Responses of sheep and goat under different physiological status to water restriction and salinity in the drylands

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Outline

1. Outlook and setting the scene
2. Water requirements & adaptation mechanisms
3. Responses to water restriction
4. Responses to water salinity
5. Concluding remarks

Outlook & setting the scene

- Drylands cover more than 40 % of the world's land area
- Home to 2.5 billion people— 1/3 of global population
- Of these, 1/3 depend on dryland agricultural for food security & livelihoods
- Widespread: poverty, food insecurity, frequent drought & land degradation and desertification (CC will only increase these problems)
- Characterized by water scarcity. The dry areas have < 8% of the world's renewable water resources
- Livestock are facing different stressors at the same time: water restriction, increasing temperature, and feed shortage

Outlook & setting the scene

Meet the food-feed demand when faced with:

- Food-feed-fuel competition
- Decrease in arable land for crop production
- Increase in population
- Water shortage & salinity
- Animal and Human health risks
- Economic instability & high cost of fossil fuel
- Frequent climate extremes
- Climate change

Outlook & setting the scene

"No/timid" focus on water although "most important nutrient"

- Livestock scientists/Nutritionists spend a lot of time discussing feed intake and digestion and the fate/impacts of common nutrients (energy. protein. minerals. etc.) with No/weak consideration of water and its consideration while interpreting performance results (productive & reproductive)
- Feeds/nutrients use efficiency would be high if adequate supply of acceptable quality water is achieved
- Water delivery systems (meet needs of the animal for clean and safe water)
- In the context of water scarcity and salinization/CC. develop strategies to produce more with less inputs including water (Water footprint/productivity for livestock)

Water requirements

Main factors

- Animal species
- Age – related to body size
- Physiological status of the animal
- Animal health
- Environmental conditions (Temp. & Humidity, …)
- Activity rhythms
- Distance between feed and water source
- Type and amount of feed (green or dry)
- Water quality

Water requirements

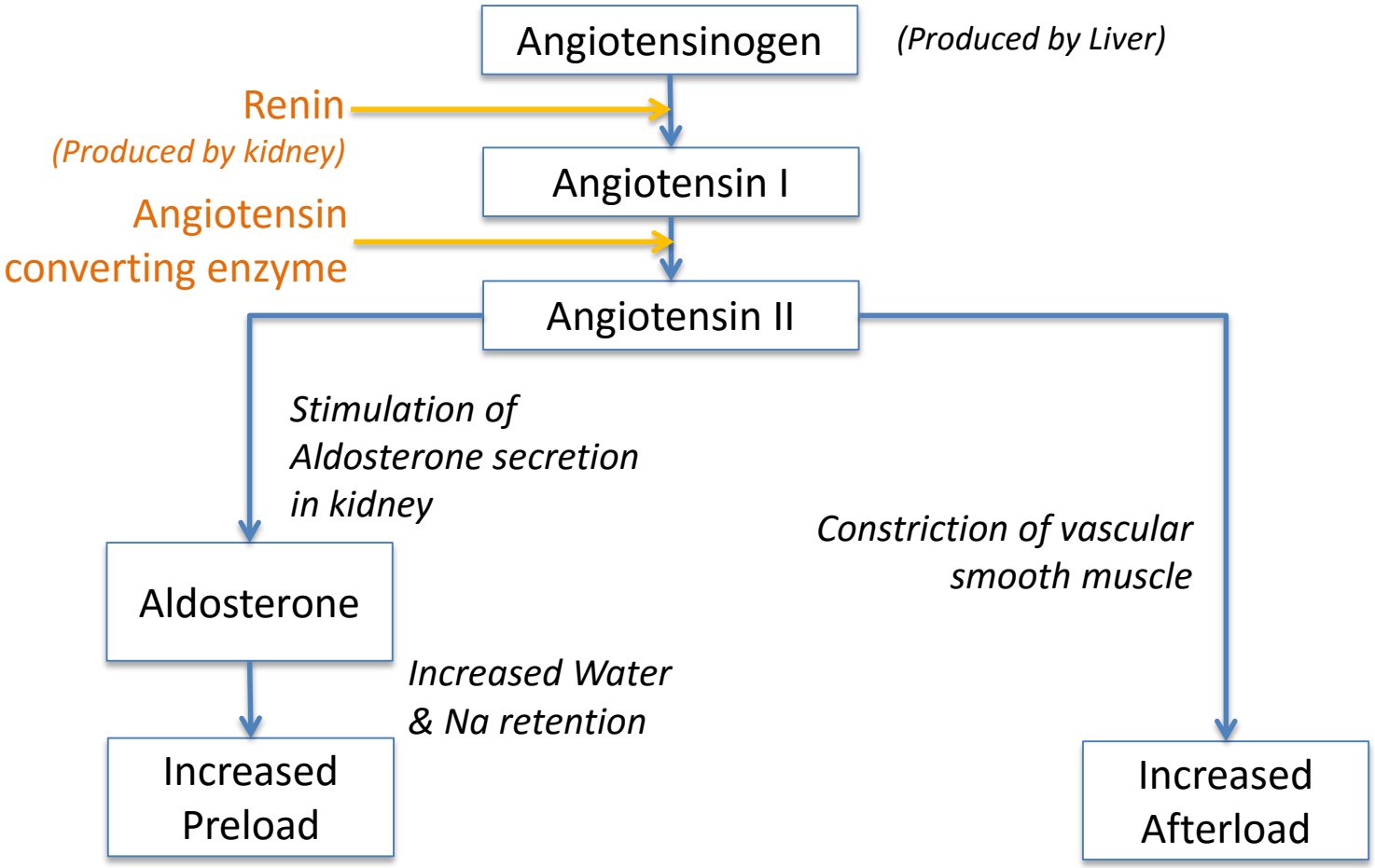
Estimates of Sheep & Goat water requirements

