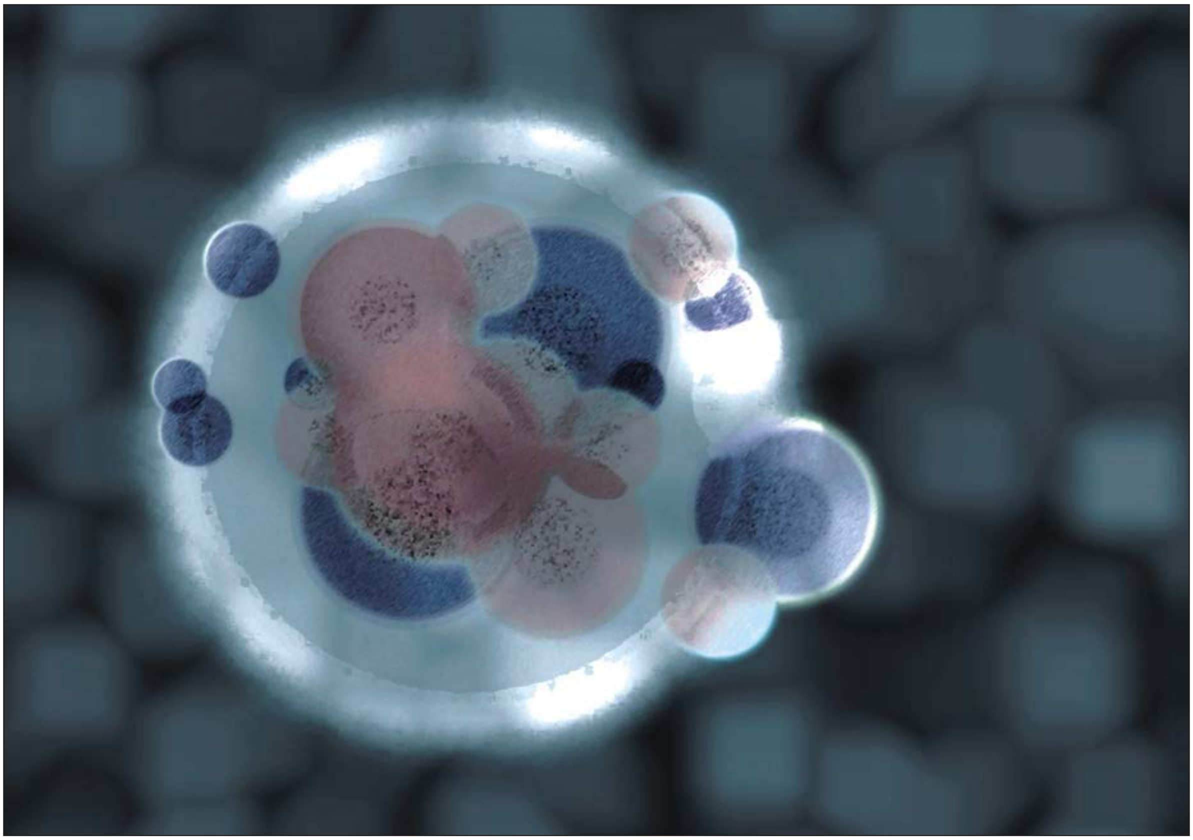

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# Ultrasound Measurements of Eye Muscle Properties and Backfat Thickness in Kivircik Lambs

[1]Ibrahim Cemal, [1]Orhan Karaca, [1]Tufan Altin, [2]Ozdal Gokdal, [1]Murat Yilmaz and [1]Onur Yilmaz
[1]Department of Animal Science, Faculty of Agriculture, Adnan Menderes University, Aydin, Turkey
[2]Cine Vocational High School, Adnan Menderes University, Cine, Aydin, Turkey

**Abstract:** The present study was conducted to determine eye muscle (m. longissimus lumborum) properties of Kivircik lambs at weaning. The depth, width and area of eye muscle and the thickness of fat covering this muscle at the cross sectional area between the 12 and 13th ribs was determined using ultrasonic measurements from 90 lambs taken from three different flocks. At this time, the weaning weights of lambs was also recorded. The overall mean weaning weight of lambs was 26.8 kg at 125 days. Weaning weight was found to be significantly affected by flock, sex and birth type of lambs except dam age. Lamb age as a covariate on weaning weight was not a significant effect. Least-squares means for ultrasonic measurement of depth, width and area of eye muscle and backfat thickness were 19.6±0.35 mm, 48.1±0.61 mm, 6.91±0.157 $cm^2$ and 1.2±0.08 mm, respectively. The variation observed between flocks means were highly significant for eye muscle width and area, significant for backfat thickness, but not significant for muscle depth. The lamb sex was found only to be a significant variable for muscle depth. Age of dam and the birth type of lamb were not significant sources of variation for the ultrasonic measurements. All phenotypic correlations within ultrasonic criteria and weaning weights of lambs, were significant and correlation coefficients ranged between 0.36 and 0.85. Lambs are marketed at weaning or a short time thereafter by the majority of breeders in Western Anatolia, such as breeders in Aydin province. It is extremely difficult to take measurements on carcasses in these regions as lambs are mainly marketed or slaughtered as small groups or individually and abattoirs do not record any measurements on carcasses characteristics. In this situation, information on body composition of lambs can be obtained practically by ultrasonic measurements on live animals. When combined in a breeding program with lamb weaning or market weights, these measurements will provide a way to increase both meat yield and the quality of Kivircik lambs.

**Key words:** Sheep, Kivircik, ultrasound, carcass traits, eye muscle, weaning weight

## INTRODUCTION

The consumption of lamb meat has decreased in the past 30 years, except in those countries primarily responsible for its exportation, such as New Zealand Australian and some Middle Eastern countries. Lamb consumers are concerned with reduced fat levels without compromised taste, continued meat quality, low levels of waste products and prefer low cost, economical cuts which are easy to cook. The demands of consumers have been addressed in studies aimed at improving meat composition through the use of intra and inter breed genetic variation (Simm and Murphy, 1996; Stanford *et al*., 1998; Simm *et al*., 2002).

Several methods have been developed to determine the composition and quality of the lamb carcass. Carcass dressing after slaughter and methods using chemical and physical analyses are effective and reliable, however these are costly, labour intensive and can involve subjective measurements. Ultrasound technology provides a way of quantifying the carcass with the primary advantages of reducing time and labour costs. This technology has been most commonly used to determine the carcass characteristics of live animals for application in selective genetic improvement programs (Fogarty *et al*., 1992; Wilson, 1992; Russel, 1995; Larsgard and Kolstad, 2003).

There are high correlations between the ultrasonic measurements taken of eye muscle and backfat thickness in live animals compared to the objective measurements assayed from the carcass after slaughter (Fernandez *et al*., 1998). However these trends do not always apply to lean animals (Hopkins *et al*., 1993). In a study using Manchego lambs (Fernandez *et al*., 1997), the correlations between

**Corresponding Author:** Ibrahim Cemal, Adnan Menderes, University Ziraat Fakultesi Zootekni Bolumu Guney Kampusu, 09100 Aydin, Turkey Tel: +90 256 7727023/2013, +90 532 6659523 Fax: +90 256 7727233

ultrasonic measurements and actual measurements taken from carcass for longissimus muscle area, muscle depth and backfat thickness were recorded as 0.88, 0.74 and 0.56, respectively. In a similar study (Fernandez *et al.*, 1998), the correlations for the fat thickness are reported as 0.90 and 0.92 for lambs weighing 25 and 35 kg, respectively. These high correlations demonstrate the aptness of ultrasound scanning in selection programs which aim to improve carcass quality. In many of the breeding programs that constructed to improve meat yield, the basic selection criterion is live weight or live weight gains in some periods. There are positive correlations between the carcass measurements and live weight or live weight gains, but only using these criteria in the selection programs to improve carcass quality is not enough. Therefore, ultrasonic measurements can be incorporated as a selection criterion for breeding schemes geared toward faster genetic gain.

As ultrasonic scanning is performed on live animals, it is imperative that the position for this measurement not only be easily and consistently identified by animal handlers, but that the position be a true reflection of carcass composition. The preferred sites are in the region of the 12th (Hopkins *et al.*, 1996; Hegarty *et al.*, 2006) or 13th rib (Gilmour *et al.*, 1994; Simm and Murphy, 1996) or the region between these ribs (Fernandez *et al.*, 1997; Hopkins *et al.*, 1998; Bedhiaf Romdhani and Djemali, 2006; Teixeira *et al.*, 2006). The 12 and 13th ribs are the last ribs in an animal and so are easy to identify. They are also longer and wider than other intercostals, simplifying the task of measuring fat depth and the eye muscle area. In most studies eye muscle width, depth, area and the thickness of fat covering the selected area is measured. However, it is difficult to measure eye muscle width accurately as its lateral boundary is not clear and so in breeding schemes like Australian LAMBPLAN (Gilmour *et al.*, 1994), only eye muscle depth along with fat thickness are included. Furthermore, mean heritability for muscle depth (0.24) has been shown to be considerably higher than width (0.06), which reflects the limitation of ultrasonic measurement for width (Safari *et al.*, 2005). The genetic correlation is also stronger between depth and area (Fogarty, 1995).

The Kivircik breed is found throughout the western regions of Turkey (Marmara and some parts of Aegean regions) where production is geared toward fat lamb sale. This thin-tailed breed is widely known for its good growth characteristics and is preferred by consumers for its better meat quality (flavor and low fat). Lambs are generally slaughtered at a young age, such as at weaning, to obtain light weight carcasses (10 to 15 kg) in accordance with costumer demand. Therefore, selection of lambs before slaughter, at an early age like weaning, is a necessity.

This study aimed to determine backfat thickness and longissimus dorsi muscle properties of Kivircik lambs using ultrasonic measurements and to evaluate the effects of flock, sex, dam age, birth type and weaning weight on these parameters. By providing the first reference for these phenotypic parameters with ultrasonic measurements, this study may assist with the initiation of a genetic breeding program which includes ultrasonic measurements to improve meat yield and in turn the quality of Kivircik lambs.

## MATERIALS AND METHODS

Ninety Kivircik lambs in three flocks, two breeders' flocks (Flock-1 and Flock-2) and a nucleus flock (Flock-3) was used as animal material in this study. The nucleus flock was formed from 38 breeders' flocks under the framework of Adnan Menderes University Group Sheep Breeding Program (AMU-GSBP) based on an open nucleus breeding system (Karaca *et al.*, 1998). Lambing season were ranged from the November to the January as a result of extended breeding season. Flocks raised in extensive conditions were kept on pastures throughout the year. However, concentrate are used in feeding of ewes as suplement during some critical periods, such as late gestation and a short period after lambing. A small amount of concentrate are also given to lambs for a short period before weaning.

Ewes were observed during the 2002-2003 birth season allowing lambs to be numbered, weighed and records of birth type (single or multiple) and sex to be recorded on day of birth. A total of 90 lambs survived to marketing age. Each of these were measured for weaning weight, depth, width and area of eye muscle (musculus longissimus lumborum) and thickness of fat covering this muscle at the area between the 12th and 13th rib using ultrasonic scan. Wool was removed from measurement areas by shearing before ultrasonic scanning. The ultrasonic measurements were performed by an experienced operator *in vivo* using a Pie Medical Falco 100 ultrasonic machine with a 6 cm length 6 MHZ linear probe. After scan image capture, the depth and width of the eye muscle and the thickness of backfat at this point was measured using electronic caliper of the scanner. The resolution of scanner caliper was 0.01 cm. Longissimus muscle area was measured on the same image after the borders of muscle had been drawn.

Ultrasonic measurements and the weaning weights of lambs were analyzed using the GLM (Generalized Linear Models) procedure of SAS (1999) according to following linear models:

Model for weaning weights of lambs:

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + b_1(X_{ijklm} - \overline{X}) + e_{ijklm}$$

Model for ultrasonic measurements:

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + b_2(V_{ijklm} - \overline{V}) + e_{ijklm}$$

Where

$y_{ijklm}$ = Weaning weights of lamb or any ultrasonic measurements
$\mu$ = Overall mean of the trait
$a_i$ = Fixed effect of flock (i = flock-1, flock-2 and flock-3)
$b_j$ = Fixed effect of sex (j = male, female)
$c_k$ = Fixed effect of dam age (k = ≤2, 3, 4, 5 and ≥6)
$d_l$ = Fixed effect of birth type (l = single and twin and triplet)
$b_1$ = Regression coefficient of lamb age at weaning on weaning weight
$b_2$ = Regression coefficient of weaning weight on ultrasonic measurements
$X_{ijklm}$ = Age of lamb at weaning
$V_{ijklm}$ = Weaning weight of lamb
$\overline{X}$ = Mean lamb age at weaning
$\overline{V}$ = Mean weaning weight of lambs and
$e_{ijklmn}$ = Random errors with the assumption of N (0, $\sigma^2$)

The phenotypic correlations between variables were obtained using the CORR procedure of the SAS (1999) statistical program.

## RESULTS

The average age of lