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EFFECT OF SALINITY LEVEL IN DRINKING WATER ON FEED INTAKE, NUTRIENT UTILIZATION, WATER INTAKE AND TURNOVER AND RUMEN FUNCTION IN SHEEP AND GOATS

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ABSTRACT

Twelve adult males of each Baladi goats and Barki sheep were divided, each, into four groups based on body weight. Animals were fed a ration consisted of berseem hay (ad lib) and concentrate feed mixture (at the rate of 1.5% of body weight). Treatments were drinking sea water diluted with fresh water to contain 4.04g, 8.15g, and 12.33g total dissolved salts/100 ml (TDS l-1), for 2nd, 3rd and 4th treatments, respectively along with fresh water (0.42 g TDS l-1) as a control.

Feed intake of both sheep and goats increased by increasing level of salinity, while species differences existed ($P<0.05$). Nutrient digestibility coefficients did not differ significantly due to salinity levels. Salinity levels effect appeared significant ($P<0.05$) on nitrogen utilization. Water intake increased in response to increasing salinity level till 8.15g TDS l-1, and then decreased at the higher level (12.33 g TDS l-1). Water intake response to load of elevated salt was higher in sheep than goats. Neither ammonia nitrogen nor total volatile fatty acid production were affected by salinity level while species effect was found to be significant ($P<0.05$ for NH3-N and $P<0.0001$ for TVFA's). Quadratic regression analysis revealed variations over time of both metabolites due to increasing salinity levels. The ruminal pH values were significantly affected by increasing salinity in drinking water. Both salinity levels (8.15 and 12.33g TDS l-1) showed lower ruminal pH than that of fresh water (0.42g TDS l-1). Drinking fresh water resulted in ruminal pH similar to that of the lowest salinity level (4.04g TDS l-1). Sheep had higher ($P<0.0001$) ruminal pH value (7.309) than goats (7.156). Turnover rate of fresh water was significantly ($P<0.05$) lower than water of higher salinity levels. The increments in turnover rate as a result of increasing salt concentrations were 42, 84 and 111% for 4.04, 8.15 and 12.33g TDS l-1, respectively. Sheep turned over more water (12%) than did goats. Relative stabilization of the rumen fermentation appeared to be restored at about the 21st day from the beginning of the treatments.

Key words: *sheep, goats, salinity, water intake, turnover, nutrient digestibility*

INTRODUCTION

Animals in dry areas are subject to certain environmental constraints that affect their performance negatively. Water is an essential nutrient, therefore, it is important for animals to have an adequate supply of good quality water to survive and maintain satisfactory production **(Schoeman and Visser, 1995).** Saline water usually available from wells in these areas may contain high concentrations of total dissolved salts

(TDS), sometimes reaching levels above 30g TDS l^{-1} **(Attia-Ismail, 2003).** High salt containing water may have certain implications on the animal **(Kellems and Church, 2002).**

The maximum safe level of salinity that can be tolerated by animals differs according to several factors; e.g. the environmental conditions, breed, genus and species of animals, type of diet, etc. **(Fahmy, 1993)**. Sheep were reported to tolerate saline drinking water containing up to 1.3 % sodium chloride without ill effects **(Tomas et al, 1973)** while goats were reported **(King, 1983)** to tolerate levels up to 1.5%. **McGregor (2004)** reported that goats adapted to drinking saline water can tolerate higher salinity levels than sheep and can even survive on sea water; but the period needed for animals to adapt to high salinity is still ambiguous.

However, excess level of salts may counteract each other at higher concentrations leading to their unavailability for rumen microorganisms **(Attia-Ismail, 2008).** The presence of certain inorganic ions may be the reason behind the deleterious effects of drinking salty water **(Kellems and Church, 2002)**. High salt level in the rumen increases the osmotic pressure leading to responses that may deviate from normal function of the rumen. The microbial activities as well as nutrients utilization may shift as a result. Most of the studies dealing with such a problem investigated pre-synthetic water where varying levels of dissolved salts were added **(Attia-Ismail, 2005)**.

In practice, it is difficult to quantify the amount of salt intake. Animals may consume halophytes and/or drink saline water of various salinity levels. Therefore, the present study was designed to introduce specific amounts of natural salts to animals through drinking water. **McGregor (2004)** recommended the investigation of the impact of salinity levels on the production of goats. Sea water was diluted to four levels to have measurable salt ingestion. Hence, it aimed at investigating the course of adaptation and effects of drinking the different levels of salinity on feed intake, nutrient utilization, water intake and turnover and rumen function under these controlled conditions in local Egyptian breeds of sheep and goats.

