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Effect of dietary cation-anion difference in dairy ewes at mid-lactation

(S35, Abstr. #6, p. 266)

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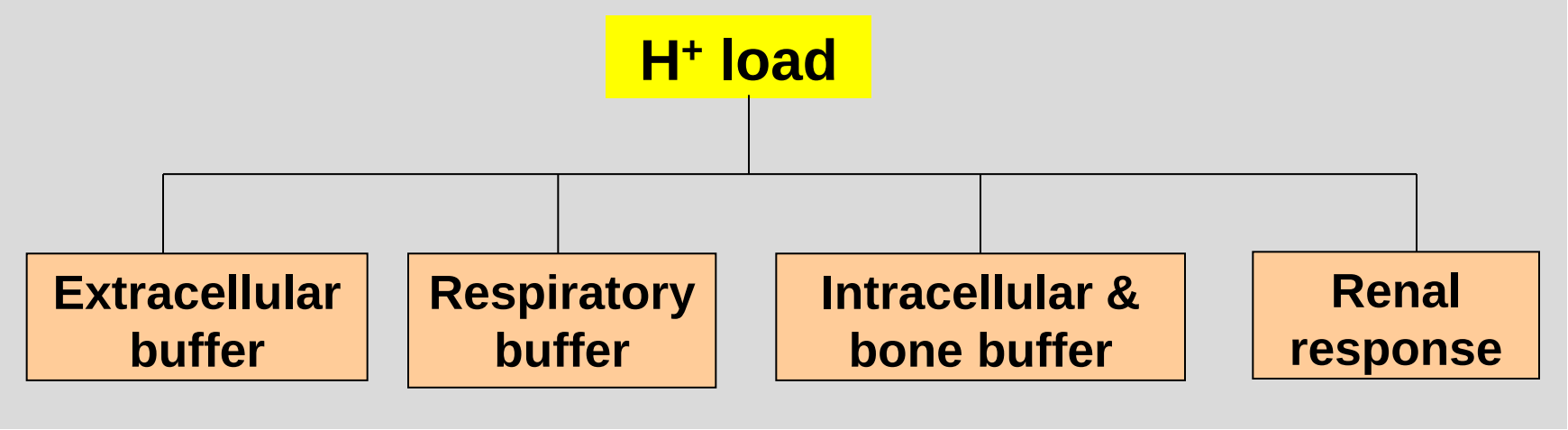
DCAD concept & interest:

- **Dietary Cation Anion Difference (DCAD, mEq per weight unit) is the difference between the ionic content in a feed or a ration:**

$$DCAD = [\Sigma Cat^+] - [\Sigma Ani^-]$$

- **Main aim for DCAD adjustment is variation of the acid-base balance in the body (H^+ load) and modifiying <u>blood Ca</u>.**



DCAD equations (mEq/100 g DM):

Basic equations for main ions:

$(Na^+ + K^+) - (Cl^- + S^{2-})$ = DCADs

$(Na^+ + K^+) - Cl^-$ DCADs ~ DCAD - 10

Extended and compensated equations:

$(Na^+ + K^+ + Ca^{2+} + Mg^{2+}) - Cl^-$

$(Na^+ + K^+ + Mg^{2+}) - Cl^-$

$(Na^+ + K^+ + 0.38Ca^{2+} + 0.30Mg^{2+}) - (Cl^- + 0.6S^{2-} + 0.5PO_4^{3-})$

$(Na^+ + K^+ + 0.15Ca^{2+} + 0.15Mg^{2+}) - (Cl^- + 0.2S^{2-} + 0.3PO_4^{3-})$

$(Na^+ + K^+ + NH_4^+) - (Cl^- + S^{2-})$

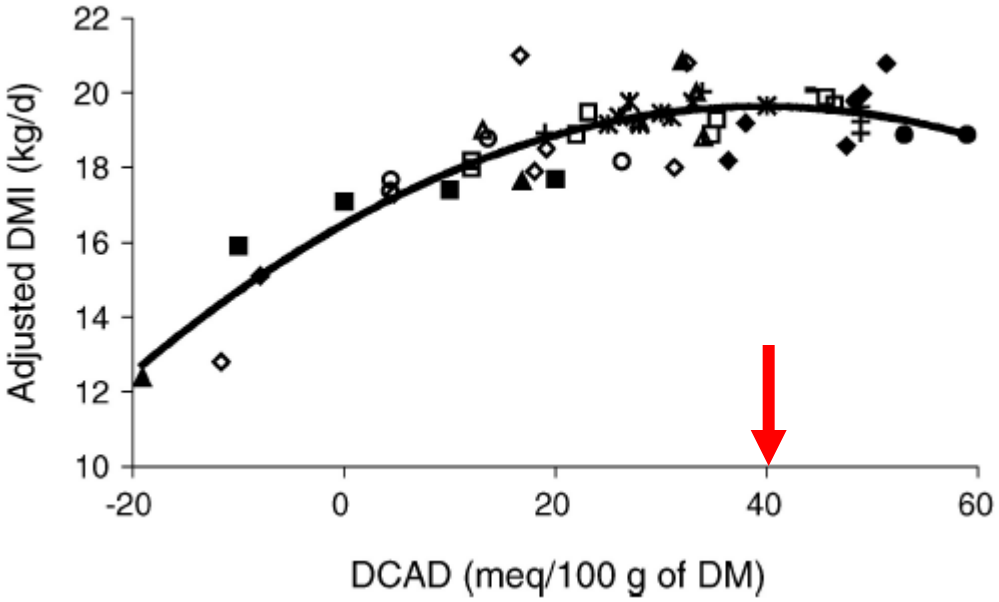
$(Na^+ + K^+ + 0.15Ca^{2+} + 0.15Mg^{2+}) - (Cl^- + 0.6S^{2-} + 0.5PO_4^{3-})$

