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Wool Production and Characteristics, Physiological and Haematological Parameters and Level of some Metabolic Hormones in Barki Ewes Shorn in Autumn as Alternative of Spring Shearing

Taha, E. A.[1*]; A. E. Abdel-Khalek[2]; W.A. Khalil[2];and Nahla R. M. Abdel Aal[1]
[1]Wool Production and Technology Department, Animal and Poultry Production Division, Desert research Center, Cairo, Egypt.
[2]Animal Production Department, Faculty of Agriculture, Mansoura University, Egypt.
***Corresponding author email: dr.emadelislam@gmail.com**

ABSTRACT

This study was conducted under the semi-arid desert conditions of the northwest coastal belt of Egypt to evaluate the effect of autumn *vs*. spring shearing on wool production, some wool traits, physiological responses, thermal gradients, haematological, biochemical parameters and hormonal profile of thyroxin (T4) and cortisol of adult Barki ewes. Results show that autumn shearing reduced ($P<0.01$) body weight loss; resulted in heavier ($P<0.05$) greasy fleece weight with lower fiber diameter ($P<0.05$) and improved the uniformity of wool fiber diameter, point of staple break ($P<0.05$) and wool staple elongation rate ($P<0.01$) compared with spring shearing. Spring shearing resulted in higher skin temperature ($P<0.05$) and thermal gradient between rectal and skin temperature ($P<0.01$), elevated ($P<0.05$) serum globulin concentration and declined ($P<0.05$) albumin/globulin ratio. Serum T4 and cortisol profiles were not affected by shearing in spring or autumn. These results indicated that altering shearing time of Barki sheep from spring to autumn may be safely conducted without negative effects on wool production, physiological responses, blood constituents and animal homeostasis. The reduction in body weight due to shearing suggests the necessity of providing additive food supplementation after shearing to avoid weight loss particularly in autumn.

Keywords: Shearing, season, wool quality, haematological traits, thyroxin, cortisol.

INTRODUCTION

Fleece plays an impotent role in protecting sheep against the surrounding environmental conditions in different seasons. Maintenance of sheep homeothermy is influenced by their fleece which represents an insulating layer protecting the animal against both heat and cold. Fleece removal modifies the thermoregulation and hence the homeostasis mechanisms (Sleiman and Saab, 1995; Pennisi *et al.*, 2004; Casella *et al.*, 2016). Seasonal variations in climatic conditions were found to be in accordance with seasonal changes in wool traits (Taha, 2004; Campbell, 2006; Khan *et al.*, 2012) and adaptability related physiological parameters(De Alvarenga *et al.*, 2013; Casella *et al.*, 2016; Altin *et al.*, 2018).

Shearing induces adaptive thermogenesis in shorn sheep under either extreme or climatically mild atmosphere conditions (Al - Ramamneh *et al.*, 2011). Shearing modificates nervous control mechanisms and readjusts the thermoregulation and energy saving mechanisms that play a major role in post shearing adaptation (Aleksiev, 2009). Under intensive and extensive production systems, shearing is considered as one of the most effective stressors that face sheep (Dikmen *et al.*, 2011; Sanger *et al.*, 2011; Hristov *et al.*, 2012).

Shearing time was found to affect the physiological responses, thermoregulation, homeostasis mechanisms, haematological traits and hormonal profile of sheep. Piccione and Caola (2003) revealed that the extremely low thermal conductivity of the fleece maintains a high thermal gradient between atmosphere and the skin in winter and summer. In fact, the conditions of the outer coat layer are modified by shearing resulting in a change of thermal conductance. Several authors reported that shearing in different seasons significantly affected thermoregulation, blood parameters and seminal traits of desert sheep (Turnpenny *et al.*, 2000; El-Zeiny, 2011; Suhair and Abdalla, 2013).

This study aimed to compare the effect of autumn *vs*. spring shearing on wool production, some wool traits, physiological responses, thermal gradients, haematological traits and hormonal profile of thyroxin (T4) and cortisol of Barki ewes raised under the semi-arid desert conditions of the northwest coastal belt of Egypt.

MATERIALS AND METHODS

This study was carried out in Maryout Research Station (32º N Latitude, 35 km southwest of Alexandria), belonging to Desert Research Center, Ministry of Agriculture and Land Reclamation in cooperation with Animal Production Department, Faculty of Agriculture, Mansoura University. This location was chosen to represent the semi-arid desert conditions of the northwest coastal belt of Egypt.

Animals and management

Twenty four adult non-pregnant and non-lactating Barki ewes, aged 3-4 years with average body weight of 37.24±4.906 (kg) were used in this study. Animals were housed in sheltered semi-open pins and were fed concentrate feed mixture (0.5 kg $head^{-1}$ day^{-1}) consisted of 50% cottonseed cake, 15% yellow corn, 18% wheat bran, 11% rice polish, 3% molasses, 2% limestone and 1% common salt. The concentrate mixture contained 60% TDN and 14% CP. Berseem hay (*Trifolium alexandrinum*) was offered *ad. Libitum.* Drinking access was available twice a day. Animals were healthy and free of internal and external parasites.

Experimental design

Ewes were randomly divided into four groups (n=6 in each), and two groups were used in each season. In spring, the first group was kept unshorn and acted as control, while the second group was shorn at the beginning of April. In autumn, the same procedures were used where one group acted as unshorn control group, while another group was shorn at middle of September. The studied parameters were compared between unshorn and shorn ewes in each season.

Meteorological data

Average ambient temperature (ºC) and relative humidity (%) were recorded daily. Temperature-Humidity

Index (THI) was calculated using the following equation that described by (Casella *et al.*, 2016):

$$THI = AT - 0.55\ (1-(0.01\ RH)\ (AT-14.5)$$

Where AT: ambient temperature (ºC) and RH: relative humidity (%).

Live body weight

Live body weight of the experimental animals was recorded monthly in the early morning before feeding and drinking to the nearest 0.1 kg.

Physiological parameters

Rectal temperature (ºC), skin temperature (ºC), and respiration rate were measured on day of shearing and on days 15, 30 and 45, thereafter. Respiration rate was recorded by counting frequency of flank movements per minute; all required precautions were considered to avoid animal's disturbance. Rectal temperature (RT) was measured to the nearest 0.1 °C using a standard clinical thermometer inserted into the rectum approximately two inches for 2 minutes. Skin temperature (ST, °C) was taken using a digital thermometer placed over the skin at the mid-side region of animal body.

Wool sampling and measurements

Wool samples (about 200 g/ewe) were obtained from the left mid-side position of each ewe during the experimental period to record wool measurements. After shearing of the experimental ewes in spring and autumn, greasy fleeces were weighed using digital balance to nearest 10 grams. The greasy samples were scoured to estimate wool yield percentage (Chapman, 1960; I.W.T.O., 1971).

$$Yield\ (\%) = \frac{Weight\ of\ scoured\ and\ dried\ sample}{Weight\ of\ greasy\ sample} \times 100$$

Fiber diameter, from unless than 300 fibers of each sample, was measured by utilizing Image Analyzer (Zen, 2012). Average fiber diameter and its standard deviation were calculated and the number of medullated fibers was counted to calculate its percentage for each sample.

After classifying the fibers into fine, coarse, hetrotype and kemp, ten fibers were taken at random from each type to measure their length using a ruler to the nearest 0.5 cm. Just enough tension was applied to straighten the fiber without stretching. The length measurement was taken as the distance between the base and the tip of the fiber. Number of crimps cm^{-1} was counted against millimeter ruler at the middle part of fibers where single crimp was regarded as the distance between the bottoms of two consecutive crimps.

About 10 staples were taken at random from each greasy wool sample were used to measure staple length using a millimeter ruler on a black velvet covered board without stretching the staple (Booth, 1964). Wool staple lengths were measured to the nearest 0.01 cm to calculate the average staple length of each sample. Agritest staple breaker (Agritest Pty. Ltd.) was used to measure staple strength (N/Ktex), point of staple break (%) and staple elongation rate. Ten regular staples were taken randomly from each wool sample to estimate these tests according to the methods and equations of Heuer (1979) and Caffin(1980):

$$Elongation\ rate\ (\%) = \left(\frac{Length\ of\ tip\ (cm) + Length\ of\ base\ (cm)}{Staple\ length(cm)}\right) x\ 100$$

$$Point\ of\ Breake\ (\%) = \left(\frac{Length\ of\ tip\ (cm)}{(Length\ of\ tip\ (cm) + Length\ of\ base(cm)}\right) x\ 100$$

Fiber type ratio (FTR) was measured by count. A small snippet was placed on black velvet and was visually divided into four types of fiber, i.e. fine (non-medullated), coarse (medullated), heterotype and kemp (more than 85% of cross sectional area as medulla) according to (Guirgis, 1967); unless than 300 fibers from each sample were used in this test. Benzene test was used to differentiate between coarse and fine fibers (Ryder and Stephenson, 1968). Then, fibers from each type were counted and their percentages were calculated. Medulation index (MI) was calculated by multiplying the percentage of each fiber type by the type score (1, 2, 3 and 4 are the scores given to fine, coarse, heterotype and kemp, respectively), summing the resulted values then dividing the sum by 10 according to the adopted equation by (Guirgis, 1973) as follow:

$$Medullation\ Index = \frac{1}{10}\sum_{i=1}^{4} ip_i$$

***(i)*: type score and (*p_i*): *i^{th}* type %.**

Blood sampling and measurements

Blood samples were collected through Jugular vein puncture using clinical needle at 9 a.m. on day 0, 15, 30 and 60 of shearing during each season. Blood samples were taken into two tubes; the first one contained ethylenediamine tetra acetic acid (EDTA) as anticoagulant for haematological parameters. Another vial without any anticoagulant was centrifuged at 3000 rpm for 15 minutes, providing serum which was stored at -20 °C in glass vials for blood biochemical analyses. Haematological parameters including count of erythrocytes (RBCs), leukocytes (WBCs), concentration of haemoglobin (g/dl) and packed cell volume (PCV%) were estimated using a full automated Haematological Analyzer (CBC, Mindray-3200). Blood biochemical parameters including concentration of total proteins, and albumin were measured in blood serum by UV automated spectrophotometer (full automated chemistry Bio-Systems A-25, Spain). However, concentration of globulin was calculated by subtracting albumin from total proteins. Also, the ratio of albumin to globulin (A/G ratio) was calculated. Concentration of serum thyroxin (T_4) and cortisol was determined in Eliza device (Eliza Sys. Teco., USA) using Accu-Bind Kits- Immunoassay technique. Overall mean of collection days for each hematological, biochemical and hormonal profile during each season was presented.

Statistical analysis

Data were statistically analyzed using T-test of SAS (2007) program according to Steel and Torrie (1980), to test the differences between shearing season or between shorn or unshorn ewe in each season.

RESULTS AND DISCUSSION

Climatic condition

Average ambient temperature (AT ºC), and temperature humidity index (THI) were higher, while relative humidity (RH %) was lower in spring than in autumn (Fig. 1). Depending on the values of AT and THI, the experimental ewes were at comfort zone during both seasons, because animals were kept at THI ≤ 72 in both seasons based on the equation of (Khalifa *et al.*, 2005). According to this equation, animals will be under mild heat stress if THI ranges between 73 and 77; moderate heat stress if THI ranges between 78 and 89 and it will suffer severe heat stress if THI ≥ 90.

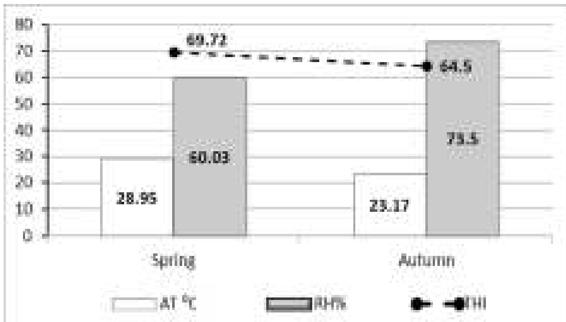


Figure 1. Average ambient temperature (AT °C), relative humidity (RH %) and thermal humidity index (THI) during spring and autumn.

Live body weight:

Shorn ewes had lower (P>0.05) final body weight than unshorn ewes in both seasons. Only autumn shearing affected body weight change (P<0.01), where shorn ewes lost more weight than unshorn ewes (Table 1).

Differences in final body weight and body weight change magnitude between control and shorn groups could be attributed partially to the greasy fleece weight loss and to the increased feed requirements caused by shearing (Elvidge and Coop, 1974). Despite the subtracted greasy wool weight, Torell *et al.* (1969) found that body weight of shorn ewes decreased in different shearing times. (Bianca, 1968) considered feed intake and body insulation as two main affectors on metabolic rate. Fleece removal enhances energy exchange between the animals and their surrounding environment that alters the level of cold and/or heat tolerance and shifts the zone of thermal indifference of sheep. Therefore shearing was found to increases feed requirements in unsheltered than in sheltered shorn sheep (Elvidge and Coop, 1974) but not under *ad libitum* feeding regime, whereas ewes had free access to pasture (Parker *et al.*, 1991). In this respect, Avondo *et al.* (2000) found that shorn ewes consumed more amounts of their body reserves than unshorn ewes. Piccione and Caola (2003) reported a transient loss of body temperature rhythm by shearing, with an exogenous component, the shearing, and an endogenous component, the modifications of metabolic levels due to shearing. These results might indicate the necessity of enhancing the nutritional level for the shorn ewes immediately after shearing to avoid any negative effect on live body weight.

Table 1. Effect of shearing on final body weight (FBW), and body weight change (BWC) of ewes in spring and autumn.

Trait	Season	Unshorn ewes	Shorn ewes	SEM	Significance
LBW (kg)	Spring	37.56	34.35	2.287	N.S.
	Autumn	40.00	37.56	2.005	N.S.
FBW (kg)	Spring	37.35	32.86	2.033	N.S.
	Autumn	39.61	34.70	1.680	N.S.
BWC (kg)	Spring	-0.21	-1.48	0.577	N.S.
	Autumn	-0.39[a]	-2.85[b]	0.265	P<0.01**

N.S.: Difference is not significant. ** Significant differences at P<0.01.

Wool production

Autumn shearing increased (P<0.05) average greasy fleece weights, being 2.48 and 1.15 (Kg) in autumn and spring, respectively (Table 2). Similar results were reported by Ralph (1971); Arnold *et al.* (1984) and Lupton *et al.* (2004), who reported that autumn shorn ewes cut heavier greasy fleeces. Winder *et al.* (1995) stated that the seasonal variations in wool growth coincide with changes in photoperiod, temperature and nutrition in most sheep breeds and the regulation of wool growth by these factors might be via systemic changes or localized responses at the wool follicle level.

Although, wool yield (%) did not significantly differ between shearing seasons (Table 2), other investigators reported higher yield of autumn-shorn wool than spring-shorn wool (Arnold *et al.*, 1984; Campbell, 2006).

In spring, ewes had obviously grown wool with coarser (P<0.05) fiber diameter (FD_{Av}) than that of autumn (Table 2). Coincidently, Taha (2004) reported a significant effect of season on Barki wool fiber diameter with higher fiber diameter in spring and summer than in autumn and winter. Similar trend of fiber diameter in Barki sheep during different seasons was reported by Abd El-Ghany (1994) and El-Ganaieny *et al.* (2000).

Table 2. Effect of shearing season on greasy fleece weight (GFW), wool yield (%), average fiber diameter (FD_{Av}), standard deviation of fiber diameter (FD_{SD}), crimps frequencies and staple length (SL).

Wool trait	Spring shearing	Autumn shearing	SEM	Significance
GFW	1.15[a]	2.48[b]	0.150	P<0.05*
Yield (%)	49.02	49.72	1.092	N.S.
FD_{Av}	36.26[a]	30.22[b]	1.632	P<0.05*
FD_{SD}	19.34[a]	13.07[b]	1.784	P<0.05*
FL	12.57	10.44	1.019	N.S.
Crimps/cm	0.67	0.80	0.065	N.S.
MI	13.58	13.80	0.434	N.S.

N.S.: Difference is not significant. * Significant differences at P<0.05.

Uniformity of wool fiber diameter increased in autumn shorn wool (Table 2), whereas standard deviation of fiber diameter (FD_{SD}) was lower (P<0.05) in autumn (13.07) than in spring (19.34). The less standard devastation of wool fiber diameter means more wool uniformity (Greeff, 2006). This result might be attributed to the declined FD_{Av} during autumn. Harizi *et al.* (2015) explained that a decrease in the percentage of coarse fibers causes a decrease in the average wool diameter and fiber variations. No significant differences in fiber length, crimps frequency and medulation index (MI) were detected between spring and autumn shorn wool (Table 2).

Although the percentages of fine, hetrotype and kemp fibers did not significantly differed between spring and autumn, they had a higher values in spring than in autumn. The percentage of medullated fibers was significantly affected by shearing season, being higher (P<0.05) in autumn (37.36 %) than in spring (26.43 %) as illustrated in Figure (2). As affected by month of the year, Dashab *et al.* (2006) reported higher percentage of true fibers in June than in December shorn wools, while the situations for heterotype and medullated fibers were reversed. Kemp percentage tends to increase in hot seasons compared with cold seasons. El-Ganaieny *et al.* (1992) found that coarser fiber diameter and high incidence of medullated fibers improved heat tolerance of Saidi sheep. Taha (2004) reported higher (P<0.01) kemp percentage in spring and summer than in autumn and winter in Barki sheep, indicating that the higher fiber diameter, kemp percentage and medullation index integrate with the physiological responses to increase animal resistance against overheating.

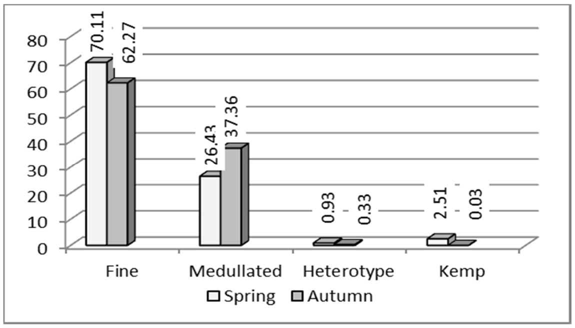


Figure 2. Mean percentages of fine fibers, medullated fibers, heterotype fibers and kemp during spring and autumn season.

Staple length (SL) did not differ between the two shearing seasons (Table 3), it accounted for almost the same average lengths (9.66 and 9.64 cm in spring and autumn, respectively). Longer staple lengths are desirable as they are easier to spin (Wood, 2003) and considered as an important determinant of wool quality and value (Gillespie and Flanders, 2010). Staple length influences wool processing performance and it determines the used manufacturer processes (Holman and Malau-Aduli, 2012). Despite the longevity of wool growth period, difference in staple length in different shearing seasons was a consequent of the seasonal pattern of wool growth (Reid and Sumner, 1991). Staple length is a function of individual fiber lengths and the extent of fiber crimping (Khan *et al.*, 2012). In the present study, these traits did not significantly differ between spring and autumn shorn wool (Table 3) and consequently, no significant effect of season was found on staple length. Although the difference was not significant, staple strength (SS) was higher in autumn than in spring produced wool (Table 3). This result could be attributed to the improvement in fiber diameter uniformity during autumn as presented in (Table 2). Total diameter variation has a strong negative phenotypic association with staple strength (Ritchie and Ralph, 1990; Reis, 1992; Schlink *et al.*, 1999). The majority of variations in staple strength were thought to be based on differences in intrinsic fiber strength (Gourdie *et al.*, 1992) and fibers stretching ability (Holman and Malau-Aduli, 2012). According to Schlink *et al.* (1999), staple strength was most highly correlated to within staple variations in fiber diameter.

Moreover, the point of staple break (POB) positioned closer (P<0.05) to the middle of the staple and the elongation rate (ELR) was increased (P<0.01) in autumn than in spring. The POB is mainly depending on staple strength (Holman and Malau-Aduli, 2012). Shearing time could be shifted to control wool staple strength and point of break (Bigham *et al.*, 1983). It is more desirable if POB was situated in the middle of staple even if it reduces staple length by about the half since it results in two parts of relatively equal length and decrease wool wastage (Wood, 2003). The almost central POB found in autumn wool may be attributed to the lower FD_{Av} and FD_{SD} recorded during this season (Table 2). In this way, Deng *et al.* (2007) claimed that within staple fiber diameter variations were found to have greater prevalence to breakages, particularly where fiber diameters were at their fineness (Gourdie *et al.*, 1992). Values of ELR increased (P<0.01) in autumn than in spring by about 6%. This trait implies the flexibility and elasticity of the wool staple (Telloglu, 1983). The higher autumn elongation rate was associated with finer FD_{Av}, lower FD_{SD} and higher crimps frequency at the same season (Table 2). When fibers imposed to stretching, crimps well extend to increase its length to a certain limit before it cut. The higher value of ELR indicted a higher processing efficiency of autumn sheared wool compared with spring sheared wool. Recent thought has indicated that these finer fibers have more flexibility than the coarser fibers (Holman and Malau-Aduli, 2012).

Table 3. Effect of shearing season on staple length (SL), staple strength (SS), point of staple break (POB) and the elongation rate of the staple (ELR).

Wool trait	Spring shearing	Autumn shearing	SEM	Significance
SL (cm)	9.66^a	9.64^a	0.227	N.S.
SS(N/Ktex)	41.25^a	46.39^a	2.740	N.S.
POB (%)	57.48^a	52.36^b	1.033	P<0.05*
ELR (%)	17.64^a	23.45^b	1.330	P<0.01**

N.S.: Difference is not significant. * Significant differences at P<0.05. ** Significant differences at P<0.01.

Physiological response:

No significant differences in respiration rate (RR) and rectal temperature (T_R) were found between shorn and unshorn ewes either in spring or in autumn. However, shorn group had lower (P<0.05) skin temperature (T_S) than that of the control only in spring (Table 4). In agreement, lower T_S of shorn than unshorn were reported in Awassi sheep (Eyal, 1963) and Saidi ewes (El-Ganaieny *et al.*, 1992). In this respect, Pennisi *et al.* (2004) stated that T_R of sheep did not differ between shorn and unshorn Comisana ewe lambs due to effective adaptability of this breed to its environment. Mohamed *et al.* (2012) stated that heat tolerance is a complex association between ambient temperature, humidity, direct and indirect solar radiation, avenues of evaporative heat loss and coat traits. Respiration rate tends to ascend with the increase in ambient temperature (Piccione *et al.*, 2008; Suhair and Abdalla, 2013).

