EFFECT OF THERMAL ENVIRONMENT ON WATER AND FEED INTAKES IN RELATIONSHIP WITH GROWTH OF BUFFALO CALVES

G. Ashour[1], F.I. Omran[2], M.M. Yousef[2] and M.M. Shafie[1]

1- Department of Animal Production, Faculty of Agriculture, Cairo University, Giza, Egypt 2- Department of Buffalo Research, Animal Production Research Institute, Dokki, Egypt

SUMMARY

Eight buffalo calves, of six months of age with an average weight of 118 kg, were used to compare and assess their water and feed intakes and the average daily weight gain in response to constant heat stress (40 °C) and comfort (25 °C) conditions in thermo-controlled labs. The calves were divided into two groups in two labs, 4 calves under 40 °C and 87.5 % relative humidity (group, A) and 4 calves under 25 °C and 64 % relative humidity. Two stages were studied, each of one month interrupted by 15 days outdoors interval between the two stages. The mean values of daily water (WI) and feed (FI) intakes were computed for weekly intervals during the experimental stages. The animals were weighed initially and finally at each stage to calculate the average daily gain (ADG). The daily WI during the 1st stage was greater under 40 °C by 20% than that under 25 °C, whereas the contrary occurred during the 2nd stage. On the other hand, the FI was distinctly reduced by the effect of heat stress during the two stages in both concentrates and roughage. This effect of heat stress was great during the 1st stage. The ADG in group (A) showed clear decrease (- 0.49 kg/day) in BW during the 1st stage while in the 2nd stage there was almost maintenance of BW. In clear contrast, group (B) showed great increase in BW (1.11 kg/day) during the 1st stage however the increase in the 2nd stage was lower (0.45 kg/day). This study revealed that the major effect of temperature on growth is through control of FI. Under comfort temperature, in the 1st stage the ADG increased positively with the increase in WI and FI, while in the 2nd stage the calves showed less increase in spite of the increase in FI.

Keywords: Buffalo, calf body gain, water and feed intakes, heat stress

INTRODUCTION

Productive performance is the most important index out of various indices of animal's adaptability to environmental conditions. Among these indices, the average daily gain is the most indicative index from the growth and meat production point of view. This index is the outcome of water and feed intakes behaviour, which is affected, greatly by stress factors mainly that of climatic and nutritional conditions. Water and feed intakes are affected markedly by ambient temperature. The optimum, comfort, temperature is not the same for different bovines. Water intake

(WI) increased (Mullic, 1964; Ashour, 1990; Ashour *et al.*, 1993; Omran, 1999 and Ashour *et al.*, 2000), while feed intake (FI) decreased (Nangia and Garg, 1992; Omran, 1999 and Ashour *et al.*, 2000), in response to rise of ambient temperature.

Growth performance deteriorated due to exposure to high air temperature or artificial heat stress experimentation (Kamal et al., 1972 & 1989; El-Masry *et al.*, 1989; Daader *et al.*, 1989; Omran, 1999and Ashour *et al.*, 2000).

Water buffaloes are potentially an important tropical bovine species, especially in very hot areas (Webster and Wilson, 1980). These authors concluded that it could compete very successfully with other bovine species, under harsh hot conditions. Cockrill (1974) stated that it would be effective, economically, to improve meat output from well-adapted buffaloes than to try to create favourable conditions for improved breeds of cattle.

The main objectives of the present study were to compare and assess the responses of buffalo calves (6 - 9 mo) to constant heat conditions, stress (40 °C) and comfort (25 °C) in thermo-control labs (Artificial condition). The main intended responses were water and feed intakes and the average daily weight gain.

MATERIAL AND METHODS

The experimental work was carried out in the Animal Physiology Lab, Animal Production Department, Faculty of Agriculture, Cairo University, Egypt. Eight buffalo calves were available from Mahalet Mousa Farm, Animal Production Research Institute, Agriculture Research Center, Egypt.

