Egyptian J. Nutrition and Feeds (2020), 23(3): 337-347

EFFECT OF GRAZING TIME ON DIGESTION AND ENERGY UTILIZATION OF GOAT DURING LACTATION PERIOD IN HALAIB-SHALATEEN PASTURES

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(Received 8/11/2020, accepted 6/12/2020)

SUMMARY

Thirty lactating Balady goats were employed in a 90-day experiment to study the effect of grazing time on pasture intake, digestion, energy expenditure (EE) and energy balance (EB) throughout early and late lactation periods in Halaib - Shalateen pastures**.** To achieve this objective, female goats were divided into three treatments, 10 per each; the first treatment (T1) was in-door without grazing and given 1% of live body weight (LBW) concentrates feed mixture (CFM) plus berseem hay ad libitum. The second (T2) and third (T3) treatments were allowed to graze daily on *Panicum turgidum* as a basal range plant for 4, 8 hours, respectively and given 1% of LBW CFM. The results could be summarized as follows: The forage intake (g/ kg $BW^{0.75}$) by goats was significantly (P≤0.01) higher in early lactation than that in late lactation period. Goats that grazed for 8 hours daily showed higher (P≤0.01) forage intake than those grazed for 4 hours daily, while, goats fed on berseem hay ad libitum without grazing had higher (P≤0.01) value of roughage intake compared to the two grazed groups whether in the early or late lactation period. Similar findings were observed for nutrients intakes (OM, CP and NDF). Grazed goats for 4 hr and 8 hr had higher (P≤0.01) values of DM, OM, CP, CF, NDF and digested energy (DE) than these in zero-grazing group whether in the early lactation or in the late lactation period. Goats grazed for 8 hr daily had higher (P≤0.01) values of digestible and metabolizable energy intake than those in 4 hr and zero-grazing groups whether in the early or late lactation periods. Grazed goats for 4 hr and 8 hr had higher (P≤0.01) values of heart rate (HR) and energy expenditure (EE) than that in zero-grazing group. The energy balance (EB), when expressed as kJ/kg $BW^{0.75}$/day, was positive and greater (P≤0.01) for zero-grazing goats than those in grazed groups. Also, 8 hr-grazing group had greater (P≤0.01) value of EB than that 4 hr-grazing group, but it was negative for the two groups. It could be concluded that, under arid-area condition, in Halaib – Shalateen pastures, grazing of goats for 8 hours daily showed better nutritional performance represented by an increase in the pasture intake, digestion, reduction energy expenditure (EE) and therefore, energy balance (EB) was better than that grazing for 4 hours during early and late lactation periods.

Keywords: *Grazing arid-area rangelands**,** grazing time, digestion, energy utilization, goat and lactation period.*

INTRODUCTION

Goats are the main source of income of farmers living in arid and semi-arid regions. However, goats raised in these areas are generally confronted with severe nutritional deficits during food scarcity period which exacerbate disease and health problems and consequently low productive and reproductive performances. Natural forage provides the least expensive source of nutrients. Available forage mass is influenced by many factors, such as the stocking rate and animals physiological state (Askar *et al*., 2013), season of the year and supplementation when practiced (El-Shaer, 2010; Askar *et al*., 2014 and 2015).Therefore, native rangelands are degrading due to overgrazing, high stocking rates and mismanagement. Among the strategies used in natural pasture management systems is to determine grazing time, especially under dry and semi-dry pasture conditions.

One of the most important factors affecting the energy requirement for maintenance (ME_m) is an animal's activity (NRC, 2007). The energy cost for grazing activity has been quite difficult to study (Goetsch *et al*., 2010); therefore, in most pastoral production systems the magnitude of energy loss is

unknown. Grazing is a good way to improve the feed self-sufficiency of dairy goat farms. To help farmers to optimize their management choices, the impact of grazing management practices on intake, performance and grazing behavior of dairy goats need to be quantified (Charpentier *et al.*, 2019). In this regard, a wide range in estimates of the energy cost for grazing activity of small ruminants had been reported (i.e. 0-100% of the MEm, Lachica and Aguilera, 2003; Beker *et al*., 2009 and 2010). The findings help to make the appropriate decisions and facilitate management practices, such as determining stocking rate, pasture access, and supplementary feeding, so as to enhance animal production while preserving the fragile dry pastoral system.

The objective of this study was to study the effect of duration of grazing on pasture intake, digestion and energy expenditure (EE) and energy balance (EB) throughout early and late lactation periods in Halaib and Shalateen pastures**.**

MATERIALS AND METHODS

The study was carried out in the Ras Hederba Valley region at the Shalateen Research Station of the Desert Research Center, some 1300 km southeast of Cairo, the capital of Egypt, at latitude 22,00,720 N and longitude 36,48,955 E. The area is bordered by Sudan to the south and the red sea to the east. It is an arid region with average annual precipitation of only 58.5 mm/year mostly as erratic showers in November and December.

***Animals and treatments*:**

Thirty lactating Balady goats, 2-4 years with an average live body weight (LBW); 19.16 ± 0.68, were employed in a 90-day experiment to study the effect of grazing time on pasture intake, digestion, energy expenditure (EE) and balance (EB) during early and late lactation period. Goats were divided into three treatments, 10 per each. The first treatment (T1) was without grazing (zero-grazing) and fed a limited concentrate feed mixture (1% from LBW) plus berseem hay ad-libitum. While, the second (T2) and third (T3) treatments were allowed to graze for 4 hours (4 hr.) and 8 hours (8 hr.) daily, respectively, beside giving them 1% of their LBW concentrate feed mixture .

Experimental procedures:

The experiment began immediately after kidding and lasted for 90 day until weaning weight at the age of 3 months. Concentrate feed mixture was offered daily for does after returning from the pasture. Goats of all groups were kept under the same managerial and hygienic conditions and animals were allowed to drink water (desalination Seawater) ad lib at 08.00 a.m. (just before grazing), and 4.00 p.m. after coming back from grazing.

***Intake and digestibility*:**

Two digestibility trials were carried out to estimate the measurements of feed intake, digestibility and energy efficiency. The first digestibility trial was conducted during the early lactation period while; the second digestibility trial was conducted during the late lactation period. The internal marker technique was used to estimate the individual intake and digestibility for 6 animals per each treatment in which bags were used for total fecal collection.

Heart rate:

Heart rate (HR) was measured on animals fitted with Vermed Performance Plus ECG electrodes (Bellows Falls, VT) attached to the chest just behind and slightly below the left elbow and at the middle right side of the back. Electrodes were secured to skin with 5-cm wide elastic bandage (Henry Schein, Melville, NY) and animal tag cement (Ruscoe, Akron, OH). Electrodes were connected by ECG snap leads (Bioconnect, San Diego, CA) to T61 coded transmitters (Polar, Lake Success, NY). Human S610 HR (Polar Electro Oy, Kempele, Finland) monitors with infrared connections to the transmitters were used to collect HR data at a 1-min interval. Heart rate data was analyzed using Polar Precision Performance SW software provided by Polar Electro Oy. Heart rate was measured for each animal on elevated cages for at least 48-h periods. The diurnal HR and EE were determined from the EE/HR ratio for each animal.

***Energy expenditure* (EE):**

All animals were fitted with a face mask of an open-circuit respiratory system for O2 consumption

measurements. Heart rate (HR) was simultaneously determined at same time to get the individual EE/HR ratio for each animal. Measurements of O2 consumption were made twice daily at the morning and afternoon as described by Landau et al. (2006). The concentration of O2 was analyzed using a fuel cell FC-1B O2 analyzer (Sable Systems, Las Vegas, NV) and EE was estimated assuming a constant thermal equivalent of 20.47 kJ per liter O2 (Nicol and Young, 1990).

Analytical procedures:

Dry matter (DM), organic matter (OM) and crude protein (CP) content of feeds and feces were determined as described by AOAC (2005). The neutral detergent fiber (NDF) content was determined according to Mertens (2002). Dry matter intake and nutrients digestibility of the range were determined using the internal marker (acid insoluble ash; A.I.A) indicator technique as followed by (Van Keulen and Young, 1977). The general equation used for calculating dry matter intake was as follows:

Marker in range plant = Marker in feces – Marker in concentrate diet

Estimated DMI, g/day = Total marker in pasture intake / concentration of marker in pasture on dry basis.

Apparent digestion coefficients of the remind nutrients were calculated using the ordinary methods of AOAC (2005). Gross energy (GE) of feed and feces were measured by bomb calorimeter (IKA, model C 200, Staufen, Germany), using benzoic acid as standard. Digestible energy (DE %) was determined according to McDonald *et al.* (1981) as follows:

$$\text{DE},\% = \frac{(\text{Gross energy of total feed intake} - \text{Gross energy of feces}) \times 100}{\text{Gross nergy of total feed intake}}$$

Metabolizable energy (ME) intake was estimated as 82% of digestible energy (DE) intake (NRC, 1981). Energy balance (EB) was calculated as the difference between ME intake (MEI) and total energy expenditure (EE). The estimation of EE associated with grazing activity was based on estimates of total EE and MEI, assuming an efficiency of ME utilization for maintenance of km at 0.62 (where km = 0.35 (qm=ME/GE) + 0.503, ARC, 1980). Incidentally, the reported ME requirements for maintenance (MEm) of Balady goats were those of Helal et al. (2010, 429 kJ/ kg $BW^{0.75}$) and Askar (2016, 431 kJ/ kg $BW^{0.75}$)

Statistical analyses:

Data were analyzed by the GLM procedure of the SAS statistical package (SAS, 2000) with a model consisting of physiological studs (early lactation and late lactation), grazing time (0, 4 and 8 hours) and their interaction. Means were presented in tables for physiological studs x grazing time regardless of the significance of the interaction effect. The least significant difference (LSD) was used for comparing means. Differences among means with $P<0.05$ were accepted as statistically significant differences.