Physiological state	Feed source	Water drunk (l/day)
Pregnant ewes/goat		
Lactating ewes/goat	Dry feed	9 - 11.5
Mature sheep/goat	Dry pasture	7 - 8.5
Fattening lambs/kids	Dry pasture	2.2-3.0

Sources: ANZECC (2000) and Noble Foundation (2015)

Adaptation mechanisms

Renin–angiotensin system (RAS)



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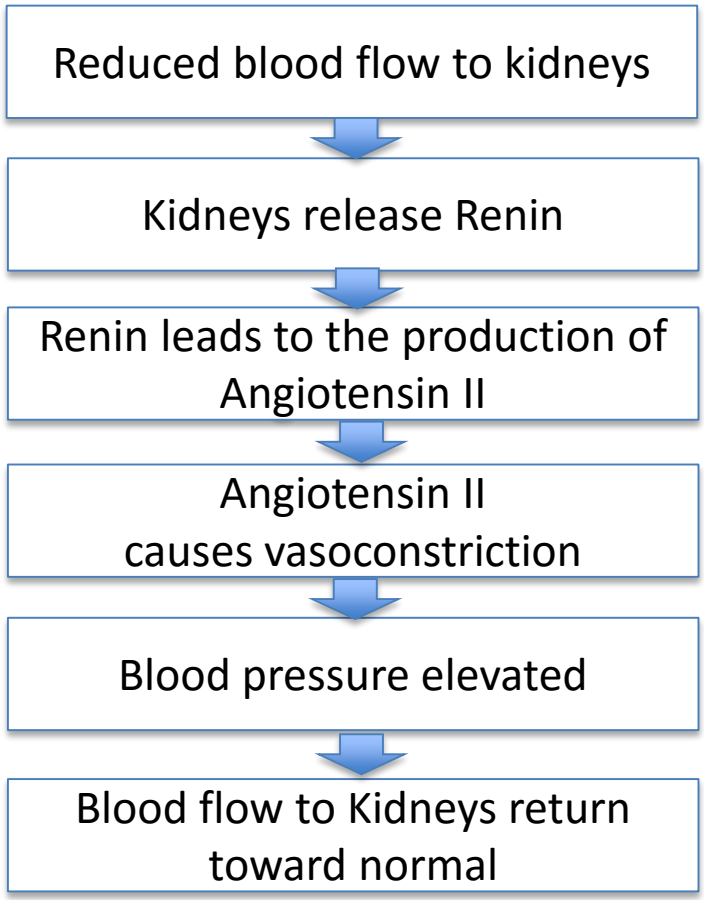
Adaptation mechanisms

Overall mechanism



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How animals cope with dehydration?

Behavioral and physiological adaptations

- The capacity of the kidney to concentrate urine and its ability to reduce water loss during dehydration is directly related with the relative kidney medullary thickness (RTM). The greater the RTM, the greater the ability of the kidney to reabsorb water.
- Sustained water restriction resulted in the activation of water saving mechanisms. Plasma vasopressin concentration increases with the extend length of dehydration. This will reduce the renal secretion which contributes to the water saving mechanism.

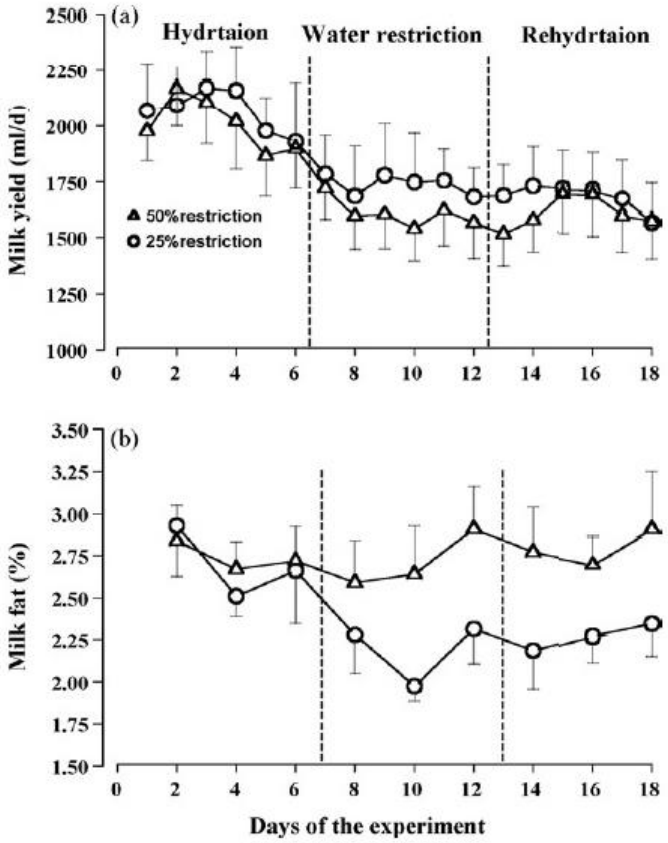
How animals cope with water salinity?

- Sheep and goats excrete more urine and increase the filtration rate to reduce the high salt load resulting from their high consumption of saline water.

- Exposure to saline water results in an induction of enzymes in the ilium, liver and kidney. The main enzyme is NaK ATPase that increases the pumping of sodium out of cells and potassium return to the intracellular space. The induction of this enzyme is a powerful adaptive mechanism.

Responses to water restriction – Lactation

	50% restriction			25% restriction		
	Hydration	Restriction	Rehydration	Hydration	Restriction	Rehydration
Water Intake (ml/kg0.75)	1071a	548e	950b	950bc	722d	867c
DMI (g/kg0.75)	109.3a	96.9b	100.7ab	105.6ab	94.8bc	97.6b



Diet – Alfalfa hay + 0.5 kg Conc.

In lactating goats, reduction of water consumption by 50% when it was coupled with high environmental temperature did not produce a dramatic fall in milk production or quality.

Location – Arabia Saudi

Alamer (2009)

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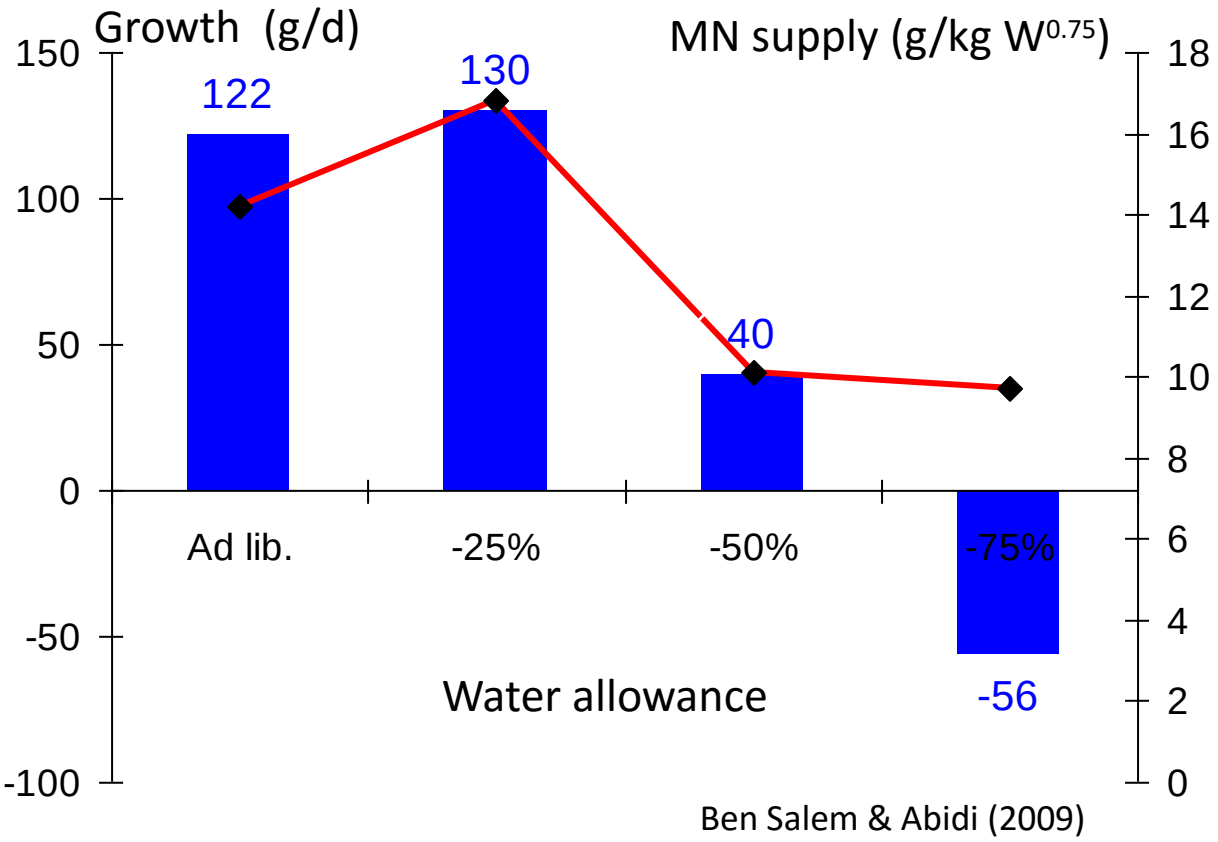
Responses to water restriction – Growing phase

Water allow.	DMI (g/Kg $W^{0.75}$)
Ad lib	89.2
- 25%	84.8
- 50%	71.6
-75%	59.5
Signif.	***
Contrast	L

Diet – Oat hay + 0.5 kg Conc.

Location - Tunisia

Barbarine lambs tolerate moderate water restriction



Ben Salem & Abidi (2009)

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Responses to water restriction – Growing phase

Lamb breeds subjected to 75% water restriction

Diet – Oat hay + 0.5 kg Conc.

	Barbarine		Queue Fine de l'Ouest		Noire deThibar		**Significance**		
Water regimen	Ad lib	Rest	Ad lib	Rest	Ad lib	Rest	Breed	Water	B x W
DMI (g/kg$^{0.75}$)	89.6	60.3	88.8	58.2	90.4	71.8	ns	***	ns
Growth (g/d)	99.2	0.51	111.9	- 6.0	105.1	-8.9	ns	***	ns

Location - Tunisia

Ben Salem et al. (2015)

Irrespective of breeds, N retention and microbial N supply decreased

Responses to water restriction – Lactation

Responses of Barbarine lactating ewes to water deprivation and salinity (11%)

	N-Daily	N-48 h Alternate	S-Daily	S-48 h Alternate	N *vs* S	Daily *vs* Alternate
24 h-Colostrum (ml)	378	367	331	306	ns	ns
Milk (g/day)						
Day 30	1180	1260	1226	1133	ns	ns
Day 60	746	773	898	876	ns	ns
Water intake (l/d) Day 60	2.9 [a]	2.2 [b]	5.4 [c]	3.0 [a]	***	***
DM intake (g/d) Day 60	1494	1546.2	1517.1	1429	ns	ns

Location - Tunisia

Yousfi & Ben Salem (unpublished)

Diet – Barley straw + Barley silage + Conc.

