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IMPACT OF FEED SHORTAGE ON THE PERFORMANCE OF DESERT BARKI SHEEP AND GOATS UNDER ARID CONDITIONS: I. SHORT AND MEDIUM FEED SHORTAGE PERIODS

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SUMMARY

Arid and semi-arid areas are characterized by frequent incidence of hot drought waves, and consequently shortage in feed availability, which affects the performance of sheep and goats raised there. The present study investigates the effect of feed shortage (FS) on the performance of Barki desert sheep (BS) and goats (BG) under hot dry conditions. Two trials were conducted:1) one week feed shortage (WFS),2) one month feed shortage (MFS).

Body weight (BW)of treated (T)desert Barki ewes and does decrease significantly (P<0.01) with WFS, through the mobilization of their body fat reserves, including fat-tail, to provide nutrients for milk production to feed their offspring. Total milk yield (TMY)of T ewes also decreased significantly with FS. Treated desert sheep and goats expressed compensatory BW gain, once returned to normal feeding.

The MFS significantly decreased BW of the treated ewes by 8.7 kg and milk yield by15.9 kg than the control (C) group. Treated Barki does lost 4.4 kg of their BW and 13.1kg of their TMY, with wide variation in the lactation curve. Persistency in milk production was higher in Barki sheep than that in Barki goats, a desirable character for desert animals. Desert Barki sheep and goats can tolerate feed shortage for a period up to one month, with significant impact on their production performance.

Keywords: desert sheep, desert goats, feed shortage, milk production, body weight

INTRODUCTION

Global warming and climatic changes affect the world rain-fall map. Arid and semi-arid areas are facing hot drought waves more frequent than before, and consequently decrease in feed and food availability (FAO 2015). In this context, desert sheep and goats are well adapted to hot dry conditions with limited water and feed resources; they walk for a long distance searching for water and scarce vegetation. They survive, produce, and reproduce under arid conditions.

Shortage in feed availability results in less milk yield (MY), body weight (BW) losses, low reproduction performance and slow kids' growth (Atti *et al*., 2004, and Morris, 2017). Morris (2017) highlight further the effect of feed shortage (FS) on the immune system and disease resistant; death may occur in extreme feed shortage conditions. Improving livestock productivity in arid areas can be achieved basically by improving feed availability. Feasibility of the livestock enterprises in the arid areas is therefore a function of feed availability and feeding management (Gowane, *et al*., 2017, and Asín *et al.*, 2021).

Barki sheep and Barki goats are the habitats of the Coastal Zone of Western Desert (CZWD), of Egypt. They have a recognizeable capability to produce and reproduce in the arid areas on sparse vegetation and limited water resources. Lambs and kids are their main outputs, milk production is basically to feed their lambs/kids. Total milk yield of desert Barki ewes increases with the improvement of feeding level (Abdallah *et al*., 2012). Similarly, Awassi sheep produced more milk given high level of feeding, than those fed medium or low levels (Al- Jassim *et al*., 2002). Barki sheep were described by Aboul Naga and Abdelsabour (2023) as a medium size breed, long legged with triangular fat-tail. Coat color is mostly white with brown or black head and legs. Barki goats are small, black in color or dark brown (Aboul-Naga *et al*., 2023).

With the frequent incidence of drought in the arid areas of Egypt, Barki desert sheep (BS) and goats (BG) are facing frequent incidence of FS periods. The present study investigates the impact of short and medium feed shortage periods on the performance of Barki sheep and goats, under the hot dry conditions of north CZWD of Egypt.

MATERIALS and METHODS

The experimental work was carried out at Borg-Arab Farm, Animal Production Research Institute; within the activity of “Adapt- Herd", a PRIMA-EU Collaborative Project with: France, Spain, Tunisia, and Egypt.

Ewes and does were subjected to individual feeding in individual pens, average dry matter intake (DMI) / kg milk was calculated for each group. Milk yield (MY) was determined for ewes and does at weekly intervals using oxytocin plus hand milking method according to Ünal *et al*. (2007).

Experimental design:

Two main trials were conducted:

Trial I: One week feed shortage (WFS):

Sixty animals (30 mature Barki ewes and 30 mature Barki does) in their second week of lactation, were distributed by age and parity in two groups; control group (C,10 ewes and 10 does) and treated ones (T,20 ewes and 20 does). The initial body weight of the ewes averaged 49.4±2.04kg, and 28.2±1.61 kg for the does. The experimental work was carried out in June2020 (Ambient temperature averaged 36.4ºC, relative humidity 45.5% and Temperature Humidity Index, estimated as 84.7).

Animals were fed on good quality roughage (Alfalfa hay) and concentrate feed mixture (CFM) of 14% CP, according to NRC (2007) allowances on 50:50% roughages: concentrate ratio. Proximate analysis of the hay and CFM as dry matter are presented in Table (1). The T groups fed Alfalfa hay for only one week, after that, they return to the normal diet.