At the beginning of the experiment the average age of the calves was six months, their live body weight ranged between 118-119.25 kg. The calves were divided randomly into 2 labs, 4 under 40°C (group A) and 4 under 25°C (group B). The experimentation comprised two stages in the destined lab, each of one month, interrupted by 15 days outdoors interval between the two stages.

The experimental artificial indoors climates were fixed in the two labs (A, 40°C and B 25°C). Lab (A) was equipped by 4 heaters controlled by highly sensitive digital thermostat along with ceiling and suction fans. Thus the ambient temperature (AT) in this lab was fixed and maintained exactly at 40°C and the relative humidity (RH) % was 87.7-87.3 %. Lab (B) was equipped by air conditioner and ceiling fan to maintain the temperature at 25°C, the relative humidity RH % ranged between 61.9 - 67.3 %.

The ambient temperature during the outdoors interval (August) was 33°C at 08:00 h and 37.42°C at 14:00 h the relative humidity was 88.5 % at 08:00 h and 77.0 % at 14:00 h.

The calves were fed and watered equally in both labs and outdoors according to the experimental procedure. Drinking fresh water was offered and recorded twice a day. The mean values of daily water and feed intakes were computed at weekly intervals during the experimental stages. A commercial concentrate ration was offered twice a day at 08:00 h and 15:00 h, it was offered in surplus amount every day to determine the free will daily feed intake (FI). Roughage (wheat straw and berseem , Egyptian clover, hay) was accessible all the day to determine the daily intake of each type. The concentrate ration was starter during the 1st stage and growing ration till the end of the experiment. The nutrients in concentrates and roughage are indicated in table (1)

Table 1. Nutrients percentages in the ration components, on dry bases

Nutrients	Crude protein	Crude fat	Crude fiber	Ash	NFE
Starter Conc.	21.40	5.26	11.45	10.70	51.19
Growing Conc.	16.40	4.80	16.53	12.70	49.57
Wheat straw	3.90	2.03	45.20	9.93	38.94
Berseem Hay	12.95	3.88	32.30	12.00	38.87

The animals were weighted initially and finally at each stage, the following equation was used to calculate the average daily gain (ADG).

ADG = (final weight – initial weight) / number of days.

The data were analyzed by least squares analysis of variance using the General Linear Models Procedure of the Statistical Analysis System (SAS, 2000) according to the following two models:

Model 1 for analyses of factors affecting water intake.

$$\mathbf{Y_{ijklm} = \mu + T_i + b_1(W_j) + b_2(C_k) + b_3(R_l) + (TW)_{ij} + e_{ijklm}} \quad \textbf{(1)}$$

Where:

Y_{ijklm} is the observation on the mth animal,
μ is the overall mean,
T_i is the effect due to the temperature, (i=1,2),
b_1 is the partial linear regression coefficient of body weight,
W_j is the body weight,
b_2 is the partial linear regression coefficient of concentrate intake,
C_k is the concentrate intake,
b3 is the partial linear regression coefficient of roughage intake,
R_l is the roughage intake,
$(TW)_{ij}$ is the interaction between temperature and body weight,
e_{ijklm} is the random error assumed N.I.D $(0,\sigma^2)$.

Model 2 for analyses of factors affecting daily weight gain.

$$\mathbf{Y_{ijklm} = \mu + T_i + b_1(I_j) + b_2(C_k) + b_3(R_l) + (TI)_{ij} + (TC)_{ik} + e_{ijklm}} \quad \textbf{(2)}$$

Where:

Y_{ijklm} is the observation on the mth animal,
μ is the overall mean,
T_i is the effect due to the temperature, (i=1,2),
b_1 is the partial linear regression coefficient of water intake,
I_j is the water intake,
b_2 is the partial linear regression coefficient of concentrate intake,
C_k is the concentrate intake,
b3 is the partial linear regression coefficient of roughage intake,
R_l is the roughage intake,
$(TI)_{ij}$ is the interaction between temperature and water intake,
$(TC)_{ik}$ is the interaction between temperature and concentrate intake,
e_{ijklm} is the random error assumed N.I.D $(0,\sigma^2)$.

