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WATER REQUIREMENT OF GROWING LOCAL GOATS MEASURED UNDER TWO CLIMATIC THERMAL CONDITIONS

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SUMMARY

In an experiment of two phases each lasting 42 days, daily voluntary water intakes by 10 growing goats (Baladi) aged six to ten month old were individually recorded at two ambient temperatures averaging 28 °C (1st phase) and 14 °C (2nd phase). A uniform ration containing 90% DM and (1:1) concentrate to roughage ratio was fed ad libitum by kids in individual cages. In vivo total body water at the beginning and end of each experimental period was determined using the antipyrine space method. The results indicate that water intake by goats increased ($P<0.01$) with increasing ambient temperatures from 14 °C to 28 °C. Daily water intakes were more correlated with DM intakes ($r = 0.82$ at 28 °C and 0.80 at 14 °C) than the body weight ($r = 0.74$ at 28 °C and 0.66 at 14 °C). Water content of weight gain as kg (retained water) was not influenced by the daily water consumption, but it was related to amount of body weight gain. Data of daily intakes of water (WI) and dry matter (DMI) were used to formulate two equations to predict WI from DMI under the two temperatures as follows:

WI, ml/day =- 1300 + 5.9 DMI, g/day (at A.T.averaging 28 °C)
WI, ml/day =- 857 + 3.7 DMI, g/day (at A.T.averaging 14 °C)

It could be concluded that, the daily water requirement for growing local goats (under such housing and feeding conditions) could be taken as 250 ml/Kgw$^{0.75}$ and 164ml/Kgw$^{0.75}$ at A.T. averaging, 28 °C and 14 °C, respectively.

Keywords: Goats, water intake, body water, water requirement, ambient temperature.

INTRODUCTION

In Egypt, the majority of goats population is located in desert territories, where they are considered the main source of animal products for small holders. Poor water availability in such areas is undoubtedly, a problem affecting animal productivity. Few studies, have been conducted on goats to estimate their daily requirement of water under different environmental conditions. There are some claims that goats are more susceptible to heat stress than other species of domestic livestock and require less water evaporation to control body temperature. Moreover, they also have the ability to

conserve water by reducing losses in urine and faeces (Macfarlane and Howard, 1972 and Shkolnik, *et al.*, 1979). However, there are many factors affecting the free water intake of animals beside the environmental temperature such as; water content of feeds consumed, extent of exercise, salt and mineral contents of the diet and the physiological status of animals, and all should be considered in similar studies.

The aim of the present study was to estimate the daily water requirement of growing goats kept indoor under two climatic thermal conditions in Egypt.

MATERIALS AND METHODS

This work was carried out in the experimental farm station of the Faculty of Agriculture, Ain Shams University, Shoubra El-Khaima, north Cairo. Ten growing Baladi goats were used in an experiment of two phases based on the climatic thermal condition of each phase. The first thermal condition (1st condition) occurred from mid September to end of October, 1994 and the second one (2nd condition) from the beginning of December to mid January, 1995. Daily ambient temperatures (A.T.) recorded during the 1st condition averaged from 20°C to 37°C with an average of 28°C, while during the 2nd condition they ranged between 11°C to 19°C with an average of 14°C. Data of daily ambient temperatures recorded during the two experimental periods are shown in Table (1).

Table 1. Ambient temperatures recorded during the two experimental periods.

Thermal condition	Experimental period	Daily measuring	Ambient temperature,°C			SD
day		time	Mini.	Maxi.	Mean	
1st	42	12 a.m.	20	37	28	3.36
2nd	42	12 a.m.	11	19	14	2.06

During the first experimental period (1st condition) age of goat kids was from 6.0 to 7.5 months and weight was from 8.9 kg ± 0.58 to 9.7kg ± 0.56 and during the 2nd condition their age and weight were 8.5 to 10.0 months and 10.8 kg ± 0.60 to 12.4 kg ± 0.63, respectively.