Table 1. Proximate analysis and nutritive value of Alfalfa hay and concentrate feed mixture CFM (%)

Nutrients	Alfalfa hay	CFM
Dry matter (DM)	90.02	90.72
Crude protein (CP)	19.47	14.30
Ether extract (EE)	1.18	3.65
Crude fiber (CF)	27.62	12.03
Nitrogen free extract (NFE)	39.69	61.23
Ash	12.40	9.73

Barki ewes and does and their offspring were weighed weekly for changes in BW. Daily milk yield (DMY) was measured over lactation period of 10 weeks; and milk samples were taken weekly for milk composition analysis (protein, fat, and total solids %). Variables measured were weekly changes in BW, ADG of lambs/kids up to weaning at eight weeks, DMY, TMY, and milk compositions.

Trial II: One month feed shortage (MFS):

Sixty animals (30 Barki mature ewes and 30 mature Barki does), in their second week of lactation, average BW of 53.3±1.91kg and32.2±1.95kg, for the two species, respectively, were involved in the experimental work. The animals were distributed by age and parity to two groups: control groups (C,10 ewes and 10 does) and treated groups (T,20 ewes and 20 does). The experimental work started on June 2021, Barki ewes and does were fed individually on CFM (14% CP) and Alfalfa hay, according to NRC (2007) allowances. Treated ewes were fed Alfalfa hay only (zero concentrates) for one month after that they returned to normal diet till end of lactation. Water was freely available all the time for all animals throughout the whole experiment.

Ewes, does and their offspring were weighed weekly and milk yield was measured daily till the end of lactation (10 weeks). Milk samples were taken weekly for milk composition analysis (protein, fat and SNF %).

Statistical analysis:

Data for ewes and does were analyzed using general linear model procedure of SAS (2013) according to the following statistical model:

$Y_{ij} = \mu + T_i + e_{ij}$ where,

Y_{ij} is the estimated value of the j^{th} animal on the i^{th} treatment,

μ is the overall mean,

T_i is the fixed effect of i^{th} treatment,

i = 1 and 2 (1 = control and 2 = treatment),

e_{ij} is the random error distributed by $(0, \sigma_e^2)$.

Gamma-type function suggested by Wood (1967) were used to describe the lactation curve as follows: $Y_n = an^b e^{-cn}$ *where:*

Y_n the test day of milk (g) in the n^{th} wk.

a initial milk yield (g);

b rate of milk increases to peak(g/wk.),

c rate of decline after peak (g)

e base of natural logarithms.

Persistency*(P)* is a variable related to shape of lactation curve, calculated as; P = -(b+1) Ln (c).

RESULTS

Trial I: One week feed shortage (WFS):

Lactating ewes and does under one week FS (WFS), showed significant losses in their BW(P<0.01). Body weight losses were significantly higher than in the control groups (Table 2). Over the whole 10-wk lactation period, T ewes lost 2.3kg, vs.0.2 kg for the C group. The treated Barki does lost 1.9 kg of their BW during one-week FSvs.0.8kg for the C ewes; and lost 3.1 kg over the whole lactation period (10 weeks) vs.2.5 kg for the C group. Treated ewes and does show clear BW compensation when returned to normal diet (Table 2). Daily gain and weaning weight of the lambs and kids of T ewes and does were insignificantly less than those from the C groups.

Feed shortage for one week, decreased DMY of T Barki ewes from 1.3 kg to 1.0 kg (Fig. 1), which led to significant decrease in TMY of T ewes during FS week by 9.6 kgvs.12.3 kg for the C group. Total milk yield during the whole lactation period was 57.6 kg and 78.6 kg for the two groups, respectively (Table 2). The corresponding figures for the Barki does were 11.7kg and 15.5 kg during the FS week, and 67.4 kg and 94.5 kg for the whole lactation period, respectively (Fig. 2 and Table 2). The percentages of milk compositions did not differ between C and T ewes or does. Differences in total fat yield of the does are associated with the significant decrease in their TMY (Table 2).

Dry matter intake per kg milk (DMI/ kg milk) differs lightly between the treated groups and the control ones during the FS for one week (WFS). However, it was significantly high (P<0.01) over the whole lactation period (2.86and 1.83 for the T ewes and does, vs.2.13and 1.33forthe C groups, respectively).

Treated Barki ewes and does show wide individual variation in their lactation curve shape and parameters, in response to the WFS (Table3, and Fig.3) resembling non-dairy animals. Some animals dried-off early at 8weeks, while others had longer lactation than 10 weeks. The lactation curve parameter “a” was lower in the ewes than that in the does, differences were also detected in "b" parameter (rate of increase in lactation curve) between sheep and goats. Persistency, defined as the extent to which the peak yield is maintained (Grossman *et al*.,1999), was higher in sheep than goats, which means that goats are better dairy animals under desert conditions.

Table 2. Productive performance of Barki sheep and goats with one week feed shortage

Traits	Sheep		Goat	
	Control	Treatment	Control	Treatment
BW change during WFS (kg)	-1.0^a ± 0.87**	-5.3^b ± 0.62	-0.8^a ± 0.36 **	-1.9^b ± 0.26
BW change during whole lactation period (kg)	-0.2^a ± 1.31	-2.3^a ± 0.93	-2.5^a ± 1.03	-3.1^a ± 0.60
Lambs/kids wean. weight (kg)	24.8^a ± 1.55	24.1^a ± 0.83	15.0^a ± 0.89	13.6^a ± 0.49
Lamb/kids daily gain (g)	209.8^a ± 15.61	201.6^a ± 9.25	114.4^a ± 8.6	101.3^a ± 4.6
TMY for one week FS (kg)	12.2^a ± 1.08*	9.6^b ± 0.57	15.5^a ± 1.51**	11.7^b ± 0.53
TMY for 10 weeks lactation (kg)	78.6^a ± 5.32**	57.6^b ± 3.76	94.5^a ± 6.91**	67.4^b ± 4.89
DMI kg /kg milk for one week FS	1.40^a ± 0.16	1.48^a ± 0.08	0.83^a ± 0.09	0.85^a ± 0.03
DMI kg / kg milk in 10 weeks lactation	2.13^b ± 0.19**	2.86^a ± 0.17	1.33^b ± 0.10**	1.83^a ± 0.10
TDN kg / kg milk in one week FS	0.93^a ± 0.11	1.00^a ± 0.05	0.55^a ± 0.06	0.58^a ± 0.02
TDN kg /kg milk in 10weeks lactation	1.41^b ± 0.13**	1.90^a ± 0.11	0.89^b ± 0.07**	1.22^a ± 0.07
Milk fat yield(kg)	59.4^a ± 7.10	52.8^a ± 3.06	59.5^a ± 9.15*	37.4^b ± 4.50
Milk solid nonfat yield (kg)	73.2^a ± 6.66	64.1^a ± 3.41	90.2^a ± 11.18	67.3^a ± 7.71
Milk protein yield (kg)	27.9^a ± 2.53	24.4^a ± 1.27	34.2^a ± 4.23	25.6^a ± 2.93

*Means with different superscript letter differ significantly at 5% P

**Means with different superscript letter differ significantly at 1% P

TMY: total milk yield, DMI: dry matter intake, TDN: total digestible nutrient

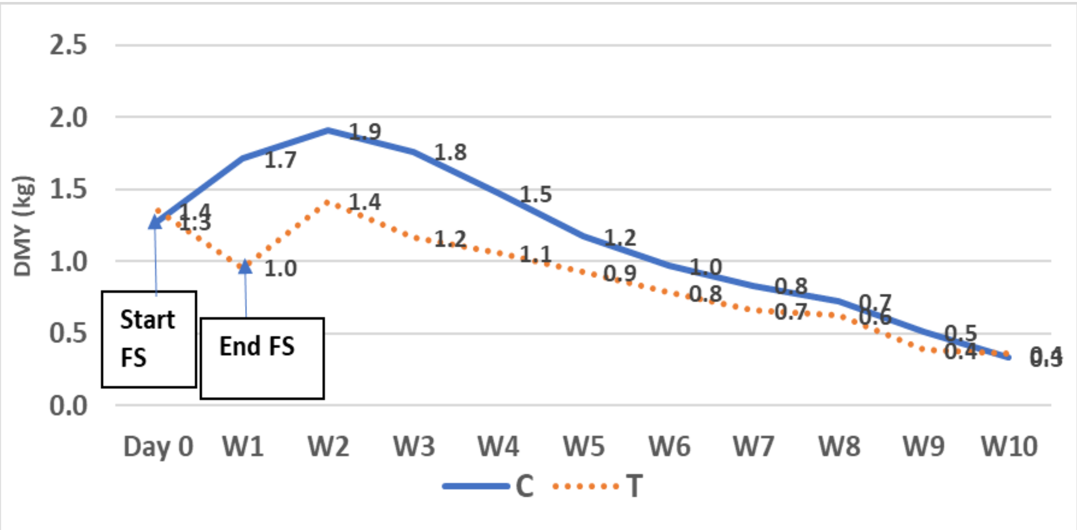

Fig. 1. Daily milk yield (kg) of Barki ewes with one week feed shortage.

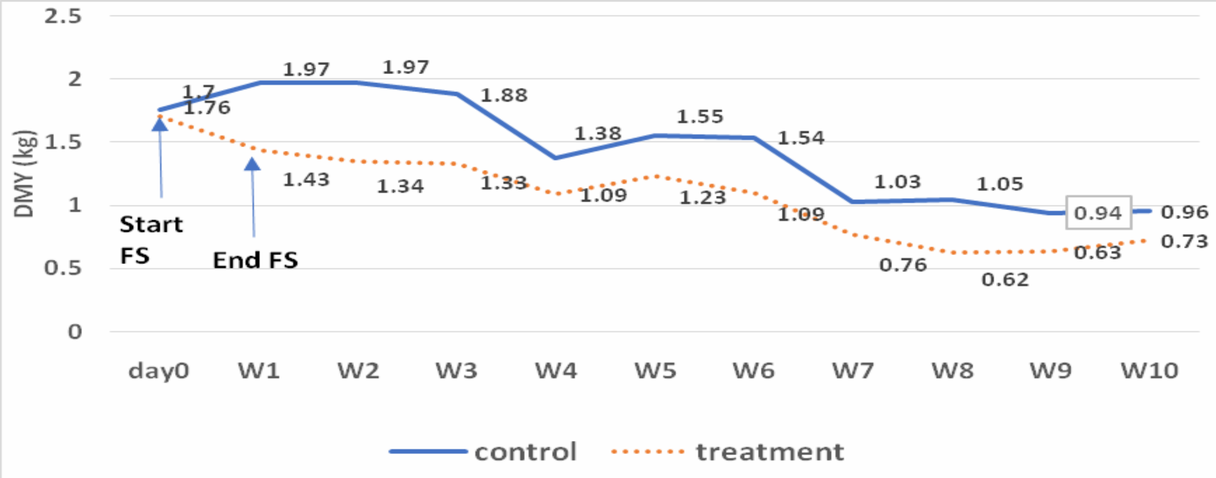

Fig. 2. Daily milk yield (kg) of Barki does with one week feed shortage.

Table 3. Lactation curve parameters for treated (T) Barki sheep and goats.

FS periods	a*	b	c	P
Barki Sheep T				
WFS	7.26^{a}**±0.06	0.47^{a}±0.08	0.22^{a}±0.02-	2.21^{a}±0.05
MFS	6.86^{b}±0.07	0.63^{a}±0. 11	-0.22^{a}±0.04	2.52^{a}±0.14
Barki goats T				
WFS	7.42^{a} ±0.06	-0.04^{a} ±0.07	-0.06^{a}±0.01	1.61^{a}±0.12
MFS	7.73^{a}±0.10	-0.71^{b}±0.13	0.02^{a}±0.04	1.29^{b}±0.32

*a: initial milk yield; b: rate of increase to peak; c: rate of decline after peak; P: presistensy
**estimates superscribed by the same symbol did not differ significantly from control

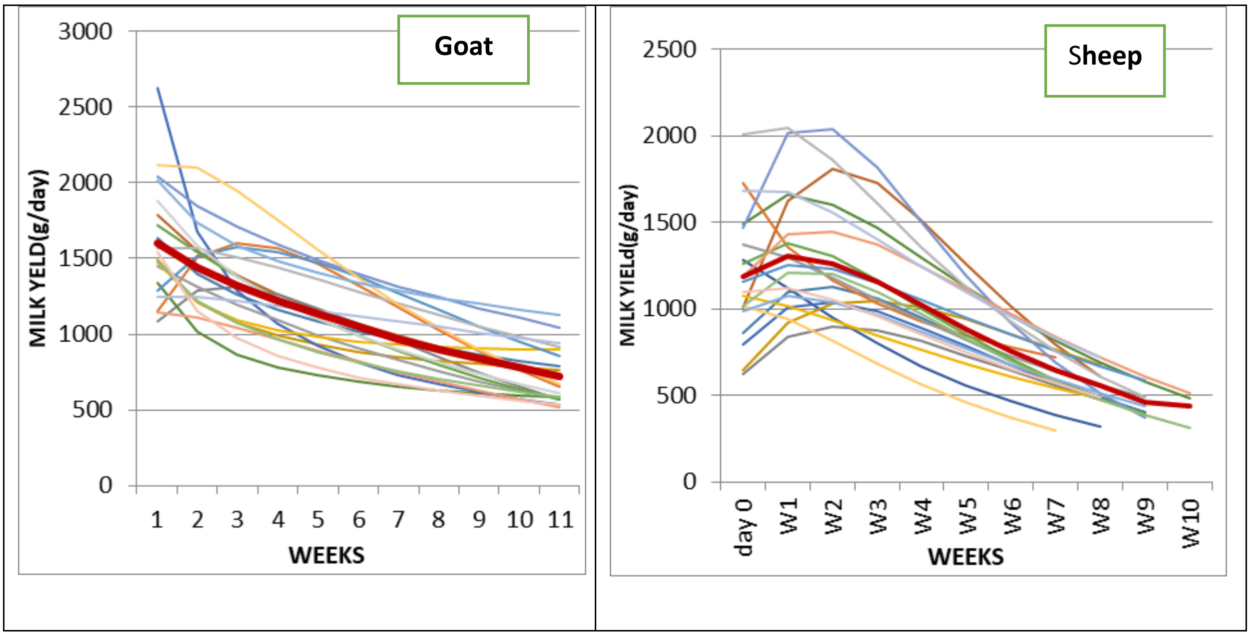

Fig. 3. Individual lactation curve of treated ewes and does in the WFS trial.

Trial II: One month feed shortage (MFS):

Losses in BW of T Barki ewes with one month FS, were significantly (P<0.01) higher in the T ewes than in the control ones (8.7 kg vs.2.4 kg). Treated ewes lost 5.5 kg of their BW over the whole lactation period *vs* 1.5 kg in the C group. Treated ewes expressed clear compensatory gain in their BW once returned to normal diet, and the differences between the two groups were diminished (Table 4).

The Losses in BW of MFS Barki does over the whole lactation period, were insignificantly differ from the C does (1.3kg vs. 2.6 kg). Weaning weight of their kids was10% lower than that in the control group (2.7kg vs. 1.9kg). The growth rate of Barki kids was 14% less in the T group than the C does (228g *vs*. 177g; Table 4); however, the differences were statistically insignificant.

Milk yield of the T ewes decreased significantly ($P<0.05$) to 55.2 kg vs. 43.3 kg for the C group, during the FS period (Fig. 4 and Table 4). Over the whole lactation period, TMY decreased also significantly ($P<0.05$), being 66.6 kg for the T ewes vs.78.5 kg for the C ones (Table 4). Estimates of MY of Barki sheep are in the line with that reported by Aboul-Naga *et al*. (1981) as non-dairy subtropical sheep. Milk yield of T Barki does during the FS period, decreased significantly ($P<0.05$) to 43.7 vs. 48.8 kg for the C group (Fig. 5 and Table 4). Over 10 weeks of lactation, TMY decreased significantly ($P<0.05$) to 78 kg vs. 91 kg for the Cones. Milk composition did not differ between the two groups in either Barki ewes or Barki does. Treated ewes and does show detectable individual variation in their DMY over the whole lactation period (Fig 4 and 5). The treated animals showed wide variation in their lactation curve shape and parameters; again, with better persistency estimates for desert sheep than for desert goats (Table 3).

Dry matter intake (DMI) and TDN per kg milk production during the FS period, differ significantly ($P<0.01$) between the control and the treated groups, in both Barki ewes and does. Differences for DMI and TDN/kg milk, between C and T groups over the whole lactation period, were statistically insignificant (Table 4).

Table 4. Productive performance of Barki sheep and goats with one month feed shortage

Traits	**Sheep**		**Goats**	
	Control	**Treatment**	**Control**	**Treatment**
Body weight changes during one month feed shortage (kg)	$-2.4^{a} \pm 1.15$ **	$-8.7^{b} \pm 0.86$	$-2.1^{a} \pm 1.02$	$-4.4^{a} \pm 0.87$
Body weight change in 10weeks lactation (kg)	$-1.5^{a} \pm 0.35$ *	$-5.5^{b} \pm 0.43$	$-1.3^{a} \pm 0.54$	$-2.6^{a} \pm 0.67$
Offspring weaning weight (kg)	$27.0^{a} \pm 2.9$	$24.3^{a} \pm 1.9$	$20.9^{a} \pm 2.4$	$18.0^{a} \pm 1.9$
Offspring daily gain (g)	$251.6^{a} \pm 4.3$	$242.7^{a} \pm 25.3$	$228.1^{a} \pm 30.7$	$177.2^{a} \pm 25.7$
TMY During month FS	$55.2^{a} \pm 2.9$*	$43.3^{b} \pm 1.7$	$48.8^{a} \pm 7.4$*	$43.7^{b} \pm 2.7$
Total milk yield (10 weeks)	$78.5^{a} \pm 5.3$ **	$66.6^{b} \pm 3.1$	$91.0^{a} \pm 0.1$**	$77.9^{b} \pm 7.3$
DMI kg/g milk for one month FS	$0.25^{a} \pm .02$**	$0.17^{b} \pm 0.01$	$0.18^{a} \pm 0.03$**	$0.10^{b} \pm 0.01$
DMI kg / kg milk for10 weeks lactation	$1.71^{a} \pm 0.14$	$1.68^{a} \pm 0.08$	$1.00^{a} \pm 0.20$	$0.86^{a} \pm 0.07$
TDN kg/kg milk during month FS	$0.16^{a} \pm .01$**	$0.11^{b} \pm 0.01$	$0.12^{a} \pm 0.02$**	$0.06^{b} \pm 0.01$
TDN kg/kg milk for 10 weeks lactation	$1.10^{a} \pm 0.09$	$1.07^{a} \pm 0.05$	$0.64^{a} \pm 0.13$	$0.55^{a} \pm 0.04$
Milk Fat yield (kg)	$66.3^{a} \pm 14.1$	$62.7^{a} \pm 7.2$	$50.9^{a} \pm 12.5$	$51.0^{a} \pm 7.0$
Milk solid nonfat yield(kg)	$70.3^{a} \pm 13.22$	$69.9^{a} \pm 6.16$	$85.6^{a} \pm 13.14$	$83.7^{a} \pm 8.13$
Milk protein yield (kg)	$26.9^{a} \pm 5.1$	$26.7^{a} \pm 2.4$	$32.5^{a} \pm 5.0$	$31.3^{a} \pm 3.1$

*Within the specie, estimates followed by the same symbol don't differ significantly at 5%

**Within the specie, estimates followed by the same symbol don't differ significantly at 1%

TMY: total milk yield, DMI: dry matter intake, TDN: total digestible nutrient

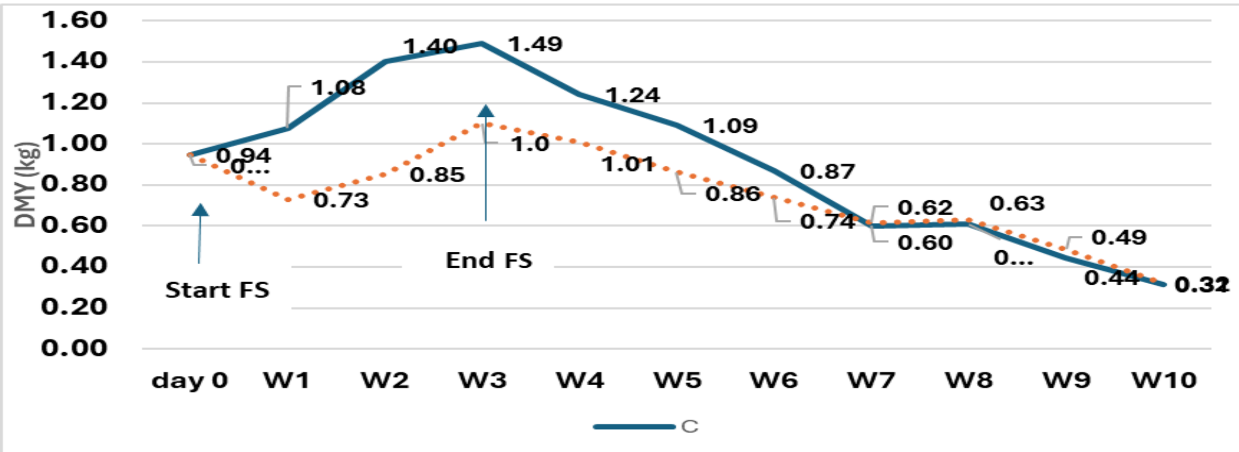

Fig. (4) Daily milk yield (kg) of control (C) and treated (T) ewes for 10 weeks lactation for one month feed shortage period.

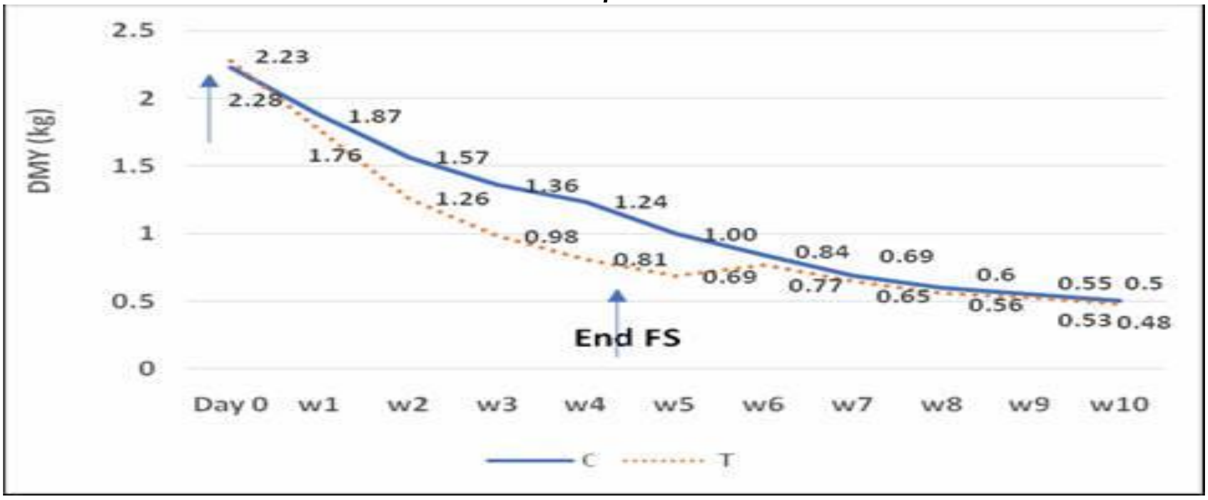

Fig. 5. Daily milk yield (kg) of control (C) and treated (T) does for 10 weeks lactation for one month feed shortage period.

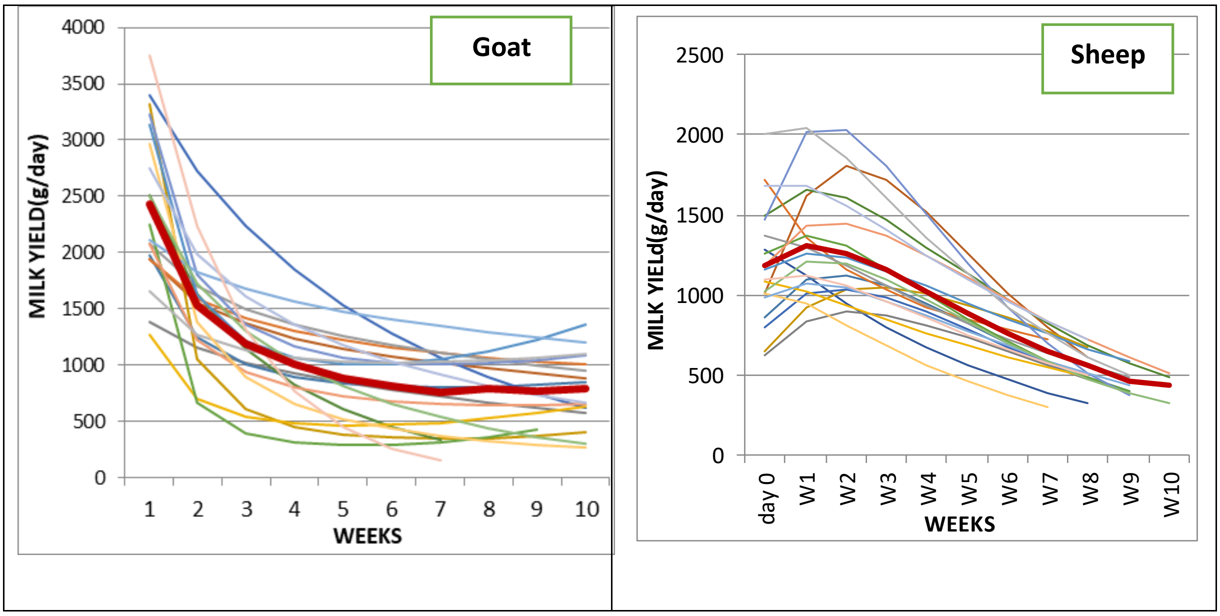

Fig. 6. Lactation curve of treated Barki sheep and goats with one month feed shortage.

DISCUSSION

Feed shortage for short (one week) or medium (one month) period, had negative impact on the performance of desert Barki sheep and goats, more recognizable in BW loss than in MY shortage (Table 5). Losses in BW were as expected, greater in one month FS than in one week FS. Treated Barki desert ewes lost 4.6 % of their weight with WFS, compared to 11.1 % with MFS. BW losses of Barki does were 9% and11%with WFS and MFS, respectively; with significant decline in MY. The projected procedure for BW losses was the mobilization of their body fat reserves, including the fat-tail in the sheep, to provide the nutrients requires for milk production to feed their lambs. Under arid conditions, Abdalla *et al.* (2014) confirmed that sheep have better tolerance to FS than goats, due to greater body fat deposition including their fat tail. Fat tail plays an important role in the adaptation of sub-tropical sheep to FS in the arid and semi-arid regions (Al Jassim *et al*., 2002, and Atti *et al.*, 2004). Sejian *et al.* (2014) reported that changes in BW of small ruminants with feed restriction in harsh environment, are influenced by multiple hormones that regulate growth performance. Improving feed availability after the FS period promotes the partition of feed energy intake to compensate losses in BW. Decrease in MY of Barki desert sheep and goats with FS did not affect milk composition. Min *et al.* (2005) reported minimal changes in feed diets on milk composition of goats, compared with its effect on MY.

The interesting finding is that losses in BW in Barki sheep and goats recovered fast, once the animals returned to normal feeding. This confirms the capability of desert sheep and goats to compensate for their BW losses, fast when return to the normal diet. Compensation of BW with feed availability, is associated with increasing diet energy, which enhances rumen microorganisms and improve nutrients digestion and microbial protein synthesis (El Shobokshy *et al*.1992 and Hosseini, 2008).

Higher losses in BW of MFS ewes could be due, partially, to climatic factors. Monthly feed shortage ewes were exposed to heat waves during lactation period (ambient temperature averaged 36.4ºC vs. 31.3ºC) for WFS. Animals consume part of their energy to get rid of the heat load through panting (Aboul-Naga *et al*., 2021). These consume part of the energy available for milk production and BW gain.

Differences in DMI and TDN/kg milk between WFS and MFS are mainly due to differences in feed consumption. With shortage in concentrations, the treated animals consume more roughages with less nutrient value. Feed consumption depends on several factors; including bodyweight, milk production, ambient temperature, and water availability (Goetsch, *et al*., 2001; Kholif, *et al*., 2014).

Table 5. Impact of the feed shortage (FS) on the productive performance of Barki sheep and goats

Traits	**Sheep**		**Goats**	
FS period	**WFS**	**MFS**	**WFS**	**MFS**
Losses in body weight during 10wks lactation(kg)	-2.3	-5.5	-3.1	-2.6
Offspring weaning weight (kg)	24.1	24.3	13.6	18.0
Offspring average daily gain (g)	201.6	242.7	101.3	177.2
Milk yield during the FS period(kg)	9.6	43.3	11.7	43.7
Total milk yield (10 weeks) (kg)	57.6	66.6	67.4	77.9
DMI kg / kg milk during FS period	1.48	0.17	0.85	0.10
DMI kg / kg milk during whole lactation period	2.86	1.68	1.83	0.86
TDN kg / kg milk during FS period	1.00	0.11	0.58	0.06
TDN kg / kg milk during whole lactation period	1.90	1.07	1.22	0.55

WFS: Week feed shortage, MFS: month feed shortage

TMY: total milk yield, DMI: dry matter intake, TDN: total digestible nutrient

CONCLUSIONS

The present findings confirmed that desert Barki sheep and goats can tolerate feed shortage for a period up to one month, with significant impact on their production performance (body weight and milk yield). However, they were capable to compensate losses in their body weight and daily milk yield once feed was available. Acharacter which had been developed by desert sheep and goats over centuries of natural selection to cope with the frequent incidence of feed shortage in the arid areas. They produce and reproduce well under desert conditions, with limited feed resources and frequent incidence of FS periods. It is interesting to notice the wide variation within the treated animals in response to FS, revealing possibility for selection within desert sheep and goats for their capability to stand FS under arid desert conditions.

Feed shortage periods in the CZWD of Egypt is reported to extended for3-4 months (Shalaby ,1999). It may be recommended to investigate the effect of longer FS period of 3-4 months on the performance of desert sheep and goats and how they cope with it, to imitate the actual desert conditions.

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أثر نقص الأعلاف على أداء الأغنام والماعز البرقي الصحراوية بالمناطق الجافه:١. نقص الأعلاف لفترات قصيرة ومتوسطة

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تواجه المناطق القاحلة موجات حارة جافة متكررة، وبالتالي نقص في توفر الأعلاف مما يؤثر على أداء الأغنام والماعز التي يتم تربيتها هناك. تناولت الدراسة تأثير نقص الاعلاف على أداء الأغنام والماعز البرقي الصحراويه تحت الظروف الحارة الجافة. أجريت تجربتان؛ (١) نقص الأعلاف لمدة أسبوع واحد (WFS)، (٢) نقص الأعلاف لمدة شهر واحد (MFS).

انخفض وزن الجسم للنعاج البرقي بشكل معنوي (P<0.01) من خلال استهلاك مخزونات الدهون في الجسم بما في ذلك دهن اللية، لتوفير العناصر الغذائية اللازمة لإنتاج الحليب لتغذية صغارها. كما انخفض إجمالي إنتاج الحليب بشكل ملحوظ. أظهرت الأغنام والماعز البرقي الصحراوية المعاملة زيادة تعويضية في وزن الجسم بمجرد عودتها إلى التغذية الطبيعية.

انخفض وزن الجسم للنعاج المعاملة لمدة شهر بمقدار ٨,٧ كجم وإنتاج الحليب بمقدار ١٥,٩ كجم مقارنة المجموعة المقارنة. فقدت الماعز البرقي٤,٤ كجم من وزن الجسم و١٣,١ كجم من إنتاج الحليب عند تعرضها لنقص الاعلاف لمدة شهر، مع تباين واسع في شكل منحنى الحليب، وكانت المثابرة على إنتاج الحليب أعلى في الأغنام منها في الماعز، وهي صفة مرغوبة في الحيوانات الصحراوية.