RESULTS AND DISCUSSION

Chemical composition:

From previous studies it was found that, *Panicum turgidum* was the dominant species in a field experiment under this study in wet and dry seasons as which showed higher frequency, abundance, coverage and plant density (Badawy, 2005, Nassar, 2008 and Osama, 2020). The chemical compositions of the experimental feeds are presented in Table (1). The chemical composition indicated that, *Panicum turgidum* (PT) had the lowest content of protein compared to concentrate feed mixture (CFM) and Berseem hay (BH), however, it had the highest content of neutral detergent fiber (NDF), followed by BH then CFM. Also, chemical composition indicated that, *Panicum turgidum, as* basal diet in pasture, had low content of gross energy (GE, Kcal/kg) compared to BH and CFM.

Table (1): Chemical composition of range plants and feed ingredients.

Item	Chemical analysis, % on DM basis								
	DM	OM	Ash	CP	CF	EE	NFE	NDF	GE-Kcal/k
Concentrate feed mixture	92.36	89.61	10.39	14.89	11.59	2.32	60.82	41.44	3989
Panicum turgidum	93.15	90.44	9.56	6.76	43.67	1.70	38.32	78.61	3710
Berseem hay	95.29	92.89	7.11	12.94	30.49	2.13	47.34	73.12	3914

Voluntary feed intake during lactation period:

Data of voluntary feed intake for goats during early and late lactation period are illustrated in Table (2). The forage intake by goats as g/day or g/ kg $BW^{0.75}$ was significantly ($P \leq 0.01$) higher in early lactation (EL) than that in late lactation (LL) period for all treatments. The increase in the forage intake in the EL period is mainly related to the increase in the nutritional requirements necessary for the production of milk.

Table (2): Effect of grazing time on feed intake by goats during early and late lactation.

	EL			LL			SEM	Significant		
	T1	T2	T3	T1	T2	T3		LP	T	LP*T
Body weight,										
BW, Kg	20.25^{ab}	18.33^{b}	17.97^{b}	22.93^{a}	18.68^{b}	19.25^{b}	1.27	ns	*	*
BW, kg	9.53^{ab}	8.85^{b}	8.71^{b}	10.47^{a}	8.95^{b}	9.17^{b}	0.45	ns	*	*
Dry matter intake,										
Forage intake,										
g/day	594^{a}	369^{d}	490^{c}	543^{b}	289^{e}	355^{d}	15.86	***	***	***
$g/kgBW^{0.75}$	62.67^{a}	41.78^{c}	56.66^{b}	52.37^{b}	32.37^{d}	38.67^{c}	1.78	***	***	***
% of BW	2.97^{a}	2.03^{c}	2.77^{a}	2.40^{b}	1.57^{d}	1.85^{cd}	0.11	***	***	***
Concentrate intake,										
g/day	203^{ab}	183^{b}	180^{b}	229^{a}	187^{b}	193^{b}	12.68	ns	*	*
$g/kgBW^{0.75}$	21.19^{ab}	20.66^{b}	20.54^{b}	21.86^{a}	20.70^{b}	20.91^{b}	0.35	ns	*	*
Total intake,										
g/day	797^{a}	552^{c}	670^{b}	772^{a}	476^{d}	548^{c}	25.96	***	***	***
$g/kgBW^{0.75}$	83.86^{a}	62.44^{c}	77.20^{b}	74.22^{b}	53.06^{d}	59.58^{c}	1.62	***	***	***
Total OM intake,										
g/day	733^{a}	498^{c}	605^{b}	710^{a}	429^{d}	493^{cd}	23.43	**	***	***
$g/kgBW^{0.75}$	77.20^{a}	56.30^{c}	69.65^{b}	68.23^{b}	47.82^{c}	53.71^{c}	1.51	***	***	***
Total CP intake,										
g/day	107.0^{a}	52.26^{bc}	59.90^{b}	104.4^{a}	47.37^{c}	52.64^{bc}	2.80	**	***	***
$g/kgBW^{0.75}$	11.27^{a}	5.92^{d}	6.89^{c}	10.03^{b}	5.27^{e}	5.73^{de}	0.20	***	***	***
Total NDF intake,										
g/day	518^{a}	366^{c}	460^{b}	492^{ab}	305^{d}	359^{c}	16.24	***	***	***
$g/kgBW^{0.75}$	54.60^{a}	41.40^{c}	53.05^{a}	47.34^{b}	34.02^{d}	39.06^{c}	1.25	***	***	***

*a, b, c Means without a common superscript letter in the row are differed ($P < 0.05$) between lactation period (LP), early lactation (EL) and late lactation (LL), grazing time, or their interactions. ns = non-significant; t < 0.10; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; SEM = Standard error of means. T1: zero hour grazing time; T2: 4 hour grazing time; T3:8 hour grazing time.*

Concerning to the interaction between lactation periods and grazing time effect, it can noticed that, goats that graze for 8 hr. (T3) daily consumed more (P≤0.01) amount of forage intake than those graze for 4 hr. (T2) daily whether in EL or LL periods, while, goats in zero-grazing group (T1) had higher (P≤0.01) roughage intake compared to grazed groups during EL and LL periods.