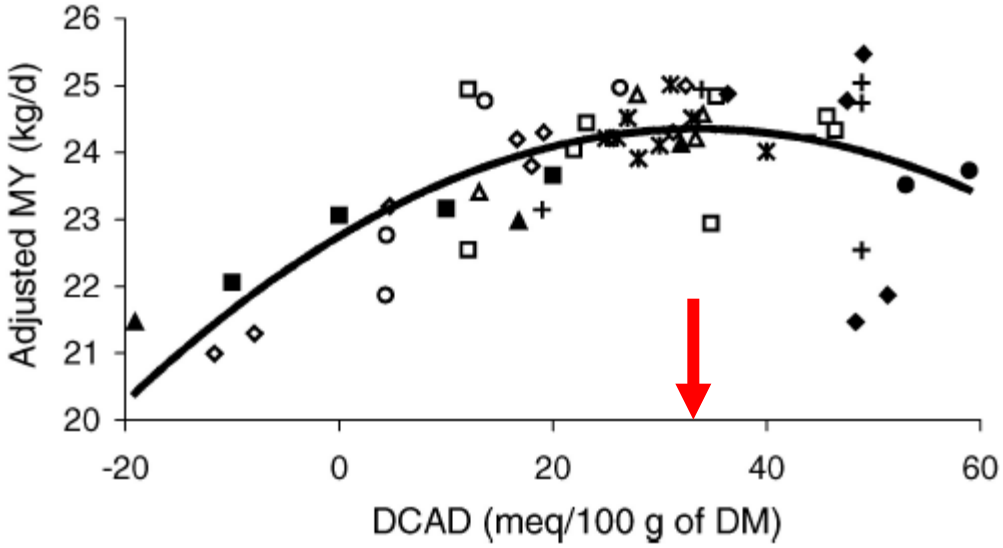
$(Na^+ + K^+) - (Cl^- + 0.6\ S^{2-})$

DCAD main effects:

- **Metabolic: Hu & Murphy (2004)**
  - **Regulation of Acid-Base balance (blood pH)**
  - **Prevention of hypo Ca at delivery**
  - **Prevention of metabolic acidosis**
  - **Alcalosis alleviation under heat stress (West et al., 1991)**
- **Productive: Hu & Murphy (2004), Meshy (2007)**
  - **Intake effects (negative?)**
  - **Milk yield effects**
  - **No effects on milk composition (normal conditions)**
- **Little information on small ruminants**
  - **Dairy goats (Meshy & Sauvant, 2002)**
  - **No information available on dairy sheep!**

DCAD effects in dairy cows: DMI & MY
(Hu and Murphy, 2004)





Meta-analysis:

$DCAD = (Na^+ + K^+) - Cl^-$

Quadratic effects on feed intake (DMI) and milk yield (MY):

- **Peak of DMI at:**
  +40 mEq/100 g of DM
- **Peak of MY at:**
  +34 mEq/100 g DM

Beede (2005), USDA (2007):

DCADs = +25 to +30 (+20 to +40)

Objectives:

To study the effects of varying the DCAD values of a TMR in the lactational performances of ewes of 2 dairy breeds (same frame) at mid-lactation:

- **Lacaune (high-yield, mid-composition)**
- **Manchega (mid-yield, high-composition)**

Materials and Methods: 1/4

- 40 ewes of 2 dairy breeds (Manchega, n = 20; Lacaune, n = 20) at mid lactation (84 ± 27 DIM).
- Allocated in 8 groups of 5 ewes, blocked by breed, BW and milk yield.
- Dietary treatments applied in pens for 15 wk (adaptation, 4 wk; cova, 1 wk; measure, 10 wk), consisted of a TMR with different DCADs:
  - AN-5 = 6.6 mEq/100 g DM
  - AN-25 = 26.3 mEq/100 g DM
  - CA-45 = 45.2 mEq/100 g DM
  - CA-65 = 64.1 mEq/100 g DM
- DCAD changed by adding NH_4Cl, $(NH_4)_2SO_4$ and $NaHCO_3$

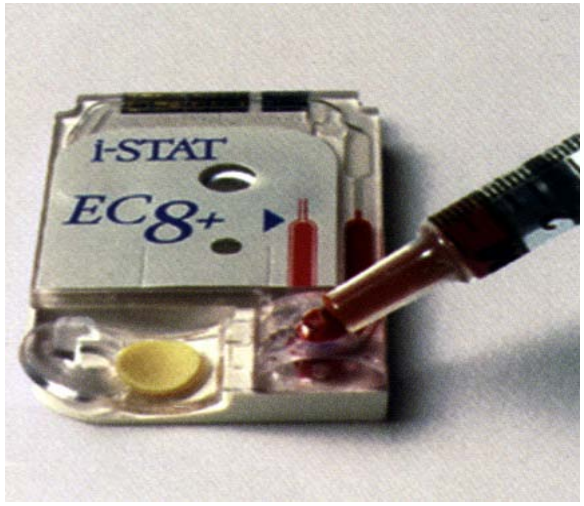
Materials and Methods: 2/4

- **TMR formulated according to INRA (2007) by INRAtion 3.3 (16% CP, 1.25 Mcal EN_L; DM basis) and offered ad libitum (115%).**
- **TMR dosed daily, sampled weekly and analyzed for DM, OM, CP (Dumas method with a Leco analyzer), NDF, ADF and ether extract.**
- **Ca, P, Na, K, S and Mg analyzed by ICPOE (inductively coupled plasma optical emission spectrometry) and Cl determined by the volumetric method (AOAC #915.01).**
- **PEG 6000 dosed orally (50 g/d) used as intake marker (15 d) and analyzed in rectal feces (5 d) by NIR (Caja et al., 2009).**
- **Milk sampled weekly and analyzed by NIR (TS, Fat, Protein and Cn).**

Materials and Methods: 3/4

- **Blood samples collected at morning feeding at wk 4 (3 ewes per pen), 8 and 10 (all ewes).**
- **Immediately analyzed after collection by i-Stat analyzer (Abbott, IL):**

  pH, pCO_2, TCO_2, HCO_3^- , BaseExcess, Na^+, K^+, Cl^-, urea, glucose, AnionGap, PCV (hematocrite) and Hb.
- **Urine pH after voluntary micturation (within 3 d after blood sampling) by a portable pH-meter.**



Materials and Methods: 4/4

Statistical analyses:

- **PROC MIXED SAS (v. 8.2) for repeated measurements .**
- **General model:**
  - **1) Fixed factors**
    - **Breed (Manchega or Lacaune)**
    - **Treatment (AN-5, AN-25, CA-45, CA-65)**
    - **Lactation number (primi- or multi-parous)**
    - **Stage of lactation (wk)**
  - **2) Random factors**
    - **Animal within group (1 to 5)**
    - **1st order interactions**
    - **Error**
- **Covariated by wk 0 performances (ß) for DMI, BW, BCS, MY and milk components.**

Results: 1/9

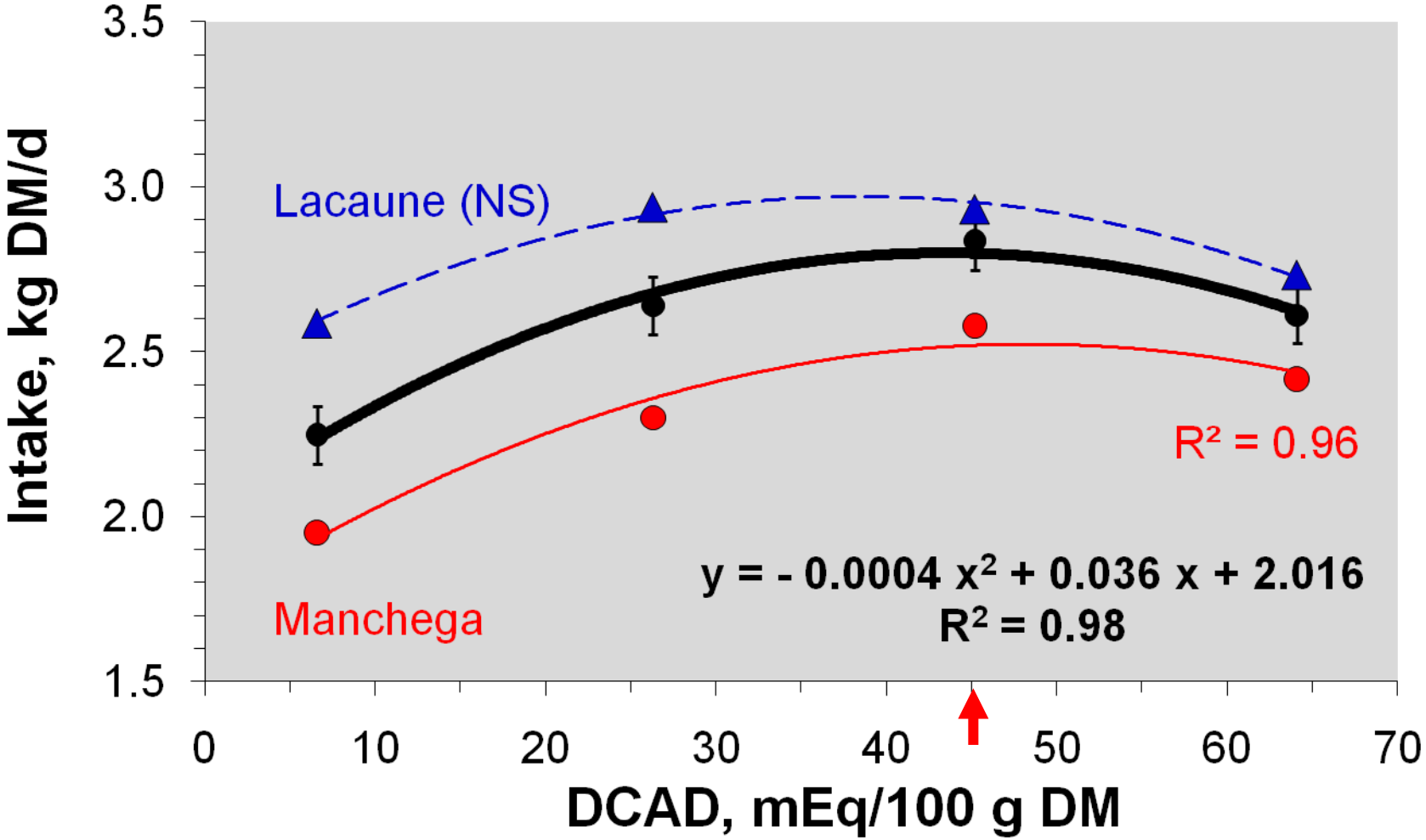
Effect of DCAD (mEq/100 g DM) on intake (DMI) of dairy ewes according to breed (values are LSM)

Item	AN-5	AN-25	CA-45	CA-65	SEM	*P* =
DMI, kg/d						
Manchega	1.95^{a}	2.30^{ab}	2.58^{b}	2.42^{b}	0.15	0.049
Lacaune	2.59	2.94	2.93	2.73	0.14	0.226
Overall	2.25^{a}	2.64^{b}	2.84^{b}	2.61^{b}	0.09	0.012
DMI/BW$^{0.75}$, g/kg						
Manchega	73^{a}	93^{b}	106^{b}	95^{b}	7	0.031
Lacaune	102^{a}	123^{b}	119^{b}	105^{ab}	5	0.042
Overall	86^{a}	108^{b}	116^{c}	101^{b}	4	0.001
BW, kg						
Manchega	76.8	78.8	79.1	80.7	1.2	0.133
Lacaune	74.3	77.6	78.9	77.4	1.4	0.130
Overall	76.2	78.4	78.8	78.8	1.1	0.161

Values are LSM; Within the same row: $^{a, b, c}$ $P < 0.05$

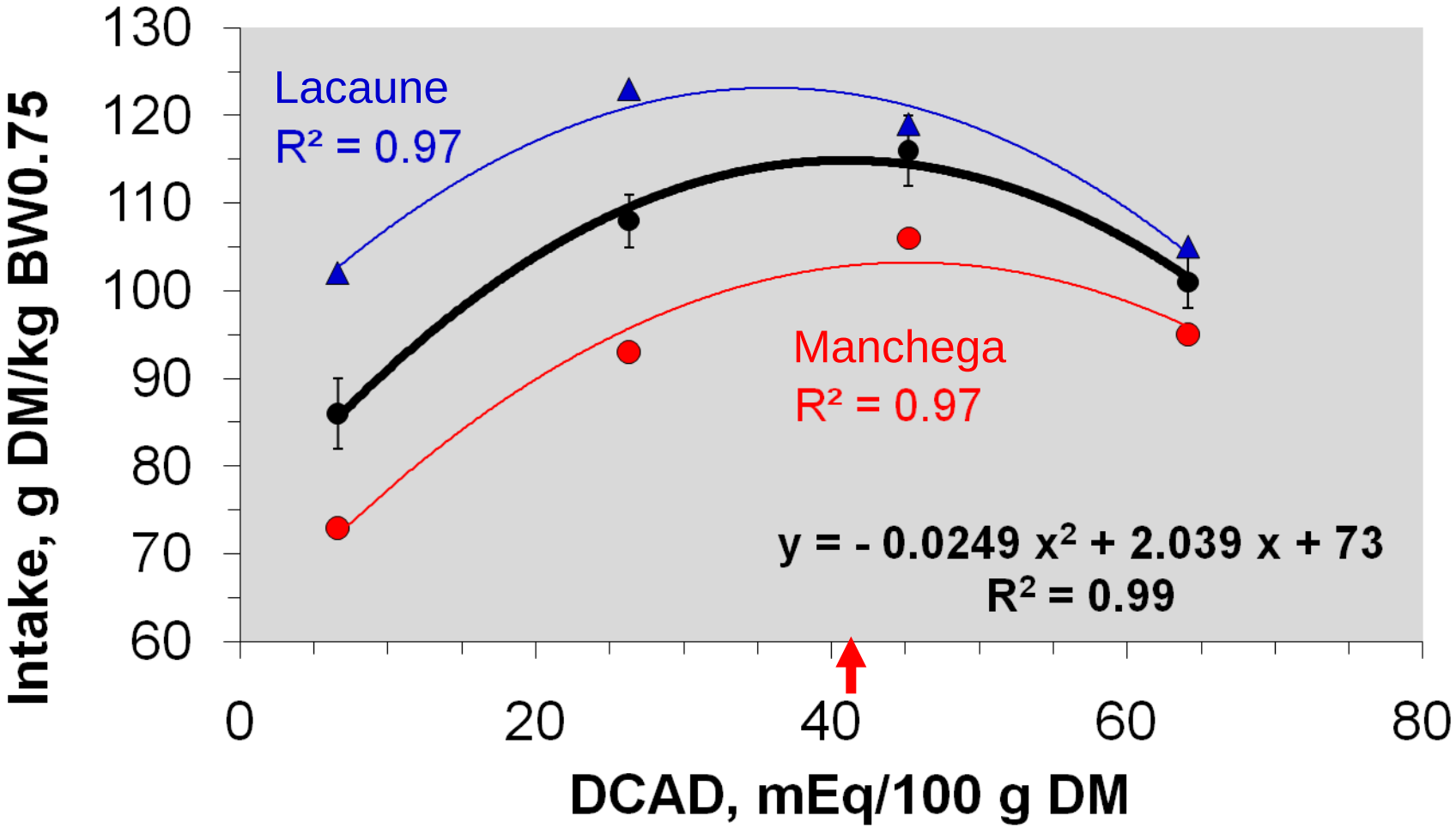
Results: 2/9

Effect of DCAD on feed intake of dairy ewes at mid-lactation according to breed



Results: 3/9

Effect of DCAD on feed intake per $BW^{0.75}$ of dairy ewes at mid-lactation according to breed



Results: 4/9

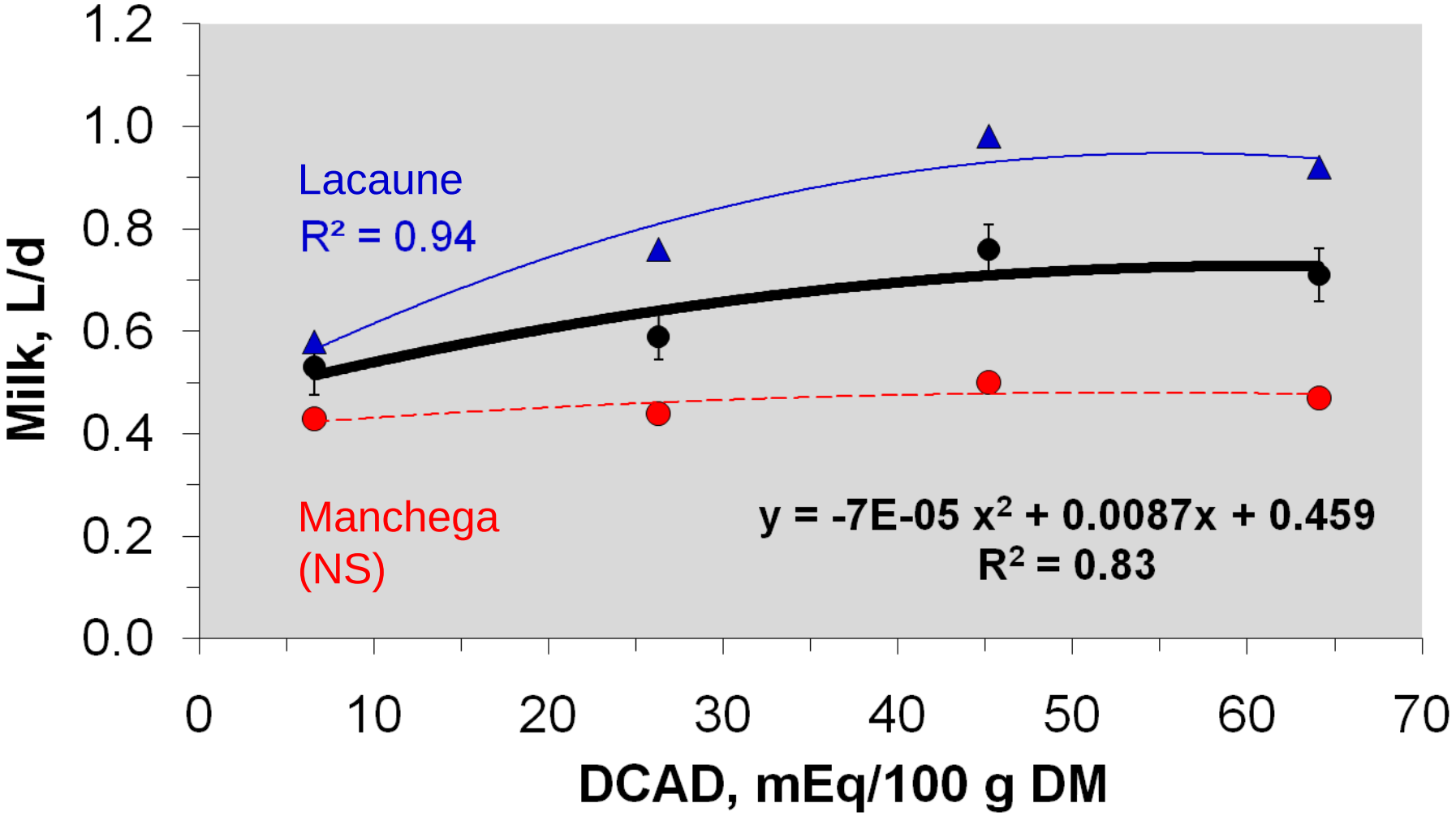
Effect of DCAD on milk yield and energy corrected milk (ECM) of dairy ewes at mid-lactation

Item	AN-5	AN-25	CA-45	CA-65	SEM	*P* =
Milk, L/d						
Manchega	0.43	0.44	0.50	0.47	0.09	0.944
Lacaune	0.58^{a}	0.76^{ac}	0.98^{b}	0.92^{bc}	0.09	0.023
Overall	0.53^{a}	0.60^{a}	0.76^{b}	0.71^{b}	0.05	0.008
ECM, L/d						
Manchega	0.48	0.52	0.61	0.54	0.09	0.660
Lacaune	0.68^{x}	0.74^{x}	0.98^{y}	0.89^{xy}	0.08	0.082
Overall	0.59^{a}	0.64^{ab}	0.81^{b}	0.73^{b}	0.06	0.040

Values are LSM; Within the same row: $^{a, b, c}$ $P < 0.05$; $^{x, y}$ $P < 0.10$

Results: 5/9

Effect of DCAD on milk yield of dairy ewes at mid lactation according to breed



Results: 6/9

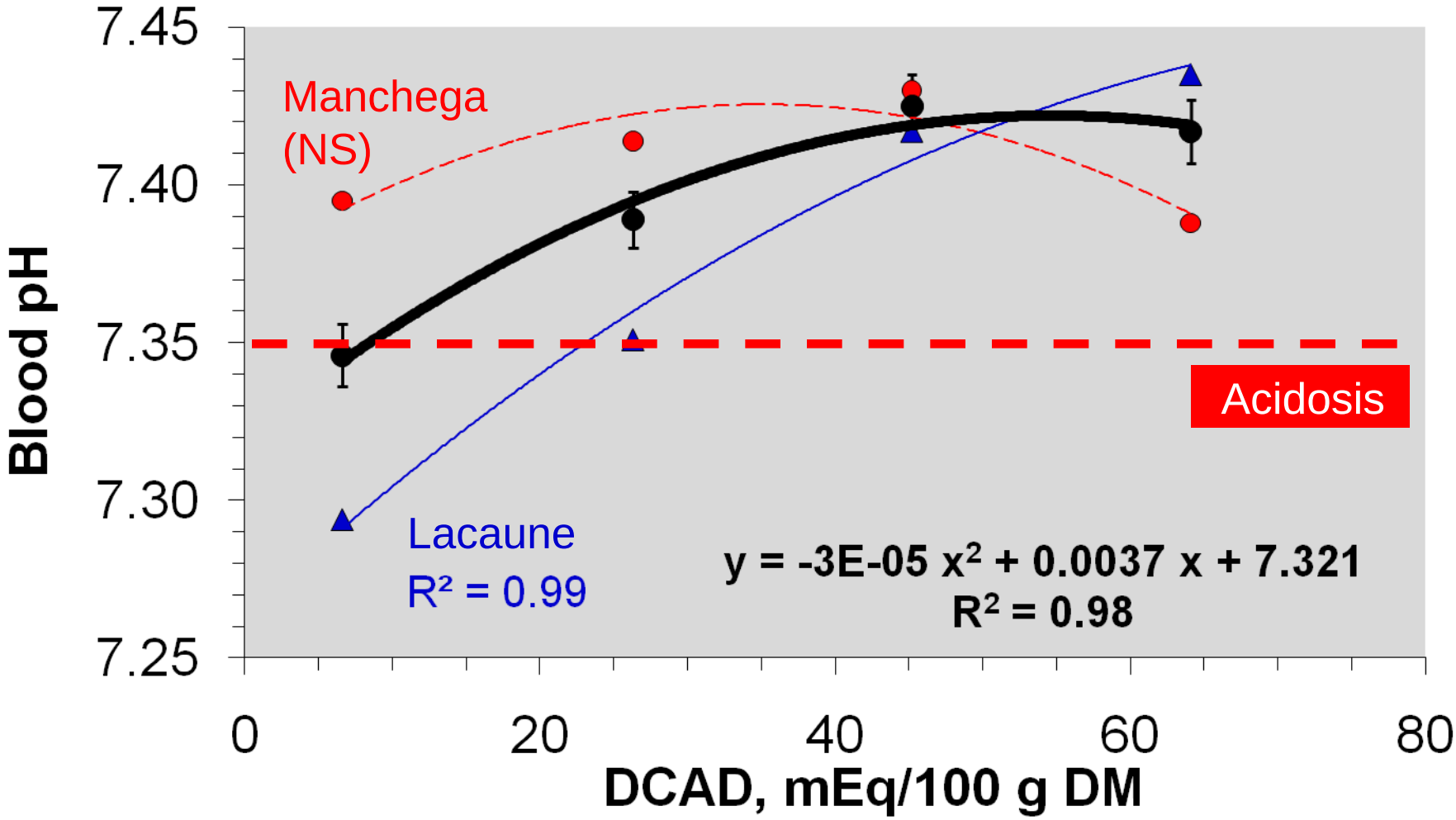
Effect of DCAD on milk composition of dairy ewes at mid-lactation according to breed

Item	AN-5	AN-25	CA-45	CA-65	SEM	*P* =
TS, %						
Manchega	20.6[a]	20.7[a]	20.9[a]	19.5[b]	0.3	0.008
Lacaune	18.1	18.1	17.4	18.1	0.6	0.640
Overall	19.6	19.5	19.2	18.9	0.5	0.355
Milk Fat, %						
Manchega	9.2[a]	9.0[a]	9.1[a]	7.9[b]	0.3	0.011
Lacaune	7.3	7.4	6.9	7.3	0.3	0.565
Overall	8.4	8.3	8.1	7.7	0.2	0.221
Milk Protein, %						
Manchega	6.9	7.1	6.7	6.9	0.2	0.832
Lacaune	6.2	6.0	5.6	6.0	0.2	0.115
Overall	6.5	6.6	6.3	6.5	0.1	0.475

Values are LSM; Within the same row: [a, b, c] $P < 0.05$

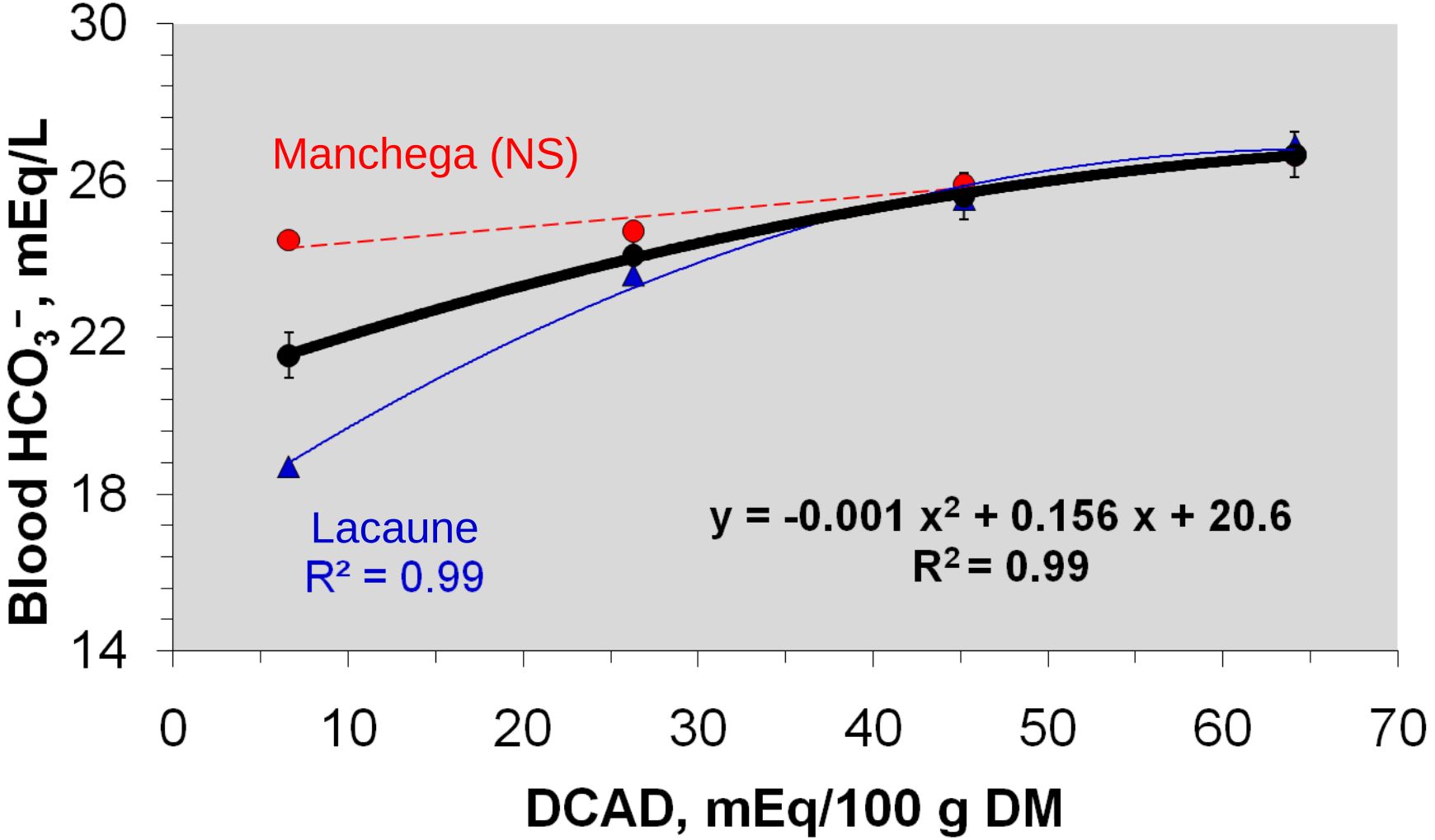
Results: 7/9

Effect of DCAD on blood pH of dairy ewes at mid lactation according to breed.



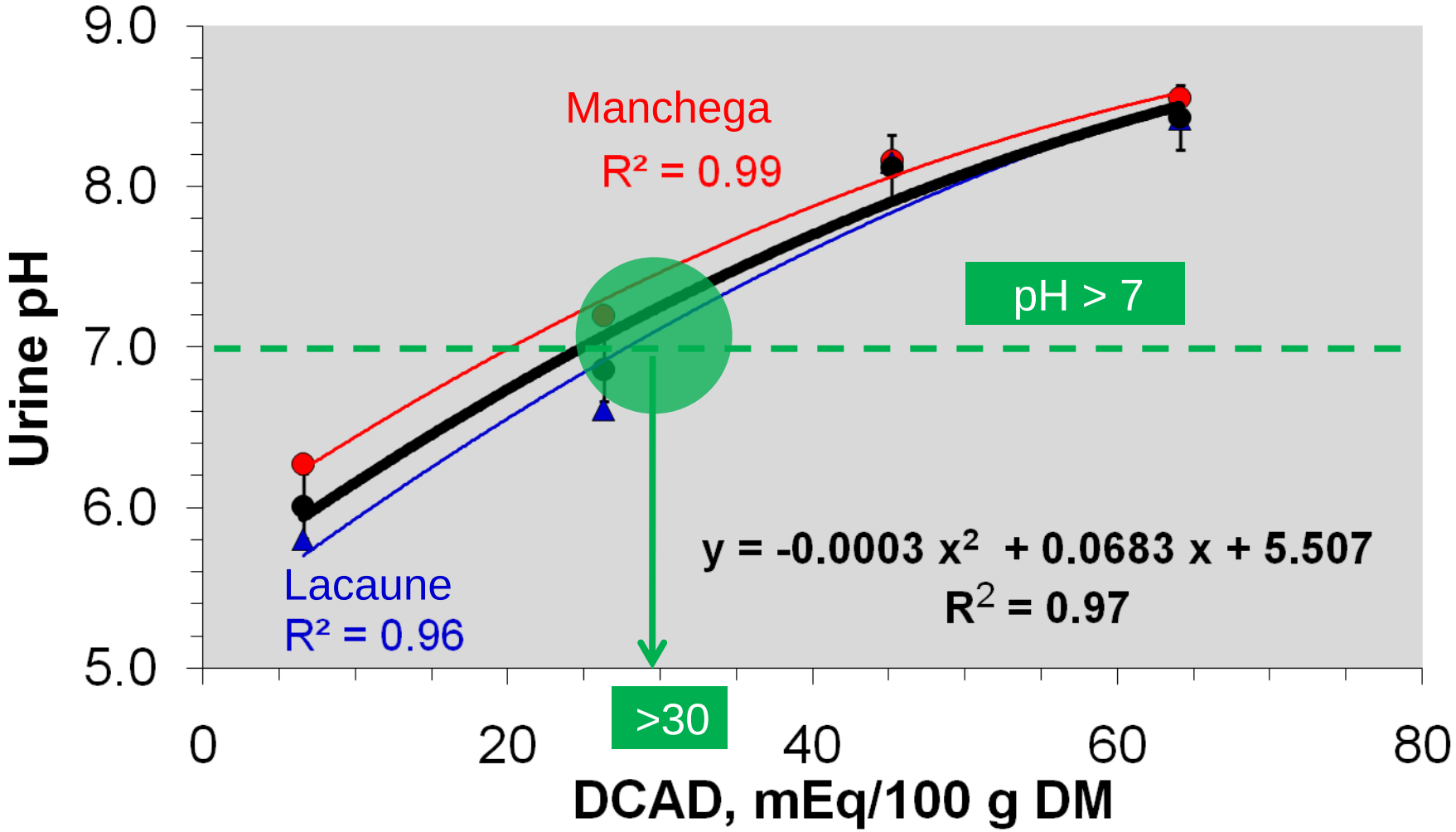
Results: 8/9

Effect of DCAD on blood HCO_3^- of dairy ewes at mid lactation according to breed



Results: 9/9

Effect of DCAD on urinary pH of dairy ewes at mid lactation according to breed.



Conclusions:

- DCAD showed effects on DMI and DMI/kg $BW^{0.75}$ but response was more marked in the high yielding dairy ewes.
- Milk yield and ECM were (or tended to be) affected by DCAD, although the response was not significant in low yielding dairy ewes.
- Milk composition did not vary by DCAD.
- Dramatic differences were observed in most Acid-Base Balance indicators, such as: blood pH, blood HCO_3^-, Base Excess and Anion Gap, according to DCAD and breed.
- Fixed anions Na^+ and Cl^- contents in blood also increased when using anionic salts in dairy ewes.

Implications:

- **High yielding dairy ewes are more sensitive to DCAD, because of their greater DMI and water intake.**
- **Diets containing DCADs values (including S) in the range of +35 to +45 mEq/100 g DM are recommended for lactating dairy ewes.**
- **Dairy sheep DCADs should be greater than for dairy cows (+20 to +40 mEq/100 g DM).**
- **Highly anionic (< 20 mEq/100 g DM) and highly cationic (> 50 mEq/100 g DM) diets should be avoided for dairy sheep feeding in practice.**

Thanks for your attention…

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