RESULTS AND DISCUSSIONS

Water intake

The daily water intake (WI) during the 1st stage was more under heat stress by 20 % over that under the comfort condition (Table 2), the contrary occurred during the 2nd stage. This contradiction is mostly due to changes in live body weight (LBW) of group (B) as indicated in table (2).

Table 2. Mean Daily water intake (WI, L/h/day) and mean daily water intake related to metabolic body weight (MBW) (L/Mkg/day) for the two calves groups (A, under 40°C and B under 25°C) during the two stages

Water intake (WI)	1st Stage (A)	1st Stage (B)	2nd Stage (A)	2nd Stage (B)
L / h / day	21.14±1.50	17.66±1.25	22.95±1.95	29.71±2.1
L / Mkg / day*	0.23±0.01 b	0.14±0.01 c	0.26±0.02 a	0.23±0.01 b
Live Body Weight (LBW,kg)**	119.3 – 104.5	118.0 – 151.3	106.0 – 106.8	153.5 – 167.0

In the same row, means with different superscripts are significantly different ($P<0.05$).

* : Intake related to metabolic body weight ($W^{0.82}$)

** : Initial and final weight for each group at each stage of one month.

The mean values of (WI) as related to metabolic body weight ($BW^{0.82}$) is reported in table (2). This table shows that the water intake was always more under heat stress, with augmented effect during the 1st stage. Omran (1999) reported that constant heat stress in lab at 40°C increased water consumption per kg $MBW^{0.75}$ by 16 % in buffalo calves and 25 % in Friesian calves. Mullick (1962) reported 50 % increase in (WI) during Indian summer (41°C) while Misra *et al.* (1963) reported 13.5 % increase in (WI) by buffaloes unprotected from solar radiation at an ambient temperature of 34.2°C. Bianca (1964) reported that increased (WI) during heat stress aid in maintaining the body core temperature by its direct cooling effect on the reticule-rumen. in Egypt, Ashour (1990) found that buffalo calves increased their (WI) in the summer than in the winter by two folds as absolute values (39.2 vs. 20.1 L/day) and by three times as relative values to metabolic body weight ($W^{0.75}$).

The increase in (WI) with hot condition is augmented by behavioral eagerness to gulp copious cold water. This increase reflects the physiological role of (WI) in counteracting heat stress by increasing water vaporization through skin and / or respiratory surface.

Table (3) shows the confounded effect on water intake by relevant factors, particularly ambient temperature and roughage intake. Anyhow concentrate intake did not show significant effect on (WI). There was no significance of water intake on weight . The interaction between weight and temperature showed significant ($P \leq 0.05$) effect.

Table 3. ANOVA for factors affecting water intake by buffalo calves

Source of variation	Significance level
Temperature (T)	**
Weight (W)	ns
Concentrate intake (C)	ns
Roughage intake (R)	***
Temperature*Weight (TW)	*

*: P≤0.05 **: P≤0.01 ***: P≤0.001 ns: P>0.05

Feed intake

Mean values of feed intake (FI) was distinctly reduced by the effect of heat stress during the two stages in both concentrates and roughage (Table 4). That effect of heat stress was great during the 1st stage, most probably at younger age since the body weight of this group (A) was almost the same during the two stages. On the other hand, the physiological mechanisms may have played a role in the readjustment for maintenance of the body weight during the 2nd stage (Table 4). The increase in (FI) of group (B) during the 2nd stage seems to be merely in accordance with increase in live body weight.