Responses to water restriction – Lactation

Lactating goats and offspring responses to saline water (6%)

Diet – Berseem hay

	Tap water	Saline water
Milk (g/day)	1198a	787b
Kids birth weight (kg)	2.43a	2.70a
Weaning weight (kg)	12.41a	10.60b
Weight gain (g/day)	123.84a	105.72b

Location - Egypt

Abdallah et al. (2003)

Responses to water salinity – Fetal programming

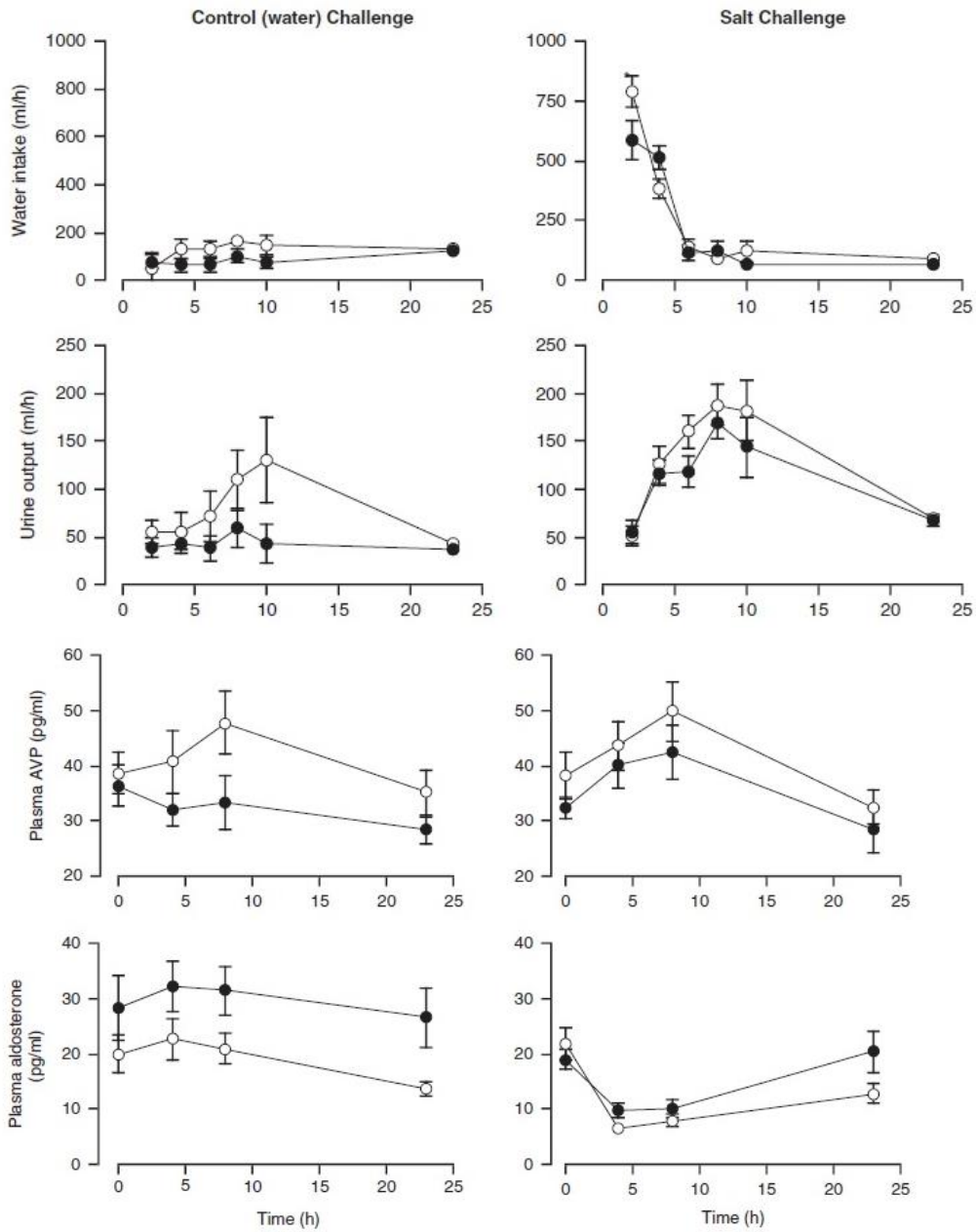
Foetal programming (FP) describes the life-long effects of in utero environmental effects