Total dry matter intake (DMI) expressed as g/day or g/kg $BW^{0.75}$ showed the same trend of forage intake among groups in EL and LL periods, mainly owing to the difference in forage intake. This higher in forage intake was associated with a significant increase in nutrients intake of OM, CP and NDF for goats in 8 hr-grazing group compared to goats in 4 hr-grazing group whether in the early or late period of lactation. At the same trend, goat in T1 group had higher (P≤0.01) OM, CP and NDF intakes than those in grazed groups in EL and LL periods. In this regard, increasing the forage intake with increasing grazing time is expected as there is a direct relationship between the length of the grazing time and the intake from the pasture. The present results are in agreement with that reported by Ayantunde *et al*., (2001) who reported that, total time spent eating was increased linearly with increasing total time allowed for grazing leads to increased forage intake and consequently provides an opportunity for better animal production, especially in the dry season. Moreover, Tovar-Luna *et al.,* (2011) reported a decrease in pasture intake by 36 g DM/d per hour when time decreased from 24 h to 12 h/d. Also, the reduction of pasture intake with restriction of access time has already been observed in grazing goats but generally to a lesser extent (Charpentier, *et al.,* 2019). On the other hand, different results were obtained in goats by Romney *et al.,* (1996) and in cows by Vallentine, (1990) where found that, eating rate in the treatment with 6 h total grazing time was almost twice that in the treatment with 15 h total grazing time.

Nutrients digestibility and nutritive values:

The results of nutrients digestibility and nutritive values are shown in Table (3). It seems that, goats that graze for 4 hr. and 8 hr. had higher (P≤0.01) DM, OM, CP, CF and NDF digestibility than that did not graze (0 hr.) whether in EL or in LL periods. In general, the increase in nutrients digestibility for grazing goats than those in zero-grazing goats may be explained on the basis of the reduction of DMI, especially forage intake, by grazed groups compared with goats did not graze, or/and increased retention time of diet in the digestive tract and exposure to the longest possible period of fermentation by the microorganisms present in the rumen and therefore increase the rate of metabolism and utilization of diet to a large extent. Also, increasing NDF in the pasture (78.61 %, table 1) may be related to increasing the retention time of diet in the digestive tract. In addition to that, grazing, walking and exercise inside the pasture leads to an improvement in the health of the animal, which is reflected on rumen turnover rate, fermentation and metabolism process within the digestive tract which lead to increase the nutrients digestibility for grazed goats compared to goats without grazing. In this respect, Ayantunde (1998) showed that allowing day-grazing cattle additional grazing time during the night improved animal performance. Moreover, Claps *et al.,* (1997) indicated that the nutritive value of the diet of grazing goats was higher than that of the zero grazing goats. The present result of the OM digestibility was in accordance with that Charpentier and Delagarde, (2018) found that, selected pasture OM was higher digested when animals access grazing for 4 h than 8 h. On the other side, restricted grazing time system can guarantee lambs both access to pastures and abundant energy requirements (Wang *et al*., 2015).

Concerning nutritive value, it can be seen that, grazed goats showed insignificantly increase for TDN, %, compared with 0 hr. group during EL period, however, in LL period 8 hr. group had higher (P≤0.01) value of TDN, % than that 0 hr. group. In this regard, the results of dry matter, crude protein intake and digestion coefficient of all nutrients were reflected on nutritive values of diet. Similar results were observed by Claps *et al.,* (1997) who indicated that the nutritive value of the diet of grazing goats is higher than that of the zero grazing goats. The lesser intake of the former is compensated by the greater nutritive value of the herbage. On the other hand, different results were observed for DCP value, zero grazing goats had higher (P≤0.01) DCP, as %, than those in 4 hr. and 8 hr. grazing groups during EL and LL periods. This result may be due to increase of intake from berseem hay, which rich in protein (12.94%, table 1), by goats in 0 hr. group during EL and LL periods.

Energy utilization:

Data of gross, digestible and metabolizable energy intakes of goats during early and late lactation periods are show in Table (4). It can notice that, zero-grazing group had higher (P≤0.01) gross energy intake than 4 hr-grazing and 8 hr-grazing groups whether EL or LL periods, when it expressed as kJ/kg $BW^{0.75}$/day. This result is mainly related to the increase in the intake of berseem hay, which rich in energy (3914 kcal/kg) by goats in zero-grazing group during EL and LL periods.

Table (3): Effect of grazing time on nutrients digestibility and nutritive values by goats during early and late lactation.