MATERIALS AND METHODS

Animals and management

This experiment was conducted at Maryout Experimental Research Station, 35 Km south west of Alexandria at spring time. Twelve adult male Baladi goats (local) and twelve adult male Barki sheep were used in this study. Animals were weighed and divided into four groups based on body weight (35.82±1.83, 34.1±1.83, 34.17±0.436 and 32.83±1.063 Kg for first, second, third and forth goat groups, and 36.67±0.918, 31.17±0.385, 29.17±0.096 and 25.83±0.674 Kg for first, second, third and forth sheep groups, respectively). All animals were subjected to a standard health management procedure of the Desert Research Center. Animals were treated for internal parasites prior to commencement of the experiment.

The experimental period lasted seven weeks. Three randomly selected animals from each group were involved in metabolism trials, at the end of the experiment. Two-weeks were allowed for adaptation followed by 7 days collection period was carried out. Five grams of chromium oxide (Cr_2O_3) was suspended in water with EDTA and dosed once to each animal before feeding on the second day of the digestibility trial. This substance passes more rapidly from the rumen than coarse fiber and tends to be more associated with the movement of the liquid fraction **(Van Soest, 1994).**

Animals were fed the regular farm ration that consisted of berseem hay and concentrate feed mixture (CFM). Rations were formulated so that CFM was supplied at the rate of 1.5% of the body weight **(Kearl, 1982)** while hay was offered ad lib. The chemical analysis of the rations fed appears in Table 1.

Table (1) Chemical analysis of the regular farm rations fed to experimental animals.

Item	CFM	Berseem hay
DM	86.96	88.71
CP	13.31	11.78
CF	16.00	29.81
EE	3.73	1.91
NFE	56.59	45.21
Ash	10.37	11.29

CFM = commercial concentrate feed mix (El-Marg Feed Factory)

Feeds were offered twice daily at 8:00 and 15:00 hr. Water was also offered twice daily two hours after feed introduction at 10.00 and 17.00 hr. Water was left in front of the animals for 30 minutes .

Treatments

Water for the four treatments was prepared by diluting sea water with the fresh water to the targeted ratios. The first treatment was fresh water that contained 0.42g TDS l^{-1} and considered as the control group. Sea water was diluted to contain 4.04g, 8.15g, and 12.33g TDS l^{-1}, for 2nd, 3rd and 4th treatments, respectively. Treatments were assigned randomly to the four animals groups.

Sampling

Water and feed samples were taken periodically once every week and also when water or feed lot were changed. Orts samples were taken every day and weekly composite samples were compiled, frozen and analyzed at a later time. Samples of the metabolism trials (feeds, orts, water, feces, and urine) were taken daily at 07:00 h. Rumen samples were collected at the 3rd, 5th, 7th days during the 1st week. Later, samples were taken once every week for the remaining three weeks. Rumen fluid samples were withdrawn through a stomach tube at 3hrs post drinking (5 hrs post feeding). Fecal samples (25 grams) for the passage rate were collected at 0,6,9,12,21,30,39,48,60,72,96 &120 hrs post drenching the chromium oxide dose **(Grovum and Williams, 1973)**. The natural logs of Cr concentrations in feces were plotted against time and a linear regression was calculated as $Y = a + bx$, where Y= chromium concentrations in feces, a= constant, b=K1 and x= time.

Analytical procedures

Composite samples of feeds, orts and feces were analyzed using standard laboratory techniques according to **AOAC (1990).** Fecal samples that were collected for the digesta passage rate were subjected to chromium analysis using atomic absorption (Pye-Unicam, model 929). Water intake was measured by difference between offered and remained. The average of the morning and evening drinkings was taken as a daily water intake.

Statistical analysis

Data were subjected to multiple statistical analyses. Repeated measurement design was used for the analysis with independent variables as animal species (2), treatments (4) and interaction. The repeated measures were feed intake, digestion parameters, nitrogen utilization and water intake and balance. Rumen parameters were subjected to varying levels of statistical analysis. The first level was performed where the first three rumen collections of the first week were grouped and averaged and treated as one week collection (period in the model). The model included independent variables as animal species (2), treatments (4), period (4) and interactions and repeated measures rumen ammonia, TVFA's and pH.

Regression analysis was used to have a powerful test of data using unequal spaces test for the six rumen collections to test for the quadratic responses of the rumen parameters. Duncan's test was employed to test for the differences between means. GLM procedures of **SAS (1985)** were employed for these purposes.