Generally, (Altin *et al.*, 2018) stated that animals feel themselves more comfortable in view of climatic environmental conditions during spring and autumn season. It seems that the differences between the two seasons in climatic condition were within the range of thermal comfort zone of the animals (Abdel Khalek, 2007), so it did not result in significant changes in RR or T_R. Keeping animal in sheltered semi-open pins is an expected reason for the absence of significant differences between shorn and unshorn groups in the current study as they were protected from direct exposure to solar radiation (Cascone *et al.*, 2001; Pennisi *et al.*, 2004). It was reported that T_S of sheep was more sensitive than T_R to the changes in climatic conditions, especially solar radiation (El-Zeiny, 2011). In coincidence, ambient and solar radiation temperature values were higher in spring than in autumn. These results might indicate the fleece role in protecting animal against increased levels of solar radiation and ambient temperature.

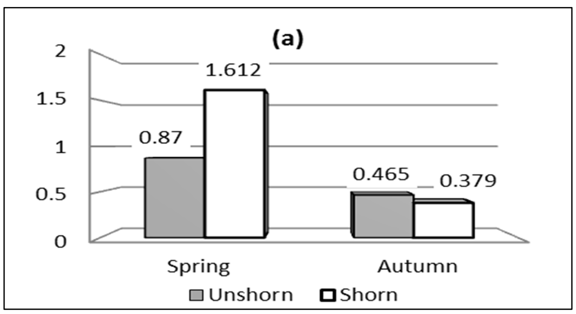
Results revealed that, shearing enhanced heat dissipation from the animal body to the skin during spring. The thermal gradient between core and skin temperature (T_R-T_S) in shorn ewes (1.612 ºC) was about two folds (P<0.01) of its value in unshorn group (0.870 ºC) as illustrated in Figure (3 a). In autumn, the situation was reversed where the (T_R-T_S) gradient was lower in shorn than in unshorn ewes. This might reflect an adaptive mechanism of Barki ewes as they reduced blood flow to the skin to reduce metabolic heat loss. According to Yousef (1985), skin circulation is mainly involved in body temperature regulation via vasoconstriction in cold climate to decrease T_S and hence restrict heat loss to the environment; while vasodilatation in hot climate increases T_S to enhance heat loss to environment. El-Ganaieny *et al.* (1992) suggested that the reduction in RR and T_S in shorn compared with unshorn Saidi ewes was due to enhancement of sweat evaporation through skin surface, which resulted in more skin cooling. El-Ganaieny *et al.* (2001) stated that coat and skin structure controls physiological equilibrium mainly via modifying heat absorption and dissipation.

Table 4. Effect of shearing on respiration rate (RR), rectal temperature (T_R) and skin temperature (T_S) in spring and autumn season.

Parameter	Season	Unshorn ewes	Shorn ewes	SEM	Significance
RR/minute	Spring	62.20	57.66	5.370	N.S.
	Autumn	59.75	59.41	5.627	N.S.
T_R (ºC)	Spring	39.29	39.42	0.146	N.S.
	Autumn	39.11	38.66	0.400	N.S.
T_S (ºC)	Spring	38.43^a	37.73^b	0.152	P<0.05*
	Autumn	38.64	38.35	0.225	N.S.

N.S.: Difference is not significant. * Significant differences at P<0.05.

Due to readjusting heat loss from the skin to the ambient air the thermal gradient between skin surface and ambient air (TS –AT) was not affected by shearing in either spring or autumn (Figure 3 b). Shearing was found to induce adaptive thermo-genesis mechanisms in shorn sheep under extreme environmental conditions or at a climatically mild atmosphere (Al-Ramamneh *et al.*, 2011). Maintenance of sheep homeothermic balance is influenced by their fleece which represents an insulating layer protecting the animal against both heat and cold, fleece removal modifies the thermoregulation and hence the homeostasis mechanisms (Pennisi *et al.*, 2004; Casella *et al.*, 2016).



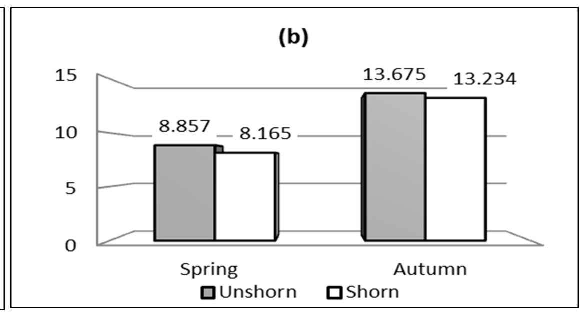


Figure 3. Means of difference between rectal and skin temperature, T_R-T_S (a) and between skin and ambient temperature, T_S-AT (b) as thermal gradients of unshorn and shorn ewes during spring and autumn.

