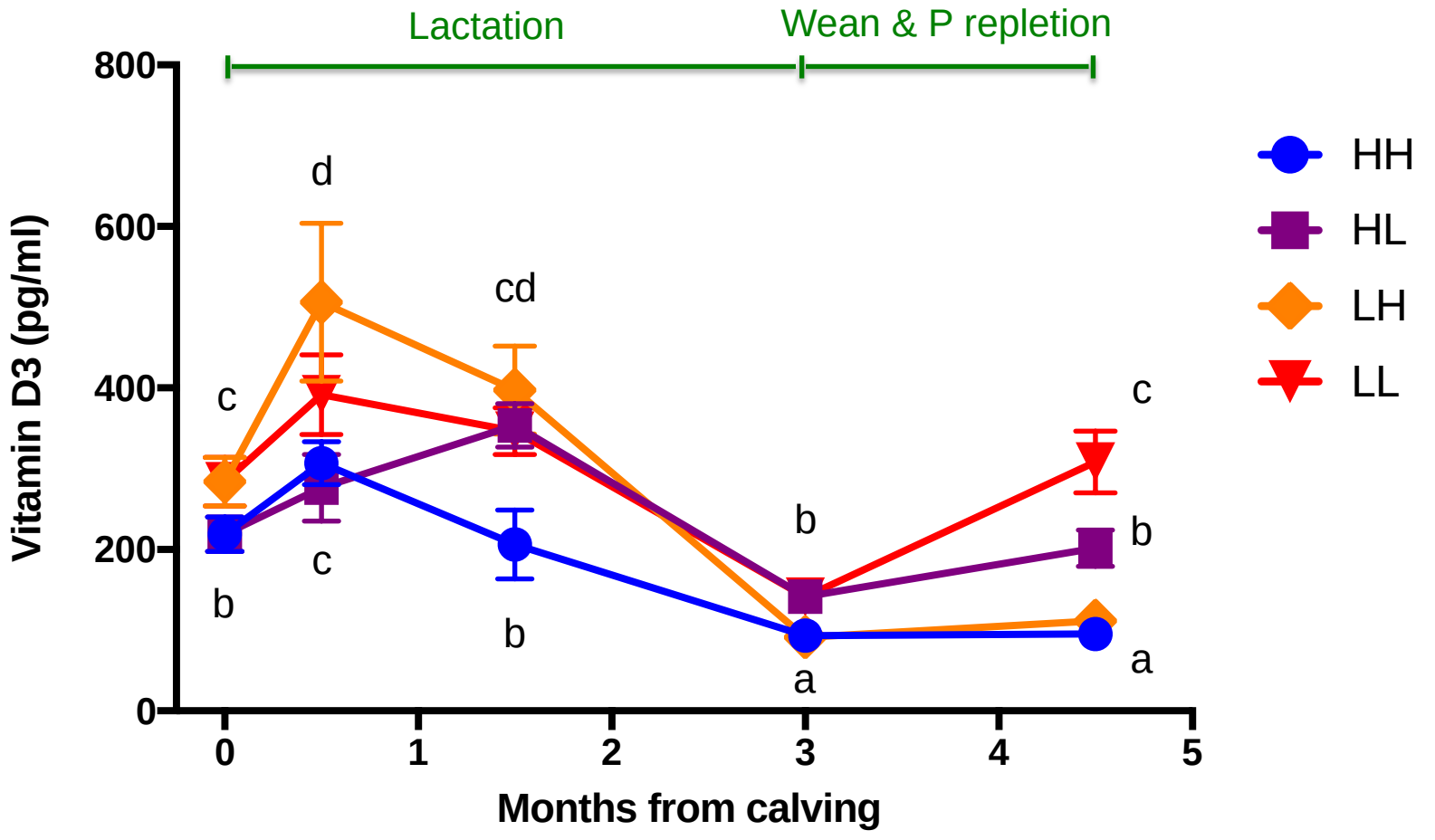
P supplementation (LH) marked increase

Results: Cortical Bone Thickness



During lactation all diets utilised cortical bone reserves, albeit LL major loss

Results: 1,25 Dihydroxy Vitamin D3



Vitamin D3 is increased early lactation
Low P diet increased Vit D

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Summary

P deficiency in lactation

Is similar to late pregnancy…..
Hypophosphatemia
Increased Calcium
Suppressed PTH

Except….
Substantial increase CTX-1
High maintained Osteocalcin (growing animal)
Further increase 1,25 diOH Vitamin D3

Conclusions

Cows ingesting severely P deficient diets attempt to achieve homeostasis through pronounced bone resorption, together with activation of 1,25diOH Vitamin D3.

Both processes appear to be independent of PTH.

In contrast, homeostasis with adequate dietary P intake appears to be regulated by PTH, in response to blood Ca.

Ongoing work is examining responses in mature cows.

Acknowledgements

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