RESULTS AND DISCUSSION

Feed intake and nutrients utilization

Table 2 shows that feed intakes ($g/Kg^{0.75}/d$) for both sheep and goats increased as the salinity level increased in drinking water. However, species were differed in between regarding feed intake. Sheep had higher feed intake ($P<0.05$) than goats for both CFM (29.47 vs. 22.62 $g/Kg^{0.75}/d$ and berseem hay (54.25 vs. 37.53 $g/Kg^{0.75}/d$) for sheep and goats, respectively, and hence, total dry matter intake.

response of feed intake to increasing salinity levels. **Youssef, (1995)** offered to Egyptian local goats water containing 10.26g TDS l^{-1} during summer and winter and found that feed intake of animals was not affected by salinity in both seasons. **Attia-Ismail, (2003)** also found no significant differences in feed intake among Barki lambs

Table (2) The effect of water salinity level on feed intake by goats and sheep, ($g/Kg^{0.75}/d$)

		Water salinity level								
Item	Species	0.42g TDS l^{-1} (T1)	4.04g TDS l^{-1} (T2)	8.15g TDS l^{-1} (T3)	12.33g TDS l^{-1} (T4)	Average	±SE	T	S	T*S
Body wiegt$^{0.75}$	Goats	14.62	14.09	14.16	13.71	14.14	0.034			
	Sheep	14.90	13.19	12.55	11.45	13.02	0.131			
CFM intake	Goats	22.48	21.39	22.03	24.57	22.62b	1.168			
	Sheep	25.77	27.96	30.01	34.14	29.47a	1.101			
	Average	24.13b	24.67ab	26.02ab	29.36a		2.203	ns	***	ns
Roughage intake	Goats	36.96	37.39	38.18	37.61	37.53b	1.736			
	Sheep	45.68	54.45	54.93	61.95	54.25a	1.637			
	Average	41.32b	45.92ab	46.55ab	49.78b		2.135	ns	***	ns
Total DMI	Goats	59.39	58.77	60.24	62.16	60.14b	2.339			
	Sheep	71.42	82.40	84.94	96.06	83.71a	2.205			
	Average	65.40b	70.59ab	72.59ab	79.11a		3.119	ns	***	ns
TDN	Goats	59.39	58.77	60.24	62.16	33.22b	1.565			
	Sheep	71.42	82.40	84.94	96.06	39.49a	1.475			
	Average	33.41b	35.01ab	35.99ab	41.03a		4.410	ns	**	ns

a,b means with different letters differ ($P<0.05$)

drinking diluted sea water (12.49g TDS l^{-1}) in comparison with fresh water (0.505g TDS l^{-1}) which might be due to other treatment (addition of falvomycin). Voluntary feed intake is controlled either by mechanical or physiological mechanisms. Chemical regulation mechanism, is encountered in the process of controlling feed intake. Increased salt load in the rumen either through the consumption of saline water or ingestion of salt plants (halophytes) or feeds with high content of osmolality activating substances (e.g. silages, berseem hay) raises the osmotic pressure in the rumen, which might be a chemical process in controlling feed intake as hypothesized. **Bergen (1972)** concluded that osmolality is not an important factor in controlling feed intake. Later studies **(Shawket et al, 1988, Kattnig, et al, 1992, Assad et al, 1997, and Attia-Ismail, 2003)** supported this finding. Same results were obtained by **Saul and Flinn (1985)** when worked on weaner heifers drinking saline water (up to 11g TDS l^{-1}). Only one study **(Ahmed et al, 1989)** reported decreased dry matter intake as a result of offering animals water containing 9.11g TDS l^{-1} compared to fresh water (0.6g TDS l^{-1}) and they had no explanation for that. That obtained result might be due to the type of salinity in water. They offered saline well water to animals while in our study the saline water was sea water. The composition of both waters might differ in respect of the type of salts present in each.

Table (3) shows the effect of salinity level as well as species effect on apparent nutrient digestibility coefficients of both goats and sheep.

Table (3) The effect of water salinity level on nutrient digestibility by goats and sheep*

		Water salinity level					
Item	Species	0.42g TDS l^{-1} (T1)	4.04g TDS l^{-1} (T2)	8.15g TDS l^{-1} (T3)	12.33g TDS l^{-1} (T4)	Average	±SE
DMD %	Goats	57.33	58.66	60.50	60.66	59.29a	1.887
	Sheep	63.00	61.33	63.00	64.66	63.00 a	1.779
	Average	60.16a	60.00a	61.75a	62.66a		2.516
CPD%	Goats	60.00	63.33	65.50	69.33	64.54a	1.590
	Sheep	65.66	64.33	66.66	68.33	66.25a	1.499
	Average	62.83a	63.83a	66.08a	68.83a		2.120
CFD%	Goats	46.33	42.33	45.50	40.00	43.54a	2.806
	Sheep	41.00	37.33	36.66	46.33	40.33a	2.645
	Average	43.66a	39.83a	41.08a	43.16a		3.741
NFED %	Goats	66.00	68.33	70.50	69.66	68.62a	1.649
	Sheep	66.33	64.66	65.00	68.00	66.00a	1.554
	Average	66.16a	66.50a	67.75a	68.83a		2.198

a,b means with different letters differ ($P<0.05$)

* Main effects of salinity level and species were not significantly differed

Different salinity levels did not affect DMD, CPD, CFD, or NFED%, neither did the species difference. **Shawket et al, (1985)** working with Barki sheep drinking saline water (9.11g TDS l^{-1}) found that nutrient apparent digestibility coefficients were not affected by salinity level in drinking water. **Youssef, (1995)** reported seasonal effect on DM digestibility (winter being lower than summer) when goats had high saline water. Goats in his experiment lost weight in winter and the reported weight gain in summer did not compensate that lost in winter. **Shawket et al (1988)** showed that sheep and camels had species differences in CPD, CFD and EED, but not in overall DMD.

Nitrogen intake (Table 4) increased as salinity levels were elevated, and significant differences ($P<0.05$) were detected in between sheep and goats. Sheep had higher nitrogen intake (2.94 g/Kg$^{0.75}$/d) than goats (1.61 g/Kg$^{0.75}$/d) which goes along with the higher feed intake of sheep than that of goats. Fecal and urine nitrogen excretion were also higher for sheep than for goats ($P<0.05$).

Nitrogen balance was, therefore, higher for sheep (1.556 g/Kg$^{0.75}$/d) than for goats (0.874 g/Kg$^{0.75}$/d). Salinity levels effect appeared significant ($P<0.05$) when nitrogen balance was related to metabolic body size (0.986, 1.142, 1.431 and 1.303

Table (4) The effect of water salinity level on nitrogen utilization by goats and sheep ($g/Kg^{0.75}/d$)

		Water salinity level								
		0.42g TDS l^{-1} (T1)	4.04g TDS l^{-1} (T2)	8.15g TDS l^{-1} (T3)	12.33g TDS l^{-1} (T4)					
Item	Species					Average	±SE	T	S	T*S
Nitrogen intake	Goats	1.57	1.6	1.55	1.7	1.61b	0.07			
	Sheep	2.53	2.93	3	3.3	2.94a	0.07			
	Average	2.05b	2.27ab	2.28a	2.50a		0.13	*	**	ns
		Average								
Fecal nitrogen	Goats	0.41	0.39	0.3	0.36	0.37b	0.04			
	Sheep	0.62	0.74	0.69	0.75	0.70a	0.03			
	Average	0.52a	0.57a	0.49a	0.56a		0.07	ns	***	ns
Urine nitrogen	Goats	0.49	0.37	0.21	0.33	0.35b	0.05			
	Sheep	0.58	0.73	0.51	0.95	0.69a	0.04			
	Average	0.53ab	0.55ab	0.36b	0.64a		0.09	ns	***	ns
Nitrogen balance	Goats	0.65	0.82	1.03	0.99	0.87	0.09			
	Sheep	1.32	1.47	1.83	1.61	1.5	0.09			
	Average	0.99b	1.14 ab	1.43a	1.30		0.13	ns	***	ns

a,b means with different letters differ ($P<0.05$)
*=P<0.05, **=P<0.01, ***=P<0.001, ns= not significant

$g/Kg^{0.75}/d$ for 0.42g TDS l^{-1}, 4.04g TDS l^{-1}, 8.15g TDS l^{-1}, and 12.33g TDS l^{-1}, respectively). Negative nitrogen balance was detected in other two studies **(Shawket et al, 1988 and Youssef, 1995)** in response to drinking saline water. Sheep and goats in the present study were in positive nitrogen balance.

Water intake and excretion

Water intake is influenced by several factors; of which is the water quality (salinity). Species adapted to arid and semi arid areas may consume more water than others **(Wilson, 1989)**. However, animals accommodated to increasing salinity level (Table 5) in drinking water by increasing water intakes till salinity level reached 8.15g TDS l^{-1}. Water intake, thereafter, decreased significantly ($P<0.05$) at the higher level of salinity, yet still higher than intake with fresh water. However, Sheep responded more than goats to increasing salinity; as they had higher water intake than goats. The higher water intake of sheep was accompanied by higher total dry matter intake (Table 3). However, treatment and species affected significantly water intake (P<0.0001 for both factors).