Item	EL			LL			SEM	Significant		
	T1	T2	T3	T1	T2	T3		LP	T	LP*T
Digestibility, %										
DM	58.77^{b}	61.95^{ab}	63.90^{ab}	60.72^{b}	65.09^{ab}	66.82^{a}	2.24	Ns	**	*
OM	58.97^{c}	63.93^{abc}	66.03^{ab}	61.28^{bc}	67.21^{a}	69.07^{a}	2.11	Ns	***	**
CP	64.00^{b}	71.31^{a}	72.60^{a}	57.02^{c}	63.39^{b}	68.50^{ab}	2.15	**	***	***
CF	48.02^{b}	74.44^{a}	75.69^{a}	50.71^{b}	73.65^{a}	76.63^{a}	2.01	Ns	***	***
NDF	57.68^{ab}	59.38^{ab}	62.15^{ab}	55.61^{b}	58.73^{ab}	64.64^{a}	2.90	Ns	*	*
Nutritive value,										
Total digestible nutrients,										
TDN, %	56.17^{c}	59.39^{abc}	61.32^{abc}	57.92^{bc}	62.07^{ab}	63.82^{a}	1.97	Ns	***	**
TDN, g/d	447^{a}	328^{c}	413^{ab}	447^{a}	298^{c}	351^{bc}	23.19	Ns	***	***
Digestible crude protein,										
DCP, %	8.60^{a}	6.74^{c}	6.52^{c}	7.72^{b}	6.29^{c}	6.59^{c}	0.27	T	***	***
DCP, g/d	68.46^{a}	37.26^{cd}	43.70^{c}	59.64^{b}	30.12^{d}	36.27^{cd}	2.94	***	***	***

*a, b, c Means without a common superscript letter in the row are differed (P < 0.05) between lactation period (LP), early lactation (EL) and late lactation (LL), grazing time, or their interactions. ns = non-significant; t < 0.10; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; SEM = Standard error of means. T1: zero hour grazing time; T2: 4 hour grazing time; T3:8 hour grazing time.*

Table (4): Effect of grazing time on energy utilization by goats during early and late lactation.

Item	EL			LL			SEM	Significant		
	T1	T2	T3	T1	T2	T3		LP	T	LP*T
Gross energy,										
MJ/day	13.10^{a}	9.11^{c}	11.03^{b}	12.72^{a}	7.86^{d}	9.02^{c}	0.43	***	***	***
kJ/BW$^{0.75}$/day	1380^{a}	1029^{c}	1271^{b}	1222^{b}	876^{d}	982^{c}	26.54	***	***	***
Digestible energy,										
%	54.14^{b}	70.25	69.64	57.84^{b}	68.17	71.72^{a}	2.05	ns	***	***
MJ/day	7.09^{ab}	6.42^{bc}	7.71^{a}	7.36^{ab}	5.42^{c}	6.50^{bc}	0.43	t	***	**
kJ/kg BW$^{0.75}$/day	747^{b}	723^{b}	884^{a}	703^{b}	598^{c}	705^{b}	22.21	***	***	***
Metabolizable energy,										
MJ/day	5.68^{ab}	5.14^{bc}	6.17^{a}	5.89^{ab}	4.33^{c}	5.20^{bc}	0.34	t	***	***
kJ/kg BW$^{0.75}$/day	597^{b}	578^{b}	707^{a}	562^{b}	479^{c}	564^{b}	17.76	*	***	***
Heart rate, HR										
Beat/minute	81.25^{b}	97.47^{a}	98.76^{a}	77.13^{c}	97.91^{a}	98.54^{a}	0.79	*	***	***
Energy expenditure, EE										
kJ/kg BW$^{0.75}$/day	587^{b}	704^{a}	713^{a}	555^{c}	705^{a}	710^{a}	5.72	*	***	***
Energy balance										
kJ/kg BW$^{0.75}$/day	10.71^{a}	-125.5^{b}	- 5.87^{a}	6.72^{a}	-106.7^{b}	- 4.74^{a}	20.99	ns	***	***

*a, b, c Means without a common superscript letter in the row are differed (P < 0.05) between lactation period (LP), early lactation (EL) and late lactation (LL), grazing time, or their interactions. ns = non-significant; t < 0.10; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; SEM = Standard error of means. T1: zero hour grazing time; T2: 4 hour grazing time; T3:8 hour grazing time.*

However, digestible (DE) and metabolizable energy (ME) intakes, expressed as kJ/kg $BW^{0.75}$/day, were higher ($P \leq 0.01$) for 8 hr-grazing group than zero-grazing and 4 hr-grazing groups during EL period. While, during LL period these differences were significantly only between 8 hr-grazing group and 4 hr-grazing group. The mean values of DE intake were 884, 747 and 723 in EL period and 705, 703 and 598 kJ/kg $BW^{0.75}$/day in LL period for goats in 8 hr, 0 hr and 4 hr-grazing, respectively. The mean values of ME intake were 707, 597 and 578 in EL period and 564, 562 and 479 kJ/kg $BW^{0.75}$/day in LL period for goats in 8 hr, 0 hr and 4 hr-grazing, respectively.