- *The foetus is being programmed for its later-life functioning by the environment it is experiencing at the earliest stage*
- *FP programming may prepare the foetus for later-life events*
- *FP … predictive adaptive response*

Hypotheses

- If the foetus is exposed to maternal undernutrition during pregnancy its metabolism may be programmed to enable it to be better adapted to poorer feed supplies post-birth.
- Exposure of pregnant ewes to salt dictates how their offspring respond to the salt

Responses to water salinity – Fetal programming



Lambs born to ewes that ingest high amounts of salt (13%) during pregnancy are programmed to have an altered thirst threshold. and blunted response in aldosterone to oral salt loads (Digby et al., 2009)

Location - Australia

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Responses to water salinity – Fetal programming

Pregnant ewes change foraging behavior when exposed to saline water (11%)

	C-Ewes	S-Ewes	SE	Prob.
Grazing time (% total time, TT)	55.62	43.39	5.90	*
Walking time (%TT)	31.93	41.95	1.69	*
Resting time (%TT)	12.45	14.65	2.33	ns

Location - Tunisia

Mehdi & Ben Salem (2015)

Responses to water salinity – Growing phase

Response of growing Barbarine lambs to saline water (11%)

	C-Lambs	S-Lambs
15	137.5	99.2
30	152.9	99.6
45	100.3	58.6
60	75.2	44.0
75	88.0	89.2
90	87.4	70.7

Mehdi & Ben Salem (2015)

Water effect: $P < 0.05$
Time effect : $P < 0.05$
Interaction: ns

Responses to water salinity and restriction

Foraging behavior of range goats

	Control	3% Salt	6% Salt	Restric.	Prob.
Moving (% TT)	21.4^{a}	27.6^{ab}	23.0^{a}	30.7^{b}	***
Resting (%TT)	4.1	5.6	8.1	4.9	ns
Woody species consumption (%TT)	42.1^{a}	39.9^{a}	19.6^{b}	17.6^{b}	***
Herbaceous species consumption (%TT)	32.4^{a}	26.9^{a}	49.2^{b}	46.8^{b}	***
Woody species intake (g DM/kg0.75)	78.7^{a}	92.8^{a}	55.6^{b}	42.4^{b}	***
Herbaceous species intake (g DM/kg0.75)	7.4^{a}	4.8^{a}	38.3^{b}	22.6^{c}	***
Total intake (g DM/kg0.75)	86.1	97.6	93.9	65.0	0.05

Location - Tunisia

Cherif & Ben Salem (2015)

Concluding remarks

Water restriction

- Sheep & goats respond by decreasing feed intake causing reduction of body weight (water and body mass loss)
- Responses to WR depend on physiological status
- Caution, lactation is the most water demanding physiological status. Water restriction would reduce blood flow to the mammary gland leading to decreased milk production

- 25% restriction not harmful and even could have positive impact
- Adaptive mechanism (RAS, drop in urine output, increased blood Na+ and urea, hyperosomolality, etc.) is efficient until certain level of water restriction
- Severe dehydration has detrimental effect on productive and reproductive performances and animal health
- In hot seasons, water scarcity is associated with high ambient temperature and forage shortage, the interaction of these three stressors should be taken into account

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Concluding remarks

Water salinity

- Major homeostatic responses to high salt load: increased water intake and decreased feed intake
- With diets composed of dry feeds, S&G can tolerate the consumption of water containing up to 11%
- To adapt to salt-rich water, S&G consume more water and change their foraging behavior (more herbaceous and less shrubby vegetation)
- Exposing S&G early in life would improve their adaptation to high salt water later in their life
- More research on foetal programming

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Thank you!

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