Table (5) The effect of water salinity level on water intake and urine excretion by goats and sheep (ml/Kg$^{0.82}$/d)

		Water salinity level								
Item	Species	0.42g TDS l^{-1} (T1)	4.04g TDS l^{-1} (T2)	8.15g TDS l^{-1} (T3)	12.33g TDS l^{-1} (T4)	Average	±SE	T	S	T*S
Free Water Intake	Goats	140.00	168.00	223.00	200.33	182.83b	7.354			
	Sheep	256.67	288.33	457.00	445.00	386.75a	6.933			
	Average	198.33d	278.17c	340.00a	322.67b		13.866	***	***	**
Urine Exretion	Goats	80.48	67.88	43.95	59.54	62.96b	8.001			
	Sheep	83.12	150.59	154.09	208.02	148.95a	7.548			
	Average	81.8b	109.23ab	99.02ab	133.78a		15.0967	ns	***	ns
Fecal moisture	Goats	22.57	19.28	13.32	15.34	18.02b	1.658			
	Sheep	32.51	52.18	47.45	66.04	49.54a	1.824			
	Average	55.08a	71.46ab	60.77ab	81.37b		0.952	**	***	ns

*=P<0.05, **=P<0.01, ***=P<0.001, ns= not significant

a,b means with different letters differ (P<0.05)

WI= water intake, WUE= water excretion as urine, WFE=Water excreted in feces

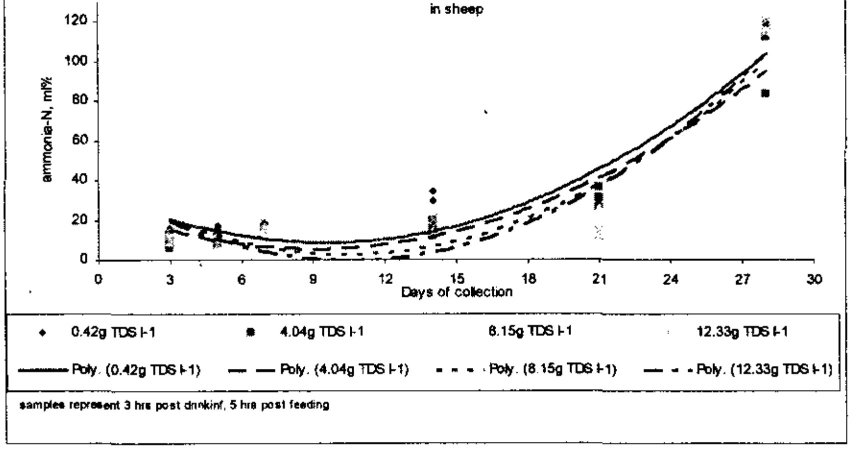
Water excretion (in urine and feces) followed the same trend. Ingestion of excess sodium by stock may lead to a higher water requirement and a decreased tolerance to saline water drinking **(Inglis, 1985). Sturki (1976)** suggested that increasing water intake in response to drinking saline water being due to the incidence of polydipsia resulted from lesions of thirst center. We see that the observed syndrome for the increased water intake upon the introduction of saline water to animals might be reversible at higher levels of salinity as animals (both sheep and goats) decreased their intake at higher levels of salinity. This decrement in water intake may represent a potential mechanism by which the animals can control salt intake at higher levels of salinity. **Judson and Mcfarlane (1998)** stated that 10,000 mg/liter of total dissolved salts is the maximum tolerable concentration for mature non-lactating livestock. **Abou El-Nasr et al, (1988)** found that sheep responded negatively through intake of water to the progressive salinity level in water. The decrement they found was 13.4% in water intake, yet the intake was still higher than that from fresh water. This finding is similar to our findings in the present study (Table 5). In general, sheep consumes more water than goats **(Aganga, 1992 and Gihad, 1976)**. Boer goats had a lower water intake per kg of feed intake and per kg of live weight gain than Mutton Merino lambs **(Ferreira et al., 2002)**. Boer goats have been recorded also as having a lower water turnover rate than Merino and other southern African sheep breeds **(King 1983)**.

Rumen function

Rumen metabolism under saline loads is shown in Table (6). Ammonia nitrogen was not affected by salinity level while species effect was found to be significant ($P<0.05$). Treatments over period effect was significant ($P<0.05$). Rumen parameters were plotted against time in quadratic models (Table7). The quadratic regression was curvilinear in response. Quadratically, ammonia-N decreased starting from day-5 of saline water introduction and increased starting from day 21st. The increase, therefore, was almost linear as appeared in figure (1).