Data in Table (4) showed that, digestible energy (%) was followed the same trend of the dry and organic matter digestibility. Grazed groups for 4 hr. and 8 hr. had higher ($P \leq 0.01$) DE as % than those in zero-grazing group whether EL or LL periods. The mean values were 69.64, 70.25 and 54.14 % in EL period and 71.72, 68.17 and 57.84 % in LL period for 8hr, 4hr and zero-grazing groups, respectively. Improvement of DE and ME intakes as well as digestible energy (%) in grazed groups is mainly related to the increase in nutrients digestibility and TDN values by grazed groups, especially in 8hr-grazing group, compared to zero-grazing group.

Data of heart rate (HR) **(**Table 4 and figures 1 & 2) showed that, 8hr and 4hr-grazing groups had higher ($P \leq 0.01$) value of HR than that in zero-grazing group whether EL or LL periods, values expressed as beats/min, were 98.76 and 97.47 vs. 81.25 in EL period and 98.54 and 97.91 vs. 77.13 in LL period, respectively. Also, data of energy expenditure (EE) **(**Table 4 and figures 1 & 2) showed that, grazed goats for 4 hr and 8 hr had a greater ($P \leq 0.01$) value of EE compared to zero-grazing group whether EL or LL periods, especially in EL period. The mean values were 713, 704 vs. 587 kJ/kg $BW^{0.75}$/day in EL period and 710, 705 vs. 555 kJ/kg $BW^{0.75}$/day in LL period for 8 hr, 4 hr vs. zero-grazing groups, respectively.

The energy balance (EB), when expressed as kJ/kg $BW^{0.75}$/day, was positive and greater ($P \leq 0.01$) for zero-grazing goats than that in grazed goats for 4 hr. also, it was negative and greater ($P \leq 0.01$) for 8 hr group than that in 4 hr group, mean values were 10.71, -125.5 and -5.87 kJ/kg $BW^{0.75}$/day in EL and 6.72, -106.7 and -4.74 kJ/kg $BW^{0.75}$/day in LL for 0 hr, 4 hr and 8 hr groups, respectively (Table 4). These results may be attributed to the significant contribution of the energy cost of grazing activity to the total EE. In this regard, Brosh *et al*., (2006) reported that, grazing activity was expected to increase the energy requirements of grazing animals compared to those in confinement. In addition, a wide range in the estimates of energy cost of grazing activity of small ruminants has been reported (i.e. 0-100% of the ME_m, Lachica and Aguilera, 2003). Moreover, Beker *et al*. (2009 and 2010) reported that grazing activity comprised a sizable proportion of the cost of energy, almost 49–54% of the reported ME_m for goats. Also, they revealed an increase in the energy cost of grazing activity of 5.79% and 5.05% of the ME_m per each hour spent in grazing/eating or grazing/eating plus walking, respectively.

On the other side, natural rangelands of the study area are characterized by poor quality forage of less than 5–7% of crude protein content, the matter which negatively affected the animals' feed intake and maintenance of body mass in dry seasons (Askar *et al*., 2013 and 2014). In this regard, Nassar, (2014) reported that, the forage quality and its utilization has been reported to affect the total EE. Moreover, small ruminants are unable to maintain their energy and/or nitrogen balance when grazing poor-quality forage or/and either in confinement (El-Meccawi *et al.*, 2009; Nassar, 2014) or under grazing conditions (Askar *et al.*, 2014).

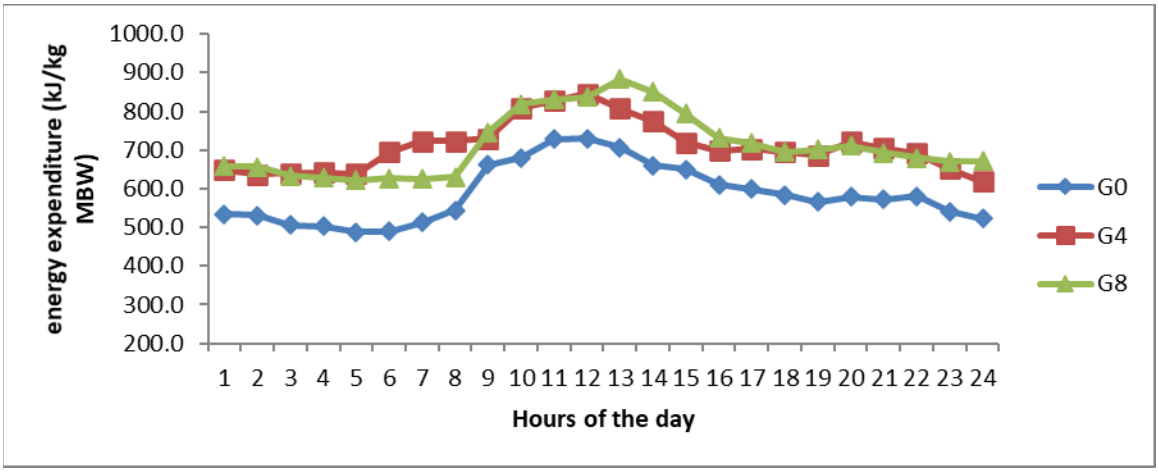

Figure (1): Hourly energy expenditure (kJ/kg MBW) of goats grazing the arid-area rangelands with different grazing times during early lactation period throughout 24-hour period.

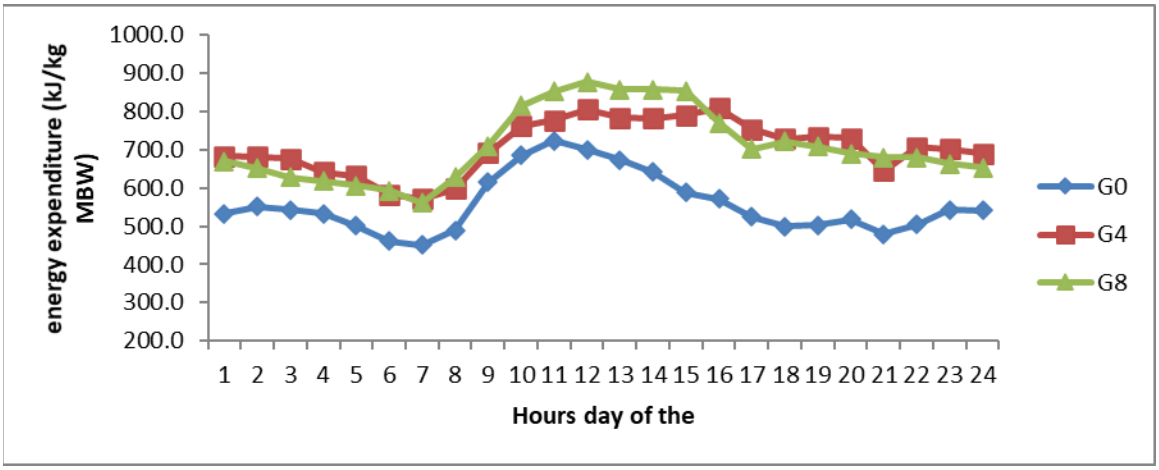

Figure (2): Hourly energy expenditure (kJ/kg MBW) of goats grazing the arid-area rangelands with different grazing times during late lactation period throughout 24-hour period.

CONCLUSION

This study demonstrates that, under the arid-area rangelands conditions, in Halaib-Shalateen region, the grazing practices (8 hours daily) for goats leads to increased forage intake and consequently provides an opportunity for better animal performance, especially during lactation period. Also, grazing for 8 hours showed an increase in digestibility and nutritive value which is reflected in reducing energy expenditure (EE) and increase of energy balance (EB) than grazing of goats for 4 hours during early and late lactation periods**.** Therefore, one of the successful strategies used in natural pastures management is determine grazing time, especially under dry and semi-dry pasture conditions.

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تأثّير وقت الرعى على الهضم والأستفادة من الطاقة للماعز أثناء فترة الحليب فى مراعى حلايب-الشلاتين

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اجريت هذه الدراسة بالمزرعة البحثية للانتاج الحيوانى التابعة لمحطة بحوث حلايب وشلاتين - مركز بحوث الصحراء - بوادى رأس حدربة بمدينة حلايب محافظة البحر الاحمر. كان الهدف من الدراسة هو دراسة تأثير تحديد وقت الرعى على المأكول من المرعى والهضم ومدى الأستفادة من الطاقة بواسطة الماعز خلال أول واخر فترة الحليب تحت ظروف المراعى الطبيعية القاحلة فى منطقة حلايب- الشلاتين.

استخدم فى هذه الدراسة عدد 30 من اناث الماعز البلدية فى بداية فترة الحليب , تم تقسيمها عشوائيا الى ثلاث مجموعات متماثلة طبقا لاوزانها الحية (10انثى ماعز / للمجموعة). اعتمدت الحيوانات فى المجموعة الأولى فى تغذيتها داخل الحظائر بدون رعى على دريس البرسيم للشبع مع تدعيمها بالعلف المركز بنسبة 1% نسبة الى وزن الجسم الحى ، بينما اعتمدت حيوانات المجموعتين الثانية والثالثة فى تغذيتها على رعيها على المرعى الطبيعى (نبات التمام الصلب) لمدة 4 , 8 ساعات يوميا على الترتيب بجانب تدعيمهما بالعلف المركز بنسبة 1% نسبة الى وزن الجسم. تم إجراء تجارب الهضم باستخدام 18 انثى بمعدل (ستة حيوانات من كل معاملة) في مرحلة اول الحليب وفى مرحلة نهاية الحليب, استخدم فيها طريقة الرماد الغير ذائب فى الحامض (AIA) كمرقم داخلى لحساب الماكول من المرعى بعد الجمع الكلى للروث عن طريق اكياس الجمع. تم تقدير الطاقة المفقودة يوميا من حيوانات التجارب (EE) باستخدام معدل ضربات القلب لمدة 48 ساعة بعد المعايرة و الضبط كمؤشر لتقديرالفاقد من الطاقة (EE). تم وضع جميع الحيوانات على جهازالطاقة لقياس كمية الاوكسجين المستهلك وقياس نبضات القلب فى نفس الوقت باستخدام جهاز قياس ضربات القلب(HR). تم دراسة تأثير المعاملات على المأكول من المرعى ومعاملات الهضم والقيمة الغذائية للغذاء ومدى الأستفادة من الطاقة المأكولة وتقدير كمية الطاقة المفقودة وميزان الطاقة تحت ظروف المراعى الطبيعية فى منطقة الدراسة. وكانت أهم النتائج المتحصل عليها كما يلى :

- اوضحت الدراسة ان الماكول من المرعى كمادة جافة محسوبة على اساس حيز الجسم التمثيلى$BW^{0.75}$ قد تأثر بشكل معنوى بالتفاعل بين فترة الحليب والمعاملات, و كان المرعى الماكول يزيد بشكل معنوى مع زيادة فترة الرعى خلال بداية ونهاية فترة الحليب. كما أظهرت الحيوانات التى تتغذى داخل الحظيرة زيادة فى المأكول من دريس البرسيم بالمقارنة بالحيوانات التى ترعى.
- اوضحت النتائج ان معامل هضم البروتين يزيد بشكل معنوى فى فترة أول الحليب بالمقارنة بأخر الحليب. وسجلت الماعز التى ترعى لمدة 4 أو 8 ساعات يوميا قيما اعلى معنويا من الماعز التى لا ترعى فى هضم جميع مكونات الغذاء سواء فى أول الحليب أو فى أخر الحليب. وانعكس ذلك على القيمة الغذائية وخاصة المواد المهضومة الكلية (TDN) التى زادت معنويا فى المجموعتين اللتين ترعى عن المجموعة التى تتغذى داخل الحظيرة بدون رعى خلال فترتى الرعى.
- عندما تم التعبير عن قيمة الطاقة الكلية بالكيلو جول لكل كجم حيز جسم تمثيلى $Kj / kgBW^{0.75}$ سجلت الحيوانات التى ترعى لمدة 8 ساعات يوميا زيادة معنوية لاجمالى الطاقة المأكولة بالمقارنة بالحيوانات التى ترعى لمدة 4 ساعات يوميا خلال فترتى الحليب. فى حين كانت الحيوانات داخل الحظيرة بدون رعى تسجل قيما اعلى ($P<0.01$) لاجمالى الطاقة المأكولة بالمقارنة بالحيوانات التى ترعى.
- كما أظهرت الحيوانات التى ترعى لمدة 8 ساعات كفاءة أكبر فى استخدام الطاقة الممثلة بالمقارنة بالحيوانات التى ترعى لمدة 4 ساعات او بدون رعى خلال فترتى الحليب
- أظهرت الحيوانات التى ترعى لمدة 4 , 8 ساعات زيادة فى معدل ضربات القلب بالمقارنة بالحيوانات التى تربى داخل الحظيرة بدون رعى سواء فى أول أو فى أخر فترة الحليب
- أيضا كان معدل أستهلاك الطاقة للحيوانات فى المجموعة التى ترعى لمدة 4 , 8 ساعات أكبر بشكل معنوى بالمقارنة بالحيوانات التى تبقى داخل الحظيرة بدون رعى سواء فى أول أو أخر الحليب.
- سجلت حيوانات المجموعة الاولى التى بدون رعى قيما اعلى بشكل معنوى ($P<0.01$) لميزان الطاقة عن مثيلاتها فى المجموعتين الثانية والثالثة اللتين سجلتا ميزان طاقة سالب. أيضا أظهرت الحيوانات التى ترعى لمدة 4 ساعات انخفاض معنوى ($P<0.01$) لميزان الطاقة عن الحيوانات التى ترعى لمدة 8 ساعات او بدون رعى خلال فترتى الحليب.

- من خلال النتائج يتضح ان رعى الحيوانات لمدة 8 ساعات خلال فترة الحليب حقق أداء غذائى افضل عن رعيها لمدة 4 ساعات تحت ظروف المراعى الطبيعية فى المناطق القاحلة كمنطقة حلايب والشلاتين. كما يتضح ان استخدام التغذية التكميلية خلال فترة الحليب بنسبة 1% من وزن الجسم غير كافية للحفاظ على ميزان الطاقة للحيوانات تحت ظروف المراعى الطبيعية فى المناطق القاحلة مثل منطقة وادى حدربة بمنطقة حلايب.