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Effect of Different Levels of Feed Consumption on the Quality of Fleece and Number of Fiber Follicles in Norduz Lambs

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SUMMARY

This study examined the effect of different forage levels and ewe's milk consumption levels on the development of fleece characters and number of follicles in Norduz lambs. Fifty Norduz sheep and their 50 lambs were used in the study. Control group lambs freely consumed alfalfa hay until the pasture season and then freely consumed pasture grass. The lambs in the control group also nursed from the ewes for 150 days. The experimental group lambs were fed milk residues for 47 days and consumed test feed after the first week. The lambs in the first, second, and third groups were fed with food consisting 2, 3, and 4% dry matter, respectively, based on their live weights. Skin samples were obtained from animals aged 7 days, 21 days, 2 months, 6 months, and 1 year in order to determine the rates and varieties of fleece follicles. Fleece samples were also obtained from one-year-old animals to determine specific fleece characteristics. The lengths (haut and barb) and strength values of the fleeces were significantly greater in the control group than in the other groups. The effect of forage and breast milk consumption in different levels were not statistically significant in secondary follicle numbers.

Key Words: *Norduz, Different feeding, Fleece, Fiber follicle*

ÖZET

Norduz Kuzularında Yapağı Kalitesi ve Lif Follikül Sayılarına Farklı Yem Tüketim Düzeylerinin Etkisi

Bu çalışmada, Norduz kuzularında bazı yapağı karakterleri ve lif follikül oluşumu üzerine aynı enerji ve protein içeriğine sahip farklı düzeylerdeki yem ve anne sütü tüketiminin etkisi araştırılmıştır. Hayvan materyali olarak, 50 baş Norduz koyunu ve bunlardan doğan 50 kuzu kullanılmıştır. Kontrol grubundaki kuzular mera dönemine kadar yonca samanı ve mera döneminde de mera otları ile serbest olarak beslenmişlerdir. Ayrıca bu kuzular 150 gün boyunca anne sütü emmişlerdir. Deneme grupları ise 47 gün boyunca kalıntı süt ile beslenmiş ve ilk haftadan itibaren deneme yemleri verilmeye başlanmıştır. Deneme yemi gruplara göre canlı ağırlıkları alınarak ikinci gruba canlı ağırlığının %2, üçüncü gruba %3 ve dördüncü gruba ise %4 kuru madde gelecek şekilde yemleme yapılmıştır. Lif folliküllerinin çeşit ve oranlarını tespit etmek için, kuzular; 7. gün, 21. gün, 2. ay, 6. ay ve 1. yaşa ulaştıklarında deri örnekleri alındı. Ayrıca bazı yapağı karakterlerinin belirlenmesi için de, 1 yaşındaki hayvanlardan yapağı örnekleri alındı. Hauter ve Barbe uzunlukları ile mukavemet değerleri bakımından kontrol grubu hayvanları muamelelere tabi tutulan grupların tümünden daha yüksek değerler almış ve farkların istatistiki olarak önemli olduğu gözlenmiştir. Farklı seviyedeki yem ve süt tüketimi ikincil follikül sayılarında önemli farklar oluşturmamıştır.

Anahtar Kelimeler: *Norduz, Farklı yemleme, Yapağı, Lif follikülleri*

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INTRODUCTION

In 2015, domestic sheep in Turkey totaled 31.507.934 animals, including 2.205.576 of the Merino breed and 29.302.358 domestic breeds. Approximately 11.5% of the Turkish fleece production (59.376 tonnes) was obtained from Merinos (Turkstat 2016).

The fleece follicles undergo two development stages: occurrence and maturation (Fraser and Short 1960). All primary follicles mature before the birth (Lyne 1961) and create hairs during the 108–110th days of sheep pregnancies (Maddocks and Jackson 1988). Corbett (1979) concluded that is was unlikely that maturation of primary follicles could be affected by undernutrition without also causing the death of the foetus and the dam. No productive breeding strategies in sheep have changed the formation times and arrangements of primary and secondary follicles (Hatcher and Johnson 2004). The primary follicles are characteristically medullated and have coarse fibers (>35 µm) (Ansari - Renani et al. 2011).

Secondary follicles continue their formation as a triangular structure that is determined by a trio group created by central and side primary follicles during the period from the 85th day of pregnancy until birth (Carter 1955; Hutchison and Mellor 1983). Between the 120–145th days of pregnancy, fiber formation begins (Maddocks and Jackson 1988) and 10–50% of secondary follicles will be in the state where they can produce fiber at birth (Cottle 2006). Short (1955) reported that between the 7-21 days after birth, the period in which matures at the maximum rate of secondary follicles.

Denney et al. (1988) reported that low postnatal nutrition reduced the secondary follicle and total number of follicles per sheep at weaning. Also reduced wool production and quality.The pre-weaning environment is the critical period for development of follicle population.

The secondary follicles are more numerous than primary follicles and produce nonmedullated fine fiber (<35 µm) (Ansari - Renani et al. 2011).

Genetic factors play an important role in the production and quality of wool and number of follicles of an individual sheep. Heritability of strength fleece between 0.23 and 0.47, fleece efficiency 0.46 and 0.72 (Safari and Fogarty 2003), heritability of wool length 0.48 and fiber diameter 0.57 (Safari et al. 2005), total follicle density h^2 ranges between 0.18 to 0.46 (Hill et al. 1997), depending on the strain of Merino studied. However environmental factors also play an important role quality of wool and number of seconder follicle. Environmental factors can be divided into pre-weaning and post-weaning influences (Hatcher and Johnson 2004). The aim of this study was to investigate the effect of different weaning strategies and the amount of forage consumption, given the same protein and energy content, on specific fleece characters and secondary fleece follicle formation in the Norduz sheep breed.

MATERIALS and METHODS

The study conducted on the Yuzuncu Yil University Research and Application Farm in 2010.

After birth, 50 lambs were divided into four groups. The control group did not undergo the foraging program applied to the other three groups. They were kept with the ewes in the main and pasture seasons. They consumed alfalfa hay until the pasture season and then freely consumed pasture grass. Forage grasses have a low value in the pasture. The lambs in this group nursed from the ewe for 150 days. In the experimental groups, the lambs were weaned on the 47th day and then fed milk residues. Lambs in the trial groups began to consume feed after the first week. Dry matter intake is a key determinant of growth. Lambs consume, on average, 3.8–4.2% of their live weight daily on a 'dry matter' basis (Goers and Jolly 2007). Therefore, the lambs in the 1st group were fed feed consisting of 2% dry weight based on dry weight, while the second and the third groups were fed feed consisting of 3 and 4% dry matter, respectively, based on live weight.

Dry fescue and lamb growth forage given in Table 1 were formulated based on a rate of 1:3 (25%:75%) for the lamb diets (Sarı et al. 2008). The groups were fed with dry material to allow determination of changes in protein and energy levels. The mixture of dry fescue and lamb growth forage was provided twice daily, in the morning and in the evening. Fresh and clean water was provided for the animals.

Table 1. Composition and nutrient content of the feed used in research

Lamb growth forage		Dry fescue	
Feed ingredient	**%**	**Feed ingredient**	**%**
Cottonseed meal	32.0	Grasses	50
Corn	23.0	Pulp	30
Barley	10.0	Bran	10
Wheat	15.0	Others	10
Bran	10.0		
Molasses	7.0		
Di calcium phosphate	1.5		
Mineral	1.0		
Vitamin	0.2		
Salt	0.5		

When the lambs reached one year of age, one palm-sized fleece area was removed and the fleeces were kept in labelled paper bags. The remaining fleeces, after shearing, were cut out with a razor blade without damaging the epidermis. When the lambs were 7 days, 21 days, 2 months, 6 months, and 1 year old, a piece with a Mean Fiber Diameter of 0.5 cm was taken from the skin with normal tension from a location on the last rib of the right side section with the help of a scalpel.

The mean fiber diameter, haut and barb length, efficiency, strength, and elasticity determinations of the fleece samples from an old yearling were performed at the Lalahan Livestock Research and Development Center.

Histopathological examinations were conducted on tissue samples with mean fiber diameters of 0.5 cm, obtained after sterilization of the shaved parts located at the last rib on the right side of the sheep at age 1 week, 21 days, 2 months, 5 months, and 1 year. The collected tissue samples were fixed in 10% buffered formalin for 24–48 hours. After fixation, they were embedded in Paraplast parallel to the epidermis surface using routine histologic tissue technique. Sections 6–7 µm thick were made from the prepared blocks and stained with Mallory Trichrome Stain (Bancroft and Cook 1984). The numbers and ratios of primary and secondary follicles were determined and their distribution in mm^2 was obtained by ocular micrometry in 100 frames using 20x lenses. The relevant areas were photographed.

Descriptive statistics for the properties were expressed as averages and standard errors. One-way analysis of variance and one or two-factor variance analyses were used for comparison of the groups and time. Following analysis of variance, a Duncan multiple comparison test was used to compare the different groups and times. The Spearman correlation coefficient was calculated to determine the relationship between the properties. The statistical significance level was taken as 5% in the calculations and the SPSS (Ver: 13) software package was used for all calculations.

RESULTS and DISCUSSION

Live weight in Norduz lambs

Differences in live weight between control and treatment groups are shown in table 2.

The live weights at six months were significantly higher in the control group than in the experimental group ($P<0.01$) (Table 2). The higher live weights in the control group were explained by the weaning date (150th day). The live weights of the treatment groups in this period were compatible with the differences in the feeding amounts.

Fleece characters in Norduz lambs

Statistical values related to the fleece properties of 1 year old Norduz lambs are given in Table 3.

No statistical differences were found in terms of mean fiber diameter, elasticity, or efficiency values.

Haut lengths were determined as 42.40, 30.45, 30.93, and 32.82 mm for the control group, group I, group II, and group III, respectively, while the barb lengths were 65.30, 51.70, 47.55, and 49.38 mm and the strengths were determined as 40.81, 25.79, 24.40, and 24.6 g, respectively. Higher live weights were observed in the control group (Table 3), as were greater lengths (haut and barb) and strengths in terms of fleece characteristics. These results were comparable to those found in the literature (Özcan 1971), which also indicated statistically higher values for control animals in terms of haut, barb and strength values. No differences were observed in terms of fleece properties between the trial groups ($P<0.05$).

The mean fiber diameters values in the control group and group III were similar to those reported by Çivi (1999) for Karakas sheep, by Karakuş et al. (2005) for Karakas and Norduz sheep, by Ünal et al. (2004) for Akkaraman sheep, and by Tuncer and Cengiz (2009) for Norduz and Karakas breeds. The mean fiber diameter value reported by Çivi (1999), again for Norduz sheep, was thicker than that for the fleeces of all groups in our study. The mean fiber diameter values found by İmik et al. (2003) and Aytaç (2004) for Akkaraman were similar to that reported in the present study for group I and group II Norduz sheep and thinner than that of group III.

The haut lengths of the control group was quite long from the treated Norduz groups and was longer than the values reported by İmik et al. (2003) and Aytaç (2004) for Akkaraman sheep, but was similar that reported by Ünal et al. (2004). It was also higher than the value reported by Tuncer and Cengiz (2009) for Norduz and Karakas sheep. Similarly, the barb length of the control group, which was significantly longer than that of the other groups in the present study, was also longer than the values reported for Norduz and Karakas sheep (Tuncer and Cengiz 2009) and Akkaraman sheep (İmik et al. 2003; Aytaç 2004; Ünal et al. 2004).

The average fleece elasticity was higher in the control group than in the other 3 groups in the present study. The average elasticity of all groups in the study was lower than the values reported by Çivi (1999) for Karakas and Norduz sheep. The fleece elasticity ratios of all Norduz groups studied were similar to the value found by İmik et al. (2003) for Akkaraman sheep and higher than that reported by Ünal et al. (2004). The fleece elasticity average for the Norduz control group in the present study was similar to the value reported by Tuncer and Cengiz (2009) for Norduz sheep and higher than the value reported for Karakas sheep. The elasticity values of for the three treated Norduz sheep groups were lower than the value reported by Tuncer and Cengiz (2009) for Norduz, but were similar to the values reported for Karakas sheep.

The fiber strength value was higher for the control group than for the average value of all three trial groups. The fiber strength values of the trial groups in this study were similar to the value reported by Çivi (1999) for Karakas sheep, while the value for the Norduz control group was similar to the fiber strength value determined by Çivi for Norduz sheep. In addition, fiber strength values of all groups used in the study were substantially higher than the values reported in the studies of Norduz and Akkaraman sheep (Aytaç 2004; Ünal et al. 2004; Karakuş et al. 2005; Tuncer and Cengiz 2009).

Fleece follicle number in Norduz lambs

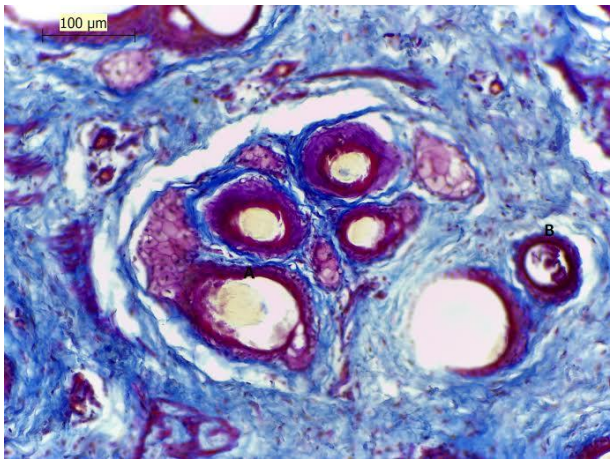

Figure 1. Norduz skin, 10% TF, triple staining, A: Primary follicular, B: Secondary follicular.

Primary follicle number: The numbers of primary follicle per 1 mm^2 skin surface of Norduz lambs subjected to different levels of forage consumption, but containing same energy and protein levels, are given in Table 4.

Primary follicle number of 7th day old control group of Norduz and group I was found to be higher but statistically insignificant than the primary follicle number in the same period of Norduz group II and group III. However, this difference was not detected from the skin sections obtained from 21 days old lambs. This may be caused by the death of lambs.

No statistically significant differences were observed among the groups in terms of primary follicle numbers. This is an agreement with the previous reports by the others (Lyne 1961, Maddocks and Jackson 1988, Corbett 1979).

The primary follicle number of all groups in this study was somewhat higher than the value determined by Zik et al. (1999) for Karakas sheep. The primary follicle number determined by Kocamış and Aslan (2004) for Tuj sheep was higher than the average values of all 1-year-old Norduz groups in the present study. The primary follicle numbers

obtained in Norduz sheep in this study were higher than the values determined by Tuncer and Cengiz (2009) for Norduz and Karakas sheep. The primary follicle numbers of Norduz sheep were higher than those of Iranian Afshari, Zandi, Mehrabani, Lori and Balouchi sheep (Ansari -Renani et al. 2011).

Secondary follicle number: The number of secondary follicles is given in Table 5.

Table 2. The average live weight of Norduz lambs at birth and after specific days of nutrition (kg)

	$\overline{X} \pm S_{\overline{x}}$			
	Control group	**I. group**	**II. group**	**III. group**
Birth	4.51±0.45	4.60±0.20	4.48±0.60	4.40±0.86
7th day	6.71±0.80	6.40±0.20	6.37±1.58	6.60±1.10
21th day	9.0±1.37	9.30±0.9	9.17±1.97	9.37±1.38
1th month	10.54±1.64	10.81±1.02	10.67±2.05	11.72±1.29
2th month	16.54±1.94	16.0±2.16	15.32±2.99	17.14±2.07
6th month	40.52±5.94a#	28.32±3.15c	31.68±3.45bc	35.97±2.17ab

Different letters within the same line are significantly different.

Table 3. Fleece characteristics in Norduz groups

	$\overline{X} \pm S_{\overline{x}}$			
	Control group	**I. group**	**II. group**	**III. group**
Haut Length (mm)	42.40±4.46a #	30.45±3.26b	30.93±1.62b	32.82±2.12b
Barb Length (mm)	65.30±2.36a	51.70±2.12b	47.55±3.22b	49.38±2.64b
Mean Fibre Diameter (μ)	33.58±2.99	29,05±0.88	27.30±1.55	31.12±1.29
Elasticity (%)	37.51±2.87	34.88±1.63	30.64±3.12	30.41±1.95
Strength (g)	40.81±7.35a	25.79±3.51b	24.40±3.07b	24.61 ± 2.31b
Efficiency (%)	64.15±4.15	54.63±8.26	62.35±2.03	51.67±5.87

Different letters within the same line are significantly different

Table 4. The number of primary follicles in Norduz groups

	$\overline{X} \pm S_{\overline{x}}$			
	Control group	**I. group**	**II. group**	**III. group**
7th day	14.65±1.03	12.00±1.99	9.86±2.37	8.00±1.41
21th day	5.00±0.58	7.64±3.00	8.65±1.03	7.32±0.39
2th month	5.77±0.23	7.65±0.80	6.95±0.80	5.11±1.11
6th month	6.21±0.89	5.64±1.00	8.43±1.60	5.99±0.67
1 year	6.00±0.052	5.23±0.39	6.38±1.10	5.50±0.36
$p_{group} = 0.613$		$p_{time} = 0.341$	$p_{groupx\ x\ time} = 0.457$	