In goats, the quadratic response (Figure 2) varied among treatments. It was only curvilinear for salinity levels of 8.15g TDS l^{-1} and 12.33g TDS l^{-1}. It seems that the ability of microorganism to produce ammonia-N under elevated salinity levels differs among both goats and sheep and also responds differently to the raised salt load in the rumen. Also, it could be concluded that proteolytic bacteria species in sheep took longer time to adapt to salinity conditions than those found in goats.

Fig (1) Quadratic response of the effect of varying levels of salinity in drinking water on ruminal ammonia in sheep



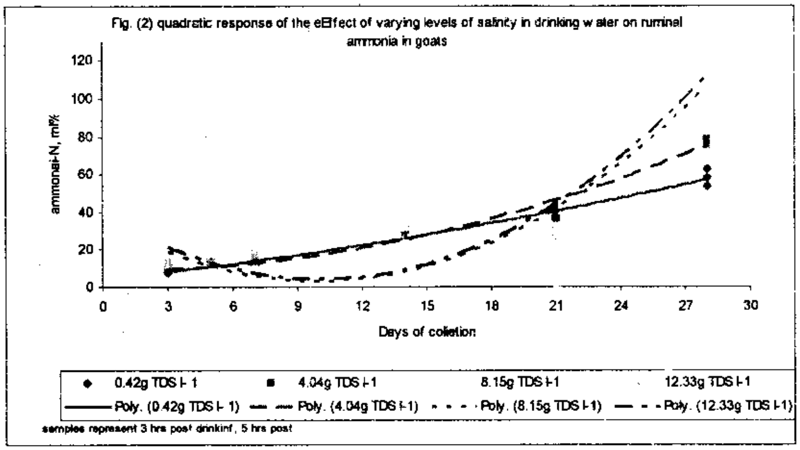


Fig. (2) quadratic response of the eEffect of varying levels of salinity in drinking w ater on ruminal ammonia in goats
ammonai-N, ml%
Days of colletion
0.42g TDS l- 1
4.04g TDS l-1
8.15g TDS l-1
12.33g TDS l-1
Poly. (0.42g TDS l- 1)
Poly. (4.04g TDS l-1)
Poly. (8.15g TDS l-1)
Poly. (12.33g TDS l-1)
samples represent 3 hrs post drinkinf, 5 hrs post

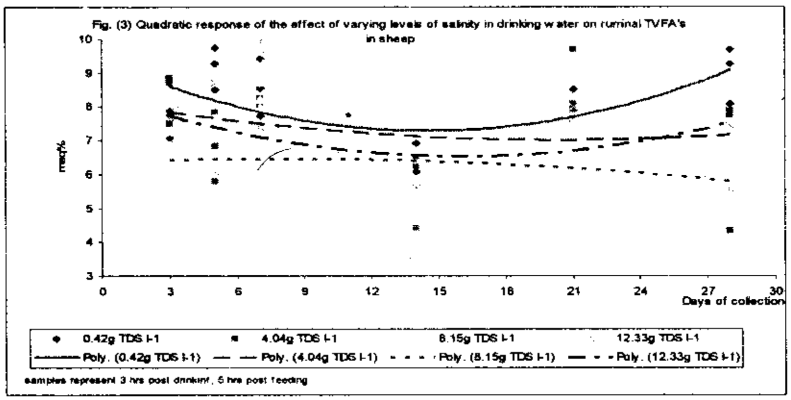


Fig. (3) Quadratic response of the effect of varying levels of salinity in drinking w ater on ruminal TVFA's in sheep
meq%
Days of collection
0.42g TDS l-1
4.04g TDS l-1
8.15g TDS l-1
12.33g TDS l-1
Poly. (0.42g TDS l-1)
Poly. (4.04g TDS l-1)
Poly. (8.15g TDS l-1)
Poly. (12.33g TDS l-1)
samples represent 3 hrs post drinkinf, 5 hrs post feeding

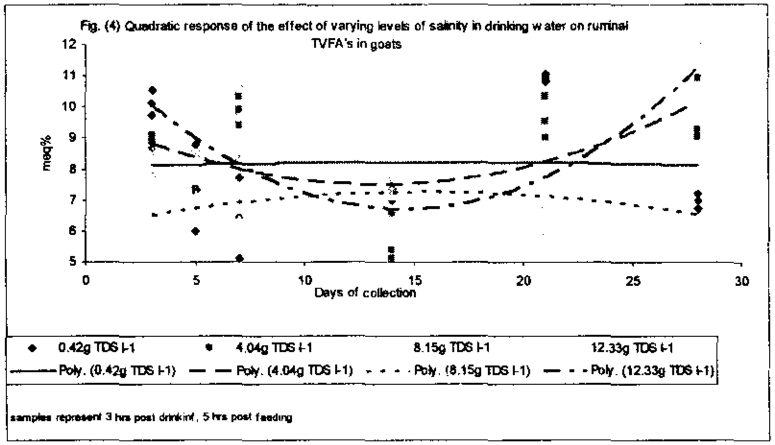


Fig. (4) Quadratic response of the effect of varying levels of salinity in drinking w ater on ruminal TVFA's in goats

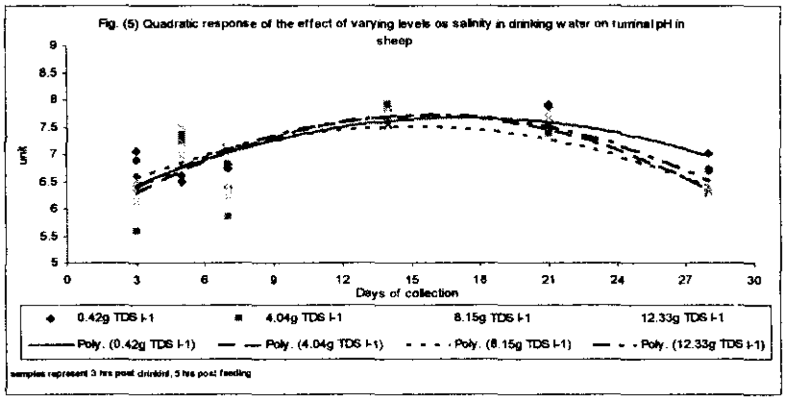


Fig. (5) Quadratic response of the effect of varying levels os salinity in drinking w ater on ruminal pH in sheep

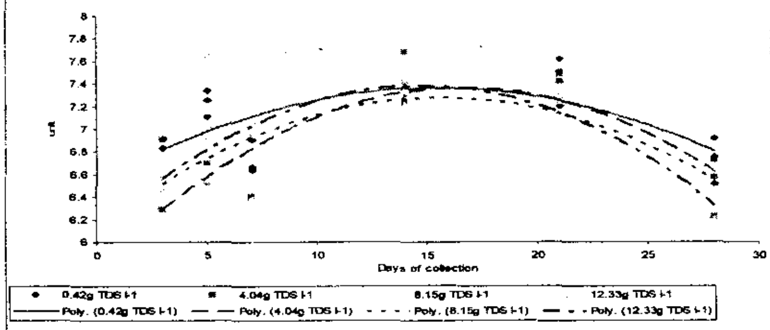


Fig. (6) Quadratic response of the effect of varying levels of salinity in drinking water on ruminal pH in goats

samples represent 3 hrs post drinkinf, 5 hrs post feeding

Increasing salinity in drinking water did not affect total volatile fatty acid (TVFA's) production in the rumen (Table 6). While, species differences existed ($P<0.0001$). As time passed treatments spelled out their effect on TVFA's (treatment, period interaction, $P<0.0001$). The production of TVFA's behaved differently from that of NH_3-N. Quadratic response of drinking fresh water by sheep was almost flat line, and so for goats. The treated sheep groups (figure 3) decreased their TVFA's production as salinity level increased in contrast to goats (figure 4). The quadratic response of sheep was curvilinear only for the highest salinity level (12.33g TDS l^{-1}) indicating the influence of salinity on TVFA's production. Both 4.04 and 12.33g TDS l^{-1} levels showed curvilinear responses of quadratic regression.

Table 6 show that sheep had higher ($P<0.0001$) rumen pH value (7.309) than goats (7.156). Salinity level affected ruminal pH significantly ($P<0.001$). Both salinity levels (8.15 and 12.33g TDS l^{-1}) showed (Table 6) lower average ruminal pH than that with fresh water (0.42g TDS l^{-1}).

Drinking fresh water resulted in ruminal pH similar to that of the lowest salinity level (4.04g TDS l^{-1}). The treatment-species interaction was, therefore significant ($P<0.05$). The linear and quadratic responses of the ion-cation balance in the rumen of both sheep and goats as represented by the pH values are shown in figures (5 and 6).

In sheep, quadratic regressions of all treatments were curvilinearly and almost similar. The quadratic regression showed increasing then decreasing trend. The same observations were noticed with goats (Figure 6) with some more variations than that with sheep (figure5). However, the digestive system is unable to cope up with a large

Table (6) The effect of water salinity level on some rumen parameters by goats and sheep

Rumen parameter	Species	Treatments 0.42g TDS l^{-1} (T1)	4.04g TDS l^{-1} (T2)	8.15g TDS l^{-1} (T3)	12.33g TDS l^{-1} (T4)	Average	±SE	T	S	T * S
NH_3-N, ml%	Goats	29.992	29.132	39.018	33.141	32.821a	1.038			
	Sheep	30.339	28.291	26.976	26.918	28.131b	1.024			
	Average	30.166a	28.712a	31.130a	30.030a		1.448	ns	*	*
TVFA's, meq%	Goats	6.749	7.071	6.974	7.340	7.035a	0.115			
	Sheep	6.929	6.547	5.985	6.151	6.403b	0.114		**	
	Average	6.8394a	6.8094a	6.4583a	6.7456a		0.161	ns	*	*
pH	Goats	6.947	7.397	7.494	6.788	7.156b	0.020			
	Sheep	6.986	7.655	7.727	6.866	7.309a	0.020	*	**	
	Average	7.317a	7.245ab	7.186b	7.203b		0.039	*	*	*
Turnover rate (liqiud phase)	Goats	1.4	3.2	5.5	5.6	3.96b	0.214	*		
	Sheep	3.9	4.1	4.2	5.3	4.4a	0.191	*		
	Average	2.6c	3.7b	4.8a	5.5a		0.383	*	ns	*

*=P<0.05, **=P<0.01, ***=P<0.001, ns= not significant

a,b means with different letters differ (P<0.05)

volume of saline water ingested to maintain fluid balance **(Wilson and Dudzinski 1973)**, which could lead to a higher osmotic pressure and a lower microbial population and activity in the rumen **(Potter et al. 1972)**.

Normal osmotic pressure in the rumen varies between 250- 280 mOsmol/kg **(Slyter 1976)**. Osmotic pressure of the rumen was not measured in the present study. The animals in the present study were not given an adaptation period so that the variations took place during that period might need to be studied. There were great variations during that period as evidenced from the results. However, non-adapted goats did not perform well when water of high electrical conductivity (EC) was provided as in drought situations adequate green herbage will not be available **(Mc Gregor, 2004)**. Treatments affected (Table 5) the turnover rate significantly (P<0.0001). Turnover rate of fresh water was significantly (P<0.05) lower than water of higher salinity levels. The increments in turnover rate as a result of increasing salt concentrations were 42, 84 and 111% of that of fresh water for 4.04, 8.15 and 12.33g TDS l^{-1}, respectively.

Table (7) Regression equations of goats and sheep rumen parameters

Rumen parameter	Treat.	Qaudratic regression equations for goats	R^2	Quadratic regression equations for sheep	R^2
NH₃-N	T1	y = 0.0239x2 + 1.219x + 4.300	0.967	$y = 0.3186x^2 - 6.2147x + 37.4$	0.867
	T2	y = 0.0846x2 + 0.0137x + 8.661	0.988	$y = 0.2495x^2 - 4.5325x + 26.063$	0.938
	T3	y = 0.6161x2 - 12.997x + 59.88	0.852	$y = 0.3641x^2 - 7.7159x + 41.71$	0.881
	T4	y = 0.3774x2 - 7.7208x + 42.15	0.932	$y = 0.367x^2 - 7.7996x + 39.987$	0.849
TVFA's	T1	y = -0.0007x2 + 0.0208x + 8.063	0.000 5	$y = 0.0099x^2 - 0.2882x + 9.3805$	0.271
	T2	y = 0.0123x2 - 0.3289x + 9.716	0.263	$y = 0.0027x^2 - 0.1105x + 8.1463$	0.045
	T3	y = -0.0048x2 + 0.1493x + 6.114	0.634	$y = -0.0017x^2 + 0.0271x + 6.359$	0.020
	T4	y = 0.025x2 - 0.728x + 12.02	0.508	$y = 0.0069x^2 - 0.2219x + 8.3251$	0.074
pH	T1	y = -0.0007x2 + 0.0208x + 8.063	0.445	$y = -0.0061x^2 + 0.2103x + 5.8553$	0.644
	T2	y = 0.0123x2 - 0.3289x + 9.716	0.633	$y = -0.009x^2 + 0.2806x + 5.5129$	0.616
	T3	y = -0.0048x2 + 0.1493x + 6.114	0.634	$y = -0.0066x^2 + 0.1974x + 6.0286$	0.310
	T4	y = 0.025x2 - 0.728x + 12.023	0.543	$y = -0.0082x^2 + 0.2582x + 5.6808$	0.652

T1=0.42g TDS l^{-1}, T2=4.04g TDS l^{-1}, T3=8.15g TDS l^{-1}, T4= 12.33g TDS l^{-1}

Sheep turned over more water (12%) than did goats. Treatment- species interaction was also significant (P<0.002). The overall view of the results may explain the necessity of small ruminants to a period for adaptation to high salinity. It seems from the obtained results that adaptation period to salinity might reach over 21 days.

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