Throughout the whole experimental period, kids were housed in individual cages of one m^2/animal, where water and feed consumption were measured daily. The ration offered to animals under the two conditions consisted of concentrate feed (CF) in cubes and chopped Berseem (*Trifolium alexandrinum*) hay. The concentrate feed was fed at the rate of 2.5% of body weight, while hay was offered ad libitum. Clean drinking water was individually available in buckets and a control bucket was used to subtract volume of water lost due to natural evaporation. Daily residuals of feeds or water were individually recorded at 8.00 a.m. before feeding and animals were weighed weekly. Chemical composition of feeds was determined according to A.O.A.C. (1984) and the results are presented in Table (2).

Initial and final in vivo body water contents were determined applying the antipyrine space method according to Panaretto and Till (1963). Two ml of antipyrine (non absorbable marker) solution (0.4 mg/ml) were intra-venously infused per animal

before feeding or watering and after 30 min. blood samples were withdrawn from the jugular vein to determine the concentration of antipyrine colormetrically. The antipyrine space was estimated by the extrapolation method and the total body water (TBW) was calculated according to the following equation suggested for goats by Panaretto(1963): TBW = Antipyrine space-0.03 x body weight. Average daily retained water (ADRW) was calculated by difference as (final TBW - initial TBW)/42 days.

Table 2. Chemical composition of feeds used.

Feeds	Moisture	Composition, % (DM basis)				
	(%)	CP	EE	CF	NFE	Ash
Concentrate feed*	10.90	14.5	4.9	17.6	53.2	9.8
Berseem hay	9.30	12.3	0.9	36.2	38.6	12.0

* Consisted of:25% undecorticated cotton seed meal, 25% yellow corn, 30% wheat bran, 15% rice bran, 2% molasses, 2% limestone and 1% common salt.

Collected data for feed intake, water intake, body weight and in vivo total body water under each thermal condition were pooled into 10 means per parameter and these were subjected to simple analysis of variance according to Steel and Torrie (1980). Two regression models based on three or two variables were computed under each condition to predict the daily water intake (ml) either from the daily dry matter intake (g) and body weight (kg) or from the daily DMI (g) as a sole independent variable applying the REG procedure of SAS statistical program (1982).

RESULTS AND DISCUSSION

Data presented in Table (3) indicate that the daily voluntary water intake by goats was higher ($P<0.01$) at higher A.T. (1328 ml at 28°C vs. 1027 ml at 14°C). In relative values drinking water expressed as percentage of body weight were 14.36 and 9.12 under 1st and 2nd thermal conditions, respectively. The positive relationship between A.T. and water consumption was reported in several studies on sheep (Forbes, 1968; El-Nouty *et al.* 1988 and El-Bedawy *et al.* 1994), however, fewer studies were conducted on goats. Maloiy and Taylor (1971) found African goats consuming water at rates of 8% and 13% of their body weight per day during winter and summer seasons respectively, when water was available ad libitum. Similar values were noted by Shkolnik and Silanikove (1981) on Bedouin black goats grazing in desert areas. They also observed that goats grazing in tropical and subtropical areas could withstand 2 to 4 days of water deprivation and drink water upto 40% of body weight per drinking time during mid-summer.

Water intake is also closely related to feed intake, and it has been noted to increase linearly with increase in feed intake (Forbes, 1968 and El-Bedawy *et al.*, 1994). In the present study, the relationship between WI and DMI was valid within each thermal condition (Table 4), however, it was masked between conditions due to the greater effect of high A.T. on the daily water consumption. Goats under the 1st condition (28°C) consumed 3.0 ml water per g DMI, while it was decreased to 2.0 ml water per g DMI under the 2nd condition (14°C). In this regard, Owen (1981) reported similar rates (2.0 kg water per kg DMI) for sheep in temperate zones.

Total weight gain of goats was higher ($P<0.01$) and daily water intake was lower ($P<0.01$) at the lower A.T. condition (averaging 14°C). Initial and final total body water proportionally calculated to body weight were not significantly different between conditions (Table 3). Water content of weight gain (retained water) calculated by difference (final-initial) was 56.4% of the total weight gain under the two thermal conditions. Average daily water intake was 0.79% at 28°C and 2.04% at 14°C. Regarding these amounts of calculated retained water, it is reasonable to assume the daily voluntary drinking water by growing goats kept under conditons as such, represents the daily water required for normal water balance without extra need of water for growth. The amount of retained water in body was noted to be increased as A.T. increased, however this trend was not noticed in the present study. Kamal *et al.* (1984) who estimated TBW by the dilution technique (TOH) demonstrated that, water retention was significantly increased in adult male goats watered ad libitum as the climatic temperature increased from 18°C to 38°C. The authors attributed the positive water balance of goats exposed to heat stress (38°C for one week and 7 hours daily) to the ability of goats to conserve body water under such condition in order to maintain normal hemostasis. In contrast, Shkolnik *et al.* (1979) stated that Bedouin goats grazing in desert areas were in an equilibrum water balance even at mid-summer.

Chemical composition of weight gain and consequently, water content of gain are more closely related to stage of maturity than to climatic condition, however, the experimental period of three months with one month interval (in this study) was not enough to detect such effect. In other words, the composition of weight gain was stable in goats during the period from 6 to 10 months of age. This conclusion was investigated from the constant value of water content % of gain (56.4) throughout the whole experimental period. The lower water content of weight gain for adult animals is the reflection of the increased proportion of fat to lean, whereas lean muscle associated with higher water content is a characteristic of the gain of growing animals (Owen, 1981). El-Bedawy *et al.* (1993) estimated the chemical composition of weight gain by difference for five adult Zaraibi male goats, and found that the water content of gain was on average 44% of the total weight gain.

Data in Table (4) summarize daily water intake (ml), daily DMI (g) and body weight (kg) as means for six observations per animal per parameter (6x10) under each of the two thermal conditions (28°C or 14°C). Two multiple regression equations were computed to predict the daily volume of drinking water(ml) consumed by each animal using ten pooled means of each of the two independent variables; DMI as x_1 and body weight (kg) as x_2 under each condition (Tables 5 and 6).The equations were:

At A.T. averaging 28°C

$$Y=-1506 + 7.2\ x_1 - 32.6\ x_2$$

At A.T. averaging 14°c

$$Y=-1477 + 6.4\ x_1 - 67.0\ x_2$$

where : Y = water intake (ml/day)

x_1 = DMI (kg)

x_2 = Bwt. (kg)

The correlation coefficients of daily WI and Bwt. were 0.74 and 0.66 at 28°C and 14°C , respectively. Higher correlation coefficients 0.82 and 0.80 were calculated for WI and DMI at 28 °C and 14 °C, respectively. Such lower values of the correlation between WI and Bwt. might affect the accuracy of the equations.

after feeding . The recorded pH and NH_3-N values indicated an optimum rumenenvironment for degradation of straw samples (Bhargava and Ørskov 1987).

Table 1. Chemical composition of the straws (% DM)

straws	Ash	CP	NDF	ADF	ADL
Common vetch (*Vicia sativa*)	4.8	9.2	55.6	40.5	8.3
Hairy vetch (*Vicia villosa*)	9.7	10.1	62.6	44.5	8.9
Horse bean (*Vicia faba*)	8.2	7.1	63.8	51.5	10.0
Wheat (*Tritcum durm*)	5.9	5.1	87.1	60.4	7.4

The potential DM degradability values of the tested legume straws (Table 2) were higher (a+b $\geq$55.1 %) than that of wheat straw which agree with the findings of Akin and Robinson (1982). Such results may be explained by the high values of the (a) fraction (a$\geq$1.2%) observed in the legume straws. One contribution to this fact is the high values of the washing losses (WL) observed to the legume straws($\geq$ 22.6%).

Table 2. Degradation parameters (a,b,c), potential degradability (a+b), washing losses (WL) and water - soluble (WS) to dry matter fraction.

Straws	a (%)	b (%)	c (% h^{-1})	a+b (%)	RSD	WL (%)	WS (%)
Common vetch	25.6A	42.5 AB	0.050A	68.1 A	1.18	30.3	18.5
Hairy bean	23.3AB	38.1 BC	0.074 B	61.4 B	0.68	27.9	18.9
Horse bean	19.2 B	35.9 C	0.055 A	55.1 C	0.93	22.6	11.2
Wheat	8.9 C	43.6 A	0.021A	52.5 D	1.91	10.5	1.4

RSD = Residual standard deviation

Values in the same columns bearing different letters are significantlydifferent($P \leq 0.05$).

The different behaviour in respect to the washing losses of the legume straws in relation to the studied cereal straws (Fig. 1) may be explaind by thier high values of the water - soluble (WS) fraction which reached more than 50% , (approximately 68,61 and 50% for hairy vetch, common vetch and horse bean straws, respectively) whereas it was only about 13% for wheat straw.

Another characteristic that was found for the studied legume straws , was the high degradation rate in the rumen ($\geq$ 5.5% h^{-1} whichis morethan double of that observed for wheat straw (2.2% h^{-1}). This fact means that the legume straws afermented faster in the rthan wheat straws indicating this shorter retention time in the rumen . Thence , the outflow rate of solid digesta will be quicker which would enhance voluntary feed intake (Ørskov and Ryle, 1990).

Among the tested legume straws it is noticeable the similarity of ruminal degradation characteristics of both the hairy vetch and the common vetch (Fig.2) although the common vetch showed larger degradation extent (a+b).

The horse bean straw showed the lowest degradability among the legume straws, which reflects its high contents of NDF and ADF as it 22 can be confirmed through the coefficients of linear correlation (r = - .94 23; $p \leq 0.05$).

Table 4. Simple statistics of water intake (WI), dry matter intake (DMI) and body weight (BW) for growing goats recorded under the two thermal conditions.

Trait	observation No	Mini.	Maxi.	Mean	SD
1st condition (28°C)					
WI ml/day	60	850	2530	1328	353.11
DMI, g/day	60	337	570	433	50.65
Bw, kg	60	7.0	14.9	9.8	1.86
2 nd condition (14°C)					
WI, ml/day	60	460	2030	1027	278.34
DMI, g/day	60	408	665	515	54.37
Bw, kg	60	7.3	16.0	11.1	1.99

Table 5. Regression of water intake (ml/day) on dry matter intake (g/day) and body weight (kg) under A.T. averaging 28°C.

Variable	Reg.coeffi.	SE	T(DF=7)	Prob.	Partial r
Constant	-1506				
DMI	7.2	4.23	1.69	0.13	0.29
Bwt	-32.6	105.62	-0.31	0.77	0.01
r^2 = 0.68			Multiple r	= 0.83	

Analysis of variance of Table (5)

Source	Sum of squares	DF	Mean squares	F. value	Prob.
Regression	737055.9	2	368527.9	7.49	0.02
Residual	344451.06	7	49207.29		
Total	1081506.9	9			

Table 6. Regression of water intake (ml/day) on dry matter intake (g/day) and body weight (kg) under A.T. averaging 14°C.

Variable	Reg.coeffi.	SE	T(DF=7)	Prob	Partial r
Constant	-1477.16				
DMI	6.35	2.55	2.50	0.04	0.47
Bwt	-67.02	59.12	-1.13	0.29	0.16
r^2=	0.70	Multiple r=	0.84		

Analysis of variance of Table (6)

Source	Sum of squares	DF	Mean squares	F. value	Prob.
Regression	284170.66	2	142085.33	8.23	0.01
Residual	120825.90	7	17260.84		
Total	404996.56	9			

Based on previous equations, the average daily volume of drinking water consumed by goats under the high A.T (28°C) was 250 ml/kgw$^{0.75}$ while it was 164 ml/kgw$^{0.75}$ under the low A T (14°C) The latter value was close to 145.6 g water/kgw$^{0.75}$ reported by Morand-Fehr and Sauvant (1978) for goats in temperate zones.

It could be concluded from the results of the present study that, the daily voluntary intake of water by growing goats kept under confinement is equal to the daily water requirement needed for normal growth. Great attention should be given to changes in ambient temperatures, which could increase the daily intake of water by an average of 164 ml/kgw$^{0.75}$ at A.T. average of 14°C to 250 ml/kgw$^{0.75}$ at an average A.T. of 28°C for goats fed dry rations.

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الاحتياجات المائية للماعز البلدى النامية والمقاسة تحت مجالين من الحرارة الجوية

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استخدمت عشرة رؤوس من الماعز البلدى النامية خلال المرحلة العمرية من ٦ الى ١٠ أشهر فى تجربة من مرحلتين استهدفت تقدير الاحتياجات المائية لها تحت مجالين من الحرارة الجوية ، استغرقت المرحلة الاولى ستة أسابيع (٤٢ يوما) تراوحت خلالها الحرارة من ٢٠ الى ٣٧ م° بمتوسط قدره ٢٨م° واستغرقت المرحلة الثانية مدة مساوية تراوحت خلالها الحرارة الجوية من ١١ الى ١٩م° بمتوسط قدره ١٤م° . غذيت الحيوانات فردياً خلال مرحلتى التجربة على عليقة جافة (٩٠٪مادة جافة) من مخلوط العلف المركز ودريس البرسيم بنسبة ١:١ حتى الشبع وكان ماء الشرب متاح فى أى وقت لكل حيوان على حده. تم تسجيل درجات الحرارة الجوية يوميا والمستهلك اليومى من العليقة وماء الشرب . كما سجلت اوزان الحيوانات أسبوعيا . تم تقدير كمية ماء الجسم لكل حيوان فى بداية ونهاية كل مرحلة لتقدير كمية الماء المحتجز بالجسم فى كل مرحلة باستخدام نظرية حيز الأنتيبرين . أشارت النتائج الى أن كمية الماء المستهلك يوميا تزديد معنويا (١٪) بارتفاع درجة الحرارة الجوية، وكان معدل استهلاك الماء مرتبط ارتباطا ايجابيا بكمية المادة الجافة المأكولة (٨٢ر. على درجة ٢٨م° ، ٨٠ر. على درجة ١٤ م°)، بينما كان الارتباط بين معدل استهلاك الماء ووزن الجسم اقل ارتباطا (٧٤ر. ، ٦٦ر.) عند درجتى الحرارة الجوية ٢٨م° ، ١٤م° على التوالى. وجد أن نسبة الماء المحتجز يوميا بجسم الحيوان تشكل نسبة تراوحت بين ٧٩و٪ الى ٢ر٠٤٪ من حجم الماء المستهلك يوميا. قد أمكن استنباط معادلتى تنبؤ لحساب حجم الماء المستهلك يوميا (ملتر) بمعلومية كمية المادة الجافة المستهلكة يوميا (جم) كما يلى :

تحت ظروف الحرارة الجوية بمتوسط ٢٨م° .

حجم الماء المستهلك يومياً = - ١٣٠٠ + ٩ر٥ كمية المادة الجافة المستهلكة يومياً.

تحت ظروف الحرارة الجوية بمتوسط ١٤م° .

حجم الماء المستهلك يومياً = -٨٥٧ + ٧ر٣ كمية المادة الجافة المستهلكة يومياً.

مما تقدم يمكن إحتساب الاحتياجات المائية للماعز النامية على أساس ٢٥٠ مللتر/كجم ٧٥ر. تحت درجات حرارة جوية متوسطها ٢٨م° بينما تكون ١٦٤ مللتر/كجم٧٥ر. تحت درجات حرارة جوية بمتوسطى ١٤م° أخذا فى الاعتبار نوعية العليقة ونظام الايواء .