Egyptian J. Anim. Prod. (1999) 36 (2):111-119

COMPONENTS OF WOOL PRODUCTION PER UNIT AREA ON SOME BODY POSITIONS IN BARKI SHEEP

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SUMMARY

In order to define the most important components which contribute more to the wool production per unit area taken from different body positions in the coarse wool Barki sheep, the present study was undertaken. Wool samples were obtained from twenty-nine Barki ewes in summer, autumn, winter and spring . Six body positions were sampled at each occasion; three laterals and three dorsals. Wool samples were used to estimate greasy, *GWA*, and clean wool production per unit area, *CWA* as well as staple length, *STL*, fibre length, *FL* and fibre diameter, *FD*. Fibre cross-sectional area, *CSA*, was calculated as well as the total number of fibres, *TN*, and the percentages of medullated , *Med%*, and non-medullated fibres , *Non-med%* .

Multiple regression analysis was utilized to determine optimal combinations of wool components to predict the *GWA* and *CWA* from various body positions. It is impressive that models proposed to predict *CWA* were much simpler and more accurate compared with those models predicting the *GWA*. Including the *GWA* as a predictor attained a remarkable increase in the accuracy to predict *CWA*. Generally, it appeared that wool length is the most important component that accounted for higher wool production per unit area in the coarse wool Barki sheep compared with the components of thickness and number of fibres. *STL* controlled most of the variation in both *GWA* and *CWA* and was more appropriate compared with *FL*. An overall decision was reached to predict *GWA* (from the britch sample) and *CWA* (from the withers position) through the following regression equations:

$GWA = 0.1032 + 0.0045\ STL - 0.000056\ TN$, $R^2 = 0.35$ and

$CWA = -0.0081 + 0.5080\ GWA + 0.0029\ STL$, $R^2 = 0.82$.

These models were chosen partly on the basis of their reliability and partly on the basis of the cost and technical difficulty of collecting data on independent variables. The last model including the *GWA* together with *STL* was the best to predict *CWA* and being more accurate since heavier *GWA* and longer *STL*, may both reflect more vigorously growing follicles.

Keywords: Barki sheep, coarse wool, wool production, body positions

INTRODUCTION

Heavier greasy, *GFW*, or clean fleece weight, *CFW*, was accepted as the major selection objectives for improving carpet and apparel wool production, however, the selection for *CFW* was more accurate (Turner, 1977). The total *GFW* produced by an animal is made up of a number of components operating collectively, as defined by Young and Chapman (1958), Turner and Young (1969) and Atkins (1988). *GFW* consists of skin products (wax and suint), extraneous materials (dirt, vegetable matter and moisture) as well as clean fleece weight. The two major components determining the latter are the wool growing surface area and the wool production per unit area of skin. Many investigators have indicated that wool production per unit area makes far more influence on wool weight than does body surface area (Turner and Young, 1969). Wool production per unit area of skin is derived from average fibre weight and average number of fibres per unit area of skin i.e., fibre density. In turn, fibre weight is derived from average fibre length and cross-sectional area as well as the specific gravity of wool as a constant. The density of the fibres was accepted as the most important component affecting wool production per unit area in fine wool breeds. However, scanty data obtained from the coarse wool breeds suggested wool length as an important fleece component affecting clean wool production (Khalil *et.al.*,1997 ; Doney, 1963). In the present study, wool production per unit area was expressed in greasy, *GWA*, and clean states, *CWA*. Both *GWA* and *CWA* were found to be positively correlated with the greasy fleece weight and were concluded to be taken as the most indicative criteria for the fleece weight in Barki sheep (El-Gabbas, 1993 a) as well as in Drysdale sheep of New Zealand (El -Gabbas, 1986).

Selection for wool production per unit area as well as other wool traits is often based on a small wool sample taken from a given body position since the analysis of the entire fleece for various wool traits is costly, time consuming and being impossible to do especially in large flocks. While the mid-side position is mostly accepted in fine wool breeds, workers in coarse wool breeds have made no recommendations in this respect. The position, which would represent the entire fleece for a given trait, is varied with the trait in coarse wool breeds in general as well as in Barki sheep (El-Gabbas, 1993a and 1993b).

A multiple regression analysis was performed to investigate the contribution of these wool components to *GWA* and *CWA* as well as selecting the optimal combinations of these components to predict the *GWA* and *CWA* estimated from various body positions. It is of interest to reach an overall decision of such components in a given position to be sampled and used as a basis for selection to increase wool productivity in the coarse wool Barki sheep.

MATERIALS AND METHODS

The present study was conducted on a Barki sheep flock belongs to Mariout Research Station, 35 kilometer west of Alexandria. The flock was raised where rainfall averaged 80-100 mm /year. Relative humidity (%) and maximum and minimum temperature (°C) were 77.4%, 34.2 and 23.3 in July and 65.1%, 24.8 and 17.7 in October, 62.7%, 17.6 and 9.2 in January and 74.5%, 20.7 and 13.0 in April. Sheep were grazed on irrigated pastures and supplemented with concentrates. The twenty-nine Barki ewes involved in the present study were chosen at random, just after the first shearing. The animals were about two years old, all singles and looked healthy throughout the study. Wool samples were taken at three months intervals to represent wool growth in summer (July), autumn (October), winter (January) and spring (April). Thus, wool collected in one occasion represented the preceding growth period. For instance, autumn sample in October representing the wool grown in summer. At each sampling occasion, six body positions were collected; three laterals (shoulder, *Sh*; mid-side, *Ms;* britch, *Br*) and three dorsals (withers, *Wth*; back, *Bk*; rump, *Rp*).

At each sampling occasion and from the standing position, an area of 1cm^2 on each position was tattooed and wool was clipped close to the skin using fine scissors. These samples were used to obtain the total number of fibres, *TN,* as well as the percentages of medullated, *Med%,* and non-medullated fibres, *Non-med%,* according to El-Gabbas (1993 b). It should be mentioned that the sample was originally split into fine, F, coarse, C and kemp fibres, K, and the percentages of each were calculated for each sample. The preliminary analysis considered the inclusion of either F%, C%, K% or *Med%* and *Non-med%.* No differences were observed in both approaches. Therefore, the *Med%* and *Non-med%* was adopted as it is rather simpler to split the wool sample into two categories than splitting it into three classes. Moreover, while fine fibre and non-medullated fibre are both characterized by having no medulla, there is no exact definition for how thick must be the fine fibre.

At the same time, wool was cut from each animal as close as possible to the skin surface using fine scissors forming a square of about 10cm x 10cm on each of the six body positions. The entire wool samples were taken from these squares at the four sampling occasions previously mentioned. These samples were used to estimate greasy, *GWA,* and clean wool production per unit area, *CWA,* as well as staple length, *STL* (El-Gabbas, 1993 a). Fibre length *FL,* and fibre diameter, *FD,* were measured in five staples taken at random from each greasy sample of each position and season. Fibre length, *FL,* was the average of about 300 fibres to the nearest 5-mm using WIRA fibre length-measuring apparatus. Fibre diameter, *FD,* was measured on the average of 475 fibres per sample using Lanameter according to IWTO (1961). Fibre cross-sectional area, *CSA,* was estimated as equal to $\pi/4\ [D^2+ V\ (D)]$ according to Turner and Young (1969). Where D is fibre diameter and V(D) is the coefficient of variation for fibre diameter. In the present study, the latter was estimated as 22.8%.

Statistical procedures

The percentages included in the data were transformed into their arcsine values. A mixed linear model included the fixed effects of season and position as well as their interactions together with the random effect of animal was used to analyze the studied traits.

A multiple regression analysis was conducted using SAS (1995) in order to select optimal combinations of wool components to predict the *GWA* and *CWA*. Two models were performed, the first one was designed to predict the *GWA* whereas the second for *CWA*. The available criteria for length (*STL* and *FL*), thickness (*FD* and *CSA*) as well as number of fibres (*TN* , *Med%* and *Non-med%*) were included in both models as predictors. In addition , *GWA* was added to the components of the right hand-side in the second model to increase the accuracy of predicting the *CWA* . These models were obtained from the six body positions. Prediction equations were chosen partly according to their accuracy in terms of R^2 and applicability for collecting data on independent variables.

RESULTS AND DISCUSSION

Table (1) indicated an antero-posterior gradient in which *GWA*, *CWA*, *STL*, *FL*, *FD*, *CSA* and *Med%* tended to increase while Non-med% and *TN* decreased towards the posterior positions. A dorso-ventral gradient was also evident in which dorsal positions had heavier *GWA* and *CWA* as well as longer *STL* and *FL* with higher values of *FD*, *CSA* and *Non-med%* together with lower values of *TN* and *Med%*.

It appeared that antero-posterior as well as dorso-ventral gradients are affecting most studied traits. Such trends might indicate that the existence of more or less counter gradients for these traits would obviously lead to a complex interaction of numbers, thickness and length to determine the quantitative unit area production on various parts of the body. Though numbers, thickness and length of fibres vary considerably between locations. The individual body regions appeared to have characteristic localized skin growth rates that can be related to the growth of the whole body.

The wool length in the present study was taken as *FL* or *STL*. The thickness of the fibre was expressed as *FD* or *CSA*. The number of fibres was considered collectively, as a total number of fibres, *TN* or separately as *Med%* and *Non-med%*. All these variables were regarded to be the fleece attributes which directly govern wool production per unit area, the main objective of this study. Therefore, these variables were included in the multiple regression analysis. The optimal combinations of wool components to predict the *GWA* and *CWA* were obtained from different body positions and presented in tables (2 and 3).

The analysis of the models predicting *GWA* revealed that despite the highest value of R^2 was estimated from the shoulder position (0.48), the best practical prediction for the *GWA* could be attained from the britch sample ($R^2 = 0.35$). That is because of the least work involved in that model as it depends mostly on estimating the total number of fibres as well as staple length compared with the other models. Increasing *GWA* through *STL* and *TN* would be more effective through proper prenatal feeding to obtain the potential density and fibre growth.

It is impressive that models predicting *CWA* were much simpler and more accurate in terms of R^2 compared with those models predicting the *GWA* (Tables 2 and 3). This result emphasizes the fact that selection based on clean wool is more

Table 1. Least squares means ± SE of some studied traits with respect to seasons and positions

	GWA	CWA	STL	FL	FD	CSA	Non-med%	Med%	TN
Overall Mean	0.086	0.045	4.85	6.95	34.86	1003.60	52.90	47.10	794.00
Season									
January	0.079±0.002	0.045±0.001	5.15±0.08	7.01±0.1	35.90±0.3	1061.04±17.8	54.71±0.3	45.28±0.3	740.50±15.61
April	0.080±0.002	0.040±0.001	4.35±0.08	6.75±0.1	34.39±0.3	977.66 ±17.8	52.16±0.3	47.96±0.3	874.00±15.61
July	0.070±0.002	0.036±0.001	3.60±0.08	5.77±0.1	34.02±0.3	960.45 ±17.8	48.40±0.3	51.60±0.3	925.29±15.61
October	0.117±0.002	0.060±0.001	6.30±0.08	8.27±0.1	35.13±0.3	1015.24±17.8	56.35±0.3	43.65±0.3	636.20±15.61
Position									
Shoulder	0.071±0.003	0.032±0.001	4.38±0.1	6.31±0.1	31.57±0.4	818.52 ±21.9	53.60±0.3	46.40±0.3	865.74± 19.1
Mid-side	0.067±0.003	0.032±0.001	4.40±0.1	6.48±0.1	33.68±0.4	931.60 ±21.9	51.18±0.3	48.81±0.3	838.95±19.1
Britch	0.081±0.003	0.042±0.001	5.08±0.1	7.25±0.1	38.69±0.4	1228.53±21.9	47.45±0.3	52.55±0.3	789.90±19.1
Withers	0.094±0.003	0.054±0.001	5.02±0.1	7.13±0.1	33.60±0.4	926.27 ±21.9	57.23±0.3	42.77±0.3	778.03±19.1
Back	0.106±0.003	0.058±0.001	5.00±0.1	7.16±0.1	33.46±0.4	919.86 ±21.9	55.55±0.3	44.45±0.3	758.10±19.1
Rump	0.102±0.003	0.054±0.001	5.23±0.1	7.38±0.1	38.15±0.4	1196.82±21.9	52.27±0.3	47.73±0.3	733.26±19.1

GWA= greasy wool per unit area (gm), CWA= clean wool per unit area (gm), STL= staple length (cm), FD= fibre diameter (u), CSA= cross-sectional area (u), TN= total number of fibres per unit area.

accurate. Moreover, the estimation of clean wool weight involves extra cost and labor in collecting and measuring a sample for percentage clean yield. Greasy weight is a cheap and simple measure whose genetic and phenotypic correlation with clean weight are both high.

The R^2 values obtained from all positions to predict the *CWA* were in the range of 0.65 to 0.89. The major contribution to the R^2, and hence the accuracy of those models predicting *CWA* appeared to be gained from the addition of *GWA* in all positions. That is not surprising since *GWA* had a high correlation with *CWA* (0.86) and greasy fleece weight (0.62) in Barki sheep (El-Gabbas, 1993a).

Multiple regression analysis revealed that fitting *STL* controlled more of the variability in *GWA* and *CWA* than when *FL* was included in all positions. Similarly, the addition of the *TN* contributed more to the accuracy of predicting *GWA* compared with the percentages of different fibre types. Generally, the addition of *TN* or the percentages of the different fibre types as well as *FD* and *CSA* gave very minor contribution to the R^2 of *GWA* and *CWA* in all positions. In the present material, *FD* and *CSA* were found to be poorly correlated with *GWA* (0.15 and 0.13) and *CWA* (0.18 and 0.16) which might explain the negligible contribution of the thickness components. However, higher variability in these traits especially in coarse wool materials as well as the difficulty of measurements would justify excluding *FD* and *CSA* from those models used to predict *GWA* or *CWA*.

Table 2. Multiple regression models to predict *GWA* obtained from various wool componen's on different positions

Position	Optimal models	Adjusted R^2
Shoulder	*GWA*= 0.135 + 0.018 *STL* – 0.009 *FL* -0.00004 *TN* – 0.00097 *Med%*	0.48
Mid-side	*GWA*= 0.1862 + 0.0039 *FL* - 0.00004 *TN* -0.0024 *Med%*	0.39
Britch	*GWA*= 0.1032 + 0.0045 *STL* - 0.000056 *TN*	0.35
Withers	*GWA*= 0.2217 + 0.0067 *STL* - 0.00003 *TN* –0.0033 *Med%*	0.28
Back	*GWA*= -0.1241-0.0145 *STL*+ 0.0242 *FL*- 0.00003 *TN* +0.0031 *Non-med%*	0.46
Rump	*GWA*= 0.1827 + 0.0047 *STL* + 0.00085 *FD* –0.0032 *Med%*	0.26

GWA= greasy wool per unit area, *STL*= staple length, *FL*= fibre length, *TN*= total number of fibres per unit area, *FD*= fibre diameter, *Med%* and *Non-med%* = percentages of medullated and non- medullated fibres.

Wool length, was the most important component to predict the *GWA* and *CWA* in the evaluated models (Tables 2 and 3). On the other hand, table (1) revealed that most of the wool produced in terms of *GWA* and *CWA* was attained from July to October. During this period an increase of 40.2% in *GWA* was observed along with another increase of 40.0% in *CWA*. Such increase in productivity during that time is apparently composed of changes in numbers, thickness and length of wool fibres. Table (1) showed that such increase in wool production from July to October was associated with a big increase in the *STL* (42.9%), *FL* (30.2%) as well as a big reduction of 31.2% in the *TN* together with a slight increase in *FD* (3.2%) and *CSA* (5.4%). Perhaps, heavier wool production is affected mainly by the increase in wool length rather than by fibre density or fibre thickness.

Table 3. Multiple regression models to predict *CWA* from various wool components on different positions.

Position	Optimal models	Adjusted R^2
Shoulder	*CWA*= 0.0008 +0.2383 *GWA* + 0.0023 *FL*	0.65
Mid-side	*CWA*= -0.002 + 0.2942 *GWA* +0.0024 *STL* + 0.000004 *CSA*	0.75
Britch	*CWA*= 0.0197 +0.3111 *GWA* + 0.0023 *FL* -0.00042 *Med%*	0.68
Withers	*CWA*= -0.0081÷ 0.5080 *GWA* +0.0029 *STL*	0.82
Back	*CWA*= -0.0186 + 0.4706 *GWA* +0.0033 *STL* + 0.0003 *FD*	0.89
Rump	*CWA*= -0.0354 +0.4910 *GWA* + 0.0030 *STL* -0.00001*TN* -0.00036 *Non-med%*	0.83

CWA= clean wool per unit area, *GWA*= greasy wool per unit area, *STL*= staple length, *FL*= fibre length, *FD*= fibre diameter, *CSA*= cross-sectional area, *TN*= total number of fibres per unit area, *Med%* and *Non-med%* = percentages of medullated and non- medullated fibres.

Wool length appeared to contribute more to the *GWA* and *CWA* compared with the components of thickness and number of fibres. The follicle density is largely determined in early life particularly for coarse wool breeds. The genetic potential of the latter for density might be suppressed and would be compensated for by later increases in fibre volume in terms of thickness and length growth of fibres. Length growth is apparently more important than the growth of fibre thickness in the coarse wool materials. Therefore, wool length is probably the most important component, which accounted for higher wool production pér unit area in the coarse wool Barki sheep. Heavier *GWA* and *CWA* was found (El-Gabbas, 1993a) to be associated with longer *STL* (0.48 and 0.56) and *FL* (0.46 and 0.54). On the other hand, *STL* contributed more of the variation in both *GWA* and *CWA* as well as being much faster and easier to measure compared with *FL*. The present result might confirm the importance of *STL* in controlling wool production in the coarse wool materials as previously indicated for the strong wool Merino (Young and Chapman, 1958), Scottish Blackface (Doney, 1963) and Barki sheep (Khalil *et.al.*, 1997). Furthermore, from the processing point of view, *FL* measurements need very careful interpretation since *FL* in greasy wool is altered during processing by fibre breakage and the removal of short fibres as noil. It was also reported (Bow, 1979) that *STL* and staple strength have a sufficiently important effect in processing to justify further examination at the point of sale.

To reach an overall decision, it appeared that the model based on withers data gave the most practical prediction for *CWA* (Table 3). The R^2 value of the withers model was slightly less (0.82) than the highest R^2 obtained from the back sample (0.89). Though, that slight improvement in R^2 resulted from including the measurement of fibre diameter would not pay for the extra work and cost involved in estimating this trait. Thus, the regression equation including *GWA* together with *STL* appears to be the most appropriate to predict the *CWA* from the withers sample. The positive correlation between the components in that model would yield an increase in wool weight. Furthermore, such model seems more applicable since it has simple traits to measure and being more accurate in terms of R^2 (0.82). Heavier *GWA* and longer *STL* may both reflect more vigorously growing follicles.

Acknowledgement

Prof. H. Mansour made valuable comments on the statistical analysis. He is greatly acknowledged.

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مكونات وزن الصوف الناتج من وحدة المساحة على بعض مناطق الجسم فى الأغنام البرقى

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أجريت هذه الدراسة للتعرف على أهم مكونات وزن الصوف الناتج من وحدة المساحة فى مناطق الجسم المختلفة فى أغنام البرقى ذات الصوف الخشن. استخدمت فى هذه الدراسة ٢٩ نعجة برقى حيث أخذت منها عينات الصوف من ستة أماكن على جسم الحيوان، ثلاثة على الظهر وثلاثة على الجانب. أخذت هذه العينات فى الصيف، الخريف، الشتاء والربيع حيث تم قياس وزن الصوف الخام فى وحدة المساحة، وزن الصوف النظيف فى وحدة المساحة، طول الخصلة، طول الليفة، قطر الليفة، عدد ألياف الصوف فى وحدة المساحة بالإضافة إلى النسبة المئوية لألياف الصوف ذات النخاع وتلك عديمة النخاع. تم تحليل البيانات باستخدام تحليل الاعتماد المتعدد للوصول لأفضل توليفة من صفات الصوف للتنبؤ بوزن الصوف الخام فى وحدة المساحة ووزن الصوف النظيف فى وحدة المساحة وذلك فى مناطق الجسم المختلفة.

أوضحت النتائج أن النماذج المقترحة والتى تتضمن توليفات مختلفة من صفات الصوف للتنبؤ بوزن الصوف النظيف فى وحدة المساحة كانت أكثر دقة وسهولة من تلك النماذج التى تتنبأ بوزن الصوف الخام فى وحدة المساحة كما أن إضافة وزن الصوف الخام فى وحدة المساحة أضاف زيادة واضحة فى دقة التنبؤ بوزن الصوف النظيف فى وحدة المساحة. كما أوضحت النتائج أن طول الصوف هو الأكثر تأثيرا على زيادة إنتاج الصوف فى وحدة المساحة فى صوف أغنام البرقى الخشنة مقارنة بسمك الألياف أو عدد ألياف الصوف وقد كان لإضافة طول الخصلة تأثير أكبر على دقة التنبؤ بوزن الصوف الخام أو النظيف فى وحدة المساحة مقارنة بطول الليفة. وقد توصلت الدراسة إلى إمكانية التنبؤ بوزن الصوف الخام فى وحدة المسلحة (من منطقة الكفل) وكذلك التنبؤ بوزن الصوف النظيف فى وحدة المساحة (من منطقة أعلى الكتف) من خلال النموذجين التاليين:

وزن الصوف الخام فى وحدة المساحة= ٠,١٠٣٢+ ٠,٠٤٥ طول الخصلة – ٠,٠٠٠٠٥٦ العدد الكلى للألياف (حيث معامل التحديد = ٠,٣٥).

وزن الصوف النظيف فى وحدة المساحة= -٠,٠٠٨١+ ٠,٥٠٨٠ وزن الصوف الخام فى وحدة المساحة + ٠,٠٠٢٩ طول الخصلة (حيث معامل التحديد = ٠,٨٢).

وقد تم اختيار هذه النماذج على أساس الدقة فى التنبؤ (معامل التحديد) وكذلك بناء على التكاليف وسهولة جمع البيانات للصفات المكونة للنموذج المقترح. وقد كان النموذج الأخير للتنبؤ بوزن الصوف النظيف فى وحدة المساحة من خلال وزن الصوف الخام فى وحدة المساحة وطول الخصلة هو الأكثر دقة حيث أن زيادة إنتاج الصوف الخام وطول الخصلة يعبران عن وجود حويصلات ذات قدرة إنتاجية عالية.