Table 4. Mean daily feed intake (FI, kg/h/day) and mean daily Feed intake related to metabolic body weight (MBW) (kg/Mkg/day) for the two calves groups (A, under 40°C and B under 25°C) during the two stages

	1st Stage		2nd Stage	
	(A)	(B)	(A)	(B)
Intake, kg/h/day :				
Concentrate	1.11±0.09 d	3.24±0.07 b	2.35±0.07 c	4.67±0.06 a
Wheat straw	0.66±0.03 c	1.10±0.04 a	0.50±0.01 d	1.00±0.00 b
Berseem hay	0.25±0.02 a	0.31±0.02 a	0.19±0.01 a	0.28±0.02 a
Intake, kg/Mkg/day*:				
Concentrate	0.03±0.002 c	0.08±0.004 b	0.07±0.004 b	0.10±0.002 a
Roughage	0.02±0.0 b	0.03±0.0007 a	0.01±0.0003 c	0.02±0.0005 b

In the same row, means with different superscripts are significantly different (P<0.05). * : Intake related to metabolic body weight ($W^{0.75}$)

Niles *et al.* (1980) found that there was reduction in forage intake by Holestin cow, during summer. They postulated this response to diets high in fiber content resulted in higher acetate production during fermentation. Acetate metabolism results in, somewhat, higher heat increment than other VFA. Nangia and Gary (1992) reported that voluntary (FI) during months of higher air temperature was reduced to 40 % as compared to that consumed during cooler months. Baile and Forbes (1974) suggested that the reduced (FI) in summer is due to direct effect of elevated temperature on the appetite center in the hypothalamus ventromedial nucleus resulting in reduction of the production of VFA which are the main energy source in ruminants.

Baccari *et al.* (1990) found that thermal stress reduced the dry matter intake and the level of serum T_3 in young buffalo bulls, this case was also reported by Omran (1999) and Ashour *et al.* (2000).

Table (4) shows that the difference in feed intake, as related to metabolic body weight ($BW^{0.75}$), was significant between the two group during both stages. Omran (1999) found that the concentrate intake was reduced by heat stress at 40°C in lab from that pre stress by 20 % in buffaloes and 18 % in Friesian calves. This feed intake as related to metabolic body weight showed that concentrate intake was reduced in response to heat stress, from that pre stress by 13 % in buffaloes and 17 % in Friesian per kg $BW^{0.75}$.

Response of growth

Average daily gain (ADG) of the buffalo calves of the two groups showed clear decrease (-0.49 kg/day) in weight of group (A) during the 1st stage while in the 2nd stage there was almost maintenance of body weight allover that month period, (Table 5). In clear contrast, group (B) showed great increase in weight (1.11 kg/day) during the 1st stage, however the increase the 2nd stage was lower (0.45 kg/day).

Table 5. Average daily gain (ADG, kg/day) of the two calf groups (A & B) during the two stages

Items	(A)	(B)
1st Stage	(-)*0.49±0.03	1.11±0.07
2nd Stage	0.03±0.12	0.45±0.04

* : (-) Average daily loss in weight .

Omran (1999) reported that heat stress at 40°C in lab reduced the (ADG) more than the pre stress by 28 % in buffalo calves and 21 % in Friesian calves.

Table (6) shows the variation in (ADG) as induced by the studied factors. Ambient temperature, water intake and concentrate intake induced significant effects; however roughage intake had no significant effect. The interaction between water intake and temperature showed no significant effect while the interaction between concentrate intake and temperature had highly significant effect on (ADG). This contrast in that interactions proves that the major effect of temperature on growth is through control of (FI).

Table 6. ANOVA for factors affecting daily weight gain of these buffalo calves

Source of variation	Significance level
Temperature (T)	***
Water intake (I)	**
Concentrate intake (C)	**
Roughage intake (R)	Ns
Interaction :	
Temperature* Water intake (TI)	ns
Temperature*Concentrate intake (TC)	***

**: P≤0.01 ***: P≤0.001 ns: P>0.0

Table (7) shows the relationship between both (WI) and (FI) with body weight (BW) only for group (B), that under the comfort temperature (25°C). It is clear that the correlation coefficients were high during the 1st stage meaning the (BW) increased with intake. In the 2nd stage the calves showed less increase (Table 5) in spite of increase in (FI) (Table 4), could this be due to the lower level of the grow concentrate in that stage (Table 1).

Table 7. Correlation coefficients among body weight, concentrate, roughage and water intake under 25°C (Group B), above for the 1st stage and below for the 2nd stage.

	W	C	R	WI
W		0.38 *	0.66 ***	0.21 ns
C	-0.001 ns		0.44 **	-0.06 ns
R	-0.34 *	-0.21 ns		0.52 **
WI	0.11 ns	-0.32 *	0.60 ***	

*: P≤0.05 **: P≤0.01 ***: P≤0.001 ns: P>0.05

Table 8. ANOVA for factors affecting feed intake (concentrate and roughage) of buffalo calves

Source of variation	Feed intake	
	Concentrate	Roughage
Temperature (T)	***	***
Weight (W)	*	ns
Water intake (I)	***	***
Temperature*Weight (TW)	***	**

*: P≤0.05 **: P≤0.01 ***: P≤0.001 ns: P>0.05

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تأثير البيئة الحارة على المستهلك من الماء والغذاء بالنسبة الى النمو في العجول الجاموسى

جمال عاشور[1]، فايزة عمران[2]، محمد يوسف[2]، محمد الشافعي[1]

1- قسم الإنتاج الحيواني، كلية الزراعة، جامعة القاهرة، الجيزة، مصر، 2- قسم بحوث الجاموس، معهد بحوث الإنتاج الحيواني، الدقي، مصر

إستخدم في هذه التجربة 8 عجول جاموسى عمرها 6 شهور ووزنها 118 كجم وذلك لتقدير ومقارنة إستجابتها من حيث معدل المأكول والماء المستهلك ومعدل الزيادة اليومية لظروف الحرارة المستمرة (40 م°) والظروف المثلى (25 م°) في معامل التحكم الحراري. تم تقسيم العجول إلى مجموعتين كل مجموعة في معمل، المجموعة الأولى (4 عجول تحت درجة حرارة 40م) والمجموعة الثانية (4 عجول تحت درجة حرارة 25 م°). وتم دراسة استجابة هذه العجول في مرحلتين كل منهما شهر واحد يفصل بينهما فترة 15 يوم خارج المعامل تحت الظروف الطبيعية. تم حساب قيم المعدلات اليومية من كل من الماء المستهلك والغذاء المأكول على فترات أسبوعية خلال مراحل التجربة وتم وزن الحيوانات في بداية ونهاية كل مرحلة لحساب معدل الزيادة اليومية في وزن الجسم.

كان معدل الماء المستهلك أثناء المرحلة الأولى أكبر تحت درجة حرارة 40 م° بحوالى 20% عن قيمته تحت درجة حرارة 25 م° بينما حدث العكس خلال المرحلة الثانية. على الجانب الأخر إنخفض معدل المأكول بوضوح نتيجة الاجهاد الحراري اثناء المرحلتين سواء في العليقة المركزة أو الخشنة وكان هذا التأثير كبير جدا في المرحلة الاولى.

أظهرت الزيادة اليومية في وزن الجسم في المجموعة (أ) انخفاض واضح (0.49 كجم /يوم) اثناء المرحلة الأولى بينما في المرحلة الثانية كان هناك ثبات ملحوظ في وزن الجسم وعلى النقيض تماما أظهرت المجموعة (ب) زيادة كبيرة في وزن الجسم (1.11 كجم/ يوم) أثناء المرحلة الأولى بينما كانت الزيادة في المرحلة الثانية منخفضة (0.450 كجم/ يوم).

أظهرت هذه الدراسة أن التأثير الاكبر للحرارة على كفاءة النمو يكون من خلال التحكم في معدل المأكول. تحت الظروف المثلى وأثناء المرحلة الأولى ازداد معدل الزيادة اليومية إيجابيا مع الزيادة في كل من معدل المأكول والماء المستهلك بينما في المرحلة الثانية أظهرت العجول زيادة أقل بالرغم من زيادة المستهلك من الغذاء.