Haematological parameters

Count of erythrocytes (RBCs) and total leukocytes (WBCs), haemoglobin concentration (Hb) and packed cell volume (PCV) did not significantly differ between shorn and unshorn ewes in spring and autumn (Table 5). These results indicated that the shorn animals were not negatively affected by shearing in both seasons as their blood oxygen capacity (indicted by RBCs, Hb and PCV) did not differ and their pathogenic and immunity status (indicated as Hb and WBCs) were not affected (Njidda *et al.*, 2014). In agreement with the present results, Piccione *et al.* (2008) found insignificant effect of shearing on count of RBCs, Hb concentration and PCV value of Valle de Belice dairy ewes in Sicily under ambient temperature peaked 33 ºC and average relative humidity of 45%. Compared with the results of the current study, they reported higher (P<0.05)

WBCs count in shorn than in unshorn ewes. In this respect, Suhair and Abdalla (2013) mentioned that the effect of shearing on some blood constituents may differ according to the season in which the animals were shorn due to the seasonal changes in water intake and water turnover rate in different seasons. However, (Abdel Khalek, 2007) reported slight changes in ambient temperature within moderate heat stress range were of negligible effects on most of blood constituents

Table 5. Effect of shearing season on count of erythrocytes (RBCs) and leukocytes (WBCs), haemoglobin concentration (Hb) and packed cell volume (PCV) during spring and autumn season.

Parameter	Season	Unshorn ewes	Shorn ewes	SEM	Significance
RBCs	Spring	3.86	3.76	0.213	N.S.
(10^6/mm^3)	Autumn	4.00	3.80	0.183	N.S.
WBCs	Spring	11.35	11.07	2.267	N.S.
(10^3/mm^3)	Autumn	12.46	14.88	2.372	N.S.
Hb (g/dl)	Spring	11.35	11.07	0.267	N.S.
	Autumn	11.17	11.57	0.266	N.S.
PCV (%)	Spring	28.05	26.68	2.317	N.S.
	Autumn	27.85	33.90	2.303	N.S.

N.S.: Difference is not significant.

Blood biochemical parameters:

Serum total proteins (TP) and albumin (Alb) concentrations did not differ significantly between shorn and unshorn ewes in both seasons. Suhair and Abdulla (2013) reported similar results in Sudanese desert Hamari rams when they studied the effect of shearing on blood TP and Alb concentration.

Table 6. Effect of shearing on serum total proteins, albumin and globulin concentrations, and albumin: globulin ratio in spring and autumn season.

Blood biochemical	Season	Unshorn ewes	Shorn ewes	SEM	Significance
Total proteins (g/dl)	Spring	6.84	7.94	0.497	N.S.
	Autumn	6.94	6.85	0.383	N.S.
Albumin (g/dl)	Spring	4.05	4.30	0.215	N.S.
	Autumn	2.93	3.17	0.178	N.S.
Globulin (g/dl)	Spring	2.78[a]	3.63[b]	0.192	P<0.05*
	Autumn	4.01	3.67	0.335	N.S.
Albumin/globulin ratio	Spring	1.45[a]	1.19[b]	0.085	P<0.05*
	Autumn	0.76	1.00	0.120	N.S.

N.S.: Difference is not significant. * Significant differences at P<0.05.

However, serum globulin (Glb) concentration increased ($p<0.05$) in shorn ewes compared with unshorn ewes during spring, reflecting a decrease in albumin to globulin ratio in the same season. Al-Eissa *et al.* (2012) observed higher Glb concentration in Nubian goats under cold climatic conditions that led to decreased Alb: Glb ratio. In this line, Ribeiro *et al.* (2018) reported that differences in globulin values are related to physiological and genetic factors of animal adaptation.

Hormonal profile thyroxin and cortisol:

Thyroxin (T4) and cortisol concentrations were not affected significantly by shearing in both seasons (Table 7). Serum T_4 increases when animals experience heat stress and resulting in declined metabolic rate, feed intake, growth and production rates (Silanikove, 2000). Oppositely, cold stress was found to increase T4 concentrations in ewes (Hocquette *et al.*, 1992), ram lambs (Ekpe and Christopherson, 2000; Doubek *et al.*, 2003) and sheared sheep during cold climate (Morris *et al.*, 2000; Merchant and Riach, 2002). When the temperature ranges are not extreme (mild climate, indoor housing, shelter in the night time), the effect of photoperiod and season-dependent T4 Profile mainly related to the day length changes (Todini, 2007). Activation of the hypothalamic-pituitary-adrenal axis and consequent increase of plasma cortisol concentration are the most prominent responses of an animal to stressful conditions (Silanikove, 2000). Secretion of cortisol stimulates physiological adjustments that enable an animal to tolerate the stress caused by environmental conditions. It rises markedly under acute heat stress (Habeeb *et al.*, 1992). In this respect, temperature humidity index (THI) is a sensitive indicator of heat stress and is impacted by ambient temperature more than the relative humidity (Rathwa *et al.*, 2017). The later authors confirmed that higher THI was associated with significant increase in cortisol and with a significant decrease in thyroxin hormones.

In the current study THI accounted 69.72 and 64.50 in spring and autumn, respectively. These values might explain the similarity of T_4 and cortisol levels in shorn and unshorn ewes, where animals were under mild climatic conditions and sheltered protected from extreme exposure to climatic conditions in both seasons. The absence of differences between shorn and unshorn ewes in T_4 and cortisol levels emphasized the availability of conducting shearing during any of them without negative effects on animal metabolic situation, tolerability and welfare.

Table 7. Effect of shearing on serum thyroxin (T_4) and cortisol concentrations in spring and autumn season.

Hormone	Season	Unshorn ewes	Shorn ewes	SEM	Significance
T_4	Spring	12.11	11.05	0.508	N.S.
(ng/ml)	Autumn	9.44	8.93	0.424	N.S.
Cortisol	Spring	14.27	14.93	0.817	N.S.
(ng/ml)	Autumn	10.96	10.26	1.135	N.S.

N.S.: Difference is not significant.

CONCLUSION

The previous results indicated that altering shearing time of Barki sheep from spring to autumn may be safely conducted as it improved greasy fleece weight, average fiber diameter, uniformity of wool fiber diameter, point of staple break and wool staple elongation rate compared with spring shearing without appearing any negative effects on the physiological responses, blood constituents, serum proteins, animal homeostasis and thermoregulation. Further studies are required to investigate other effects of autumn shearing on other aspects out of the current study interest such as reproductive efficiency, performance and welfare of the animal, in addition to further economic investigations on this procedure should be conduct.

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دراسة مقارنة لتأثير الجز في الخريف كبديل للجز في الربيع على إنتاج وخصائص الصوف، وبعض المعايير الفسيولوجية ومكونات الدم، وبعض الهرمونات الميتابولزمية في الأغنام البرقي.

عماد الإسلام أحمد طلعت طه[1] ، عبد الخالق السيد عبد الخالق[2] ، وائل أحمد خليل[2] و نهلة رأفت محمد عبد العال[1]

[1] قسم إنتاج و تكنولوجيا الصوف – شعبة الإنتاج الحيواني و الدواجن – مركز بحوث الصحراء

[2] قسم الإنتاج الحيواني – كلية الزراعة – جامعة المنصورة

أجريت هذه الدراسة تحت الظروف الصحراوية شبه الجافة للشريط الساحلي الشمالي الغربي في مصر لدراسة تأثير جز نعاج البرقي في الخريف على وزن الجسم و انتاج و بعض صفات الصوف و الاستجابات الفسيولوجية و التدرج الحراري و بعض معايير الدم و مستوى هرموني الثيروكسين و الكورتيزل و مقارنتها بالجز خلال الربيع. أحدث الجز خلال الخريف نقصا معنويا في وزن الجسم للمجموعة المجزوزة مقارنة بالكنترول و لكنه زاد معنويا من وزن الجزة و من نعومة ألياف الصوف و أحدث تحسنا معنويا في تجانس أقطار ألياف الصوف و نقطة قطع خصلات الصوف و معدل استطالتها مقارنة بالجز في الربيع. بينما كانت حرارة الجلد أعلى في النعاج المجزوزة في الربيع وزاد التدرج الحراري بين حرارة باطن الجسم و سطح الجلد معنويا كما أدى لزيادة معنوية في تركيز جلوبيولين السيرم مع انخفاض معنوي في نسبة الألبيومين إلى الجلوبيولين ولم يظهر أي تأثير معنوي علي مستوي كل من هرمون الكورتيزول وكذلك هرمون الثيروكسين.أشارت النتائج إلى امكانية استبدال موسم الجز بأمان من الربيع إلى الخريف دون تأثيرات سلبية على معظم المعايير المدروسة بالإضافة إلى التحسن الملحوظ في أوزان الجزات و صفات الصوف الناتج.