Table 5. The number of secondary follicles in Norduz groups

	$\overline{X} \pm S_{\overline{x}}$			
	Control group	**I. group**	**II. group**	**III. group**
7th day	34.65±1.68	33.49±2.80	25.32±7.31	30.66±3.32
21th day	25.09±4.23	26.43±3.47	26.44±4.29	28.82±5.45
2th month	19.55±0.45	21.15±2.22	20.36±3.96	23.55±2.12
6th month	18.88±2.56	19.98 ±2.66	27.76±4.60	25.76±1.55
1 year	18.65±2.33	21.48±2.53	24.43±2.32	23.52±1.28
$p_{group} = 0.648$		$p_{time} = 0.331$	$p_{groupx\ x\ time} = 0.235$	

Table 6. Spearman correlation coefficients between the fleece properties and fleece follicles numbers

		HU (mm)	BU (mm)	MF Diam. (µ)	Elast. (%)	Str. (g)	Effic. (%)	Primer follicle					Seconder follicle				
								7th day	21th day	2th month	6th month	1 year	7th day	21th day	2th month	6th month	1 year
HU (mm)		1															
BU (mm)		.925**	1														
MF Diam. (µ)		.338	.211	1													
Elast. (%)		.439	.455	.665**	1												
Str. (g)		.448	.393	.668**	.816**	1											
Effic. (%)		.299	.229	.032	.387	.229	1										
Primer follicle	**7th day**	.370	.579*	.482	.516	.178	.086	1									
	21th day	-.608	-.456	-.729*	-.578	-.340	-.395	-.636*	1								
	2th month	-.294	.000	-.521	-.202	.034	-.345	-.320	.610*	1							
	6th month	-.062	-.455	-.577	.455	.577	.152	-.231	.154	.154	1						
	1 year	-.213	-.270	-.229	.142	.146	.586	-.013	.102	.196	.761*	1					
Seconder follicle	**7th day**	.072	.308	.385	.500	.082	.104	.814**	-.333	-.451	-.259	.104	1				
	21th day	-.117	-.059	-.494	-.527	-050	-745*	-.634*	.650*	.535	-.718	-.540	-.578	1			
	2th month	-.529	-.521	-.202	-.277	.235	-.445	-.671*	.767**	.481	-.816	.081	-.640*	.569	1		
	6th month	.360	-.036	-.286	-.429	-.286	-.072	-.222	-.400	-.400	.508	-.060	-.286	-.600	-.718	1	
	1 year	.080	-.287	-.032	-.178	-.041	.392	-.456	-.198	.099	.261	.436	-.498	-.333	.314	.536	1

*: P<0.05, **: P<0.01 HU: Haut Length, BU: Barb Length, MF Diam.: Mean Fiber Diameter, Elast.: Elasticity, Str.: Strength, Effic.: Efficiency

The secondary follicle numbers obtained on day 7 was higher for the control and group I (34.65 and 33.49, respectively) but the differences were not statistically significant.

As observed with the primary follicles, the secondary follicle numbers observed in the control and group I were higher at day 7 than at day 21 or at 2 and 6 months or 1 year, but the differences were not statistically significant. Previous studies (Short 1955, Denney at al. 1988) concluded that low postnatal nutrition reduced the secondary follicle. But the primary follicles were not affected by dietary differences in this study. The reason for this can be explained as; the effect of forage and breast milk consumption in different levels were not statistically significant in secondary follicle numbers.

In this study, secondary follicle numbers of all 1-year-old Norduz sheep in all groups were somewhat lower or higher than the ones reported by Zik et al. (1999) for Karakas sheep and quite higher than the values reported by Tuncer and Cengiz (2009) for Norduz and Karakas sheep. The results of the present study indicate that the secondary follicle number of Norduz sheep was higher than the value determined by Ansari-Renani et al. (2011) for Afshari, Zandi, Mehrabani, Lori and Balouchi breeds.

Correlation between fleece properties and follicle numbers in Norduz lambs

The correlation between fleece properties and follicle numbers in the Norduz groups based on different feed amounts, but the same energy and protein content, are shown in Table 6.

The barb lengths (P< 0.01) increased significantly, with high haut length. A significant positive relation was observed between barb lengths and the primary follicle number at day 7 (P<0.05). Statistically significant increases in mean fiber diameter, elasticity, and strength were also observed (P<0.01) and the primary follicle number of 21-day-old Norduz lambs decreased significantly (P<0.05). A significant positive relationship was found between fleece elasticity and fleece strength (P<0.01). The fleece efficiency and the secondary follicle number showed a statistically significant negative correlation (P<0.05) in 21-day-old lambs.

The primary follicle numbers between 7-day-old and 21-day-old Norduz lambs showed a significant negative relationship (P<0.05) in the present study, while significant positive correlation was found among the primary follicle and secondary follicle numbers of 7-day old (P<0.01). A significant negative correlation (P<0.05) was observed between secondary follicles of 7-day-old and 2-month-old Norduz lambs, while a significant positive relationship was found for primary follicles between 21-day-old and 2-month-old lambs (P<0.05), another significant positive relationship was found between primary and secondary follicles of 21-day-old lambs (P<0.05). Positive significant relationship was determined between primary follicles of 21-day-old and secondary follicles of 2-month-old lambs (P<0.01). The increase in primary follicles of 6-month-old Norduz lambs resulted in a significant increase in primary follicles in 1-year-old Norduz lambs (P<0.05). A significant negative relationship (P<0.05) was observed between primary follicles of 7-day-old and secondary follicles of 2-month-old Norduz lambs.

CONCLUSION

The absence of a statistical difference between trial groups indicates that feed amount has no significant effect on fleece characteristics. In contrast, the fleeces of the experimental groups and the control group showed significant differences in terms of the strength and length of haut and barb. This may be explained by the different weaning periods between the trial and the control groups. The maturation of the primary follicles before the birth (Lyne 1961) meant that the primary follicles were not affected by dietary differences in this study. The secondary follicles were also similar in all groups. This situation can be explained by the possibility that the nutritional levels of the groups were not sufficiently different. If the nutrition of the

groups had been more dissimilar (different feed content), differences might have been observed in the number of secondary follicles. In conclusion, small differences in nutrition levels are not expected to change the secondary follicles and fleece properties of Norduz lambs.

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REFERENCES

Ansari-Renani HR, Moradi S, Baghershah HR, Ebadi Z, Salehi M, Seyed Momen SM, Ansari-Renani MY (2011). Determination of wool follicle characteristics of Iranian sheep breeds. *Asian-Australas J Anim Sci,* 24 (8),1173-1177.

Aytaç M (2004). Akkaraman, Sakız x Akkaraman F_1 ve G_1 ile Kıvırcık x Akkaraman F_1 ve G_1 Genotiplerinde Verim Özellikleri. Ankara Univ Fen Bil Enst, (PhD Thesis), Turkey.

Bancroft JD, Cook HC (1984). Manual of Histological Tecniques. Churchill Livingstone, London.

Carter HB (1955). The hair follicle group in sheep. *Anim Breed Abstr,* 23 (2), 101–116.

Corbett JL (1979). Variation in wool growth with physiological state, in: JL Corbett (ed.) Physiological and environmental limitations to wool growth, pp. 79-98, Armidale, Australia, The University of New England Publishing Unit

Çivi A (1999). Karakaş ve Norduz Kuzularında Yapağı Verim ve Özellikleri. Yüzüncü Yıl Üniv Fen Bil Enst (PhD Thesis), Turkey.

Cottle D (2006). Animal fibres, follicles and fleeces. http://wwwpersonal.une.edu.au /~dcottle2/211-lecture2.pdf. Accessed: 22 June 2006.

Denney GD, Thornberry, KJ, Sladek MA (1988). The effect of pre and postnatal nutrient deprivation on live weight and wool production of single born Merino sheep. *Proc Aust Soc Anim Prod,* 17, 174-177.

Fraser AS, Short BF (1960). The biology of the fleece. Anim Res Laboratories Techn Paper 3. Commonwealth Scientific and Industrial Research Organization. Melbourne, Australia.

Goers H, Jollys S (2007). Meat and Livestock Australia. ISBN: 9 7817 4191 1060, Australia.

Hatcher S, Johnson PR (2004). Optimising genetic potential for wool production and quality through maternal nutrition. AFBM Network Conference, Orange NSW 2800, Australia.

Hill JA, Hynd PI, Ponzoni RW, Grimson RJ, Jaensch, KS, Kenyon RV and Penno NM (1997). 'Skin and follicle characters 1. Heritabilities and correlations among them' , in Proceedings of the Australian Association for Animal Breeding and Genetics, *Aust Assoc Anim Breeding and Genetics*, 12, 520-523

Hutchison G, Mellor DJ (1983). Effects of maternal nutrition on the initiation of secondary wool follicles in foetal sheep. *J Comp Pathol,* 93 (4), 577–583.

İmik H, Tuncer ŞD, Aytaç M, Aylanç A (2003). Akkaraman kuzu rasyonlarına arpa yerine farklı oranlarda katılan kavuzu alınmış süpürge darısının (*Sorghum vulgare*) besi performansı ve yapağı kalitesi üzerine etkisi. *Türk Vet Hayv Derg,* 27, 351–360.

Karakuş K, Tuncer SS, Arslan S (2005). Comparison of the fleece characteristics of Karakas and Norduz sheep (Local Ewes in Turkey). *J Anim Vet Adv,* 4 (6), 1-10.

Kocamış H, Aslan Ş (2004). Tuj koyunlarının derileri üzerine histolojik ve histometrik bir inceleme. *Kafkas Üniv Vet Fak Derg,* 10 (1), 91-98.

Lyne AG (1961). The postnatal development of wool follicles, sheeding and skin thickness in inbred Merino and Southdown-Merino crossbred sheep. *Aust J Biol Sci,* 14, 141–156.

Maddocks IG, Jackson N (1988). Structural studies of sheep, cattle and goat skin. *CSIRO* Division Animal Production, Blacktown, New South Wales, Australia.

Özcan H (1971). İnanlı İnekhanesi Kıvırcık koyunlarında canlı ağırlık, yapağı verimi, lüle uzunluğu ve yapağı inceliğinin kalıtım dereceleri be bu yapağı karakterleri arasındaki ilişkiler *Ankara Univ Vet Fak Derg,* 18 (2), 149-161.

Özfiliz N, Özer A, Yakışık M, Erdost H (1997). Kıvırcık ve Karacabey Merinos koyunlarının derilerinin histolojik ve morfometrik yönden karşılaştırmalı olarak incelenmesi. *Turk J Vet Anim Sci,* 21, 125-133.

Safari A and Fogarty NM (2003). Genetic parameters for sheep production traits: Estimates from the literature, NSW Agriculture, Orange.

Safari E, Fogarty NM, Gilmour AR (2005). A review of genetic parameter estimates for wool, growth, meatandre production traits in sheep. *Livest Prod Sci*, 92 (3), 271–289.

Sarı M, Bolat D, Çerçi İH, Önol AG, Deniz S, Azman MA, Şahin K, Güler T, Seven PT, Karslı MA, Şahin N, Nursoy H, Çiftçi M, Bingöl NT (2008). Hayvan Besleme ve Beslenme Hastalıkları. Medipres Matbaacılık Ltd. Şti. ISBN: 978-975-6676-29-5, Malatya.

Short B. (1955). Development of the secondary follicle population in sheep. *Aust J Agr Res*, 6 (1), 62–67.

Tuncer SS, Cengiz F (2009). Norduz ve Karakaş Koyunlarında Kıl Follikülü ile Yapağı Özellikleri Arasındaki İlişkiler. 6. Ulusal Zootekni Bilim Kongresi, Poster sunumu, Erzurum.

Turkstat (2016). Turkish Statistical Institute, Livestock Statistics. http://tuikapp.tuik.gov.tr/ hayvancilikapp/hayvancilik.zul. Accessed: 01 April 2016.

Ünal N, Akçapınar H, Atasoy F, Koçak S, Aytaç M (2004). Akkaraman, Sakız x Akkaraman ve Kıvırcık x Akkaraman melezleri (F_1, G_1) ile Karayaka ve Bafra koyunlarda canlı ağırlık ve yapağı özellikleri. *Lalahan Hayv Araşt Enst Derg,* 44 (2), 15–22.

Zık B, Özfiliz N, Erdost H, Yağcı A (1999). Karayaka koyun derileri sırt bölgesinin histolojik ve morfometrik yönden incelenmesi. *Kafkas Üniv Vet Fak Derg,* 5 (2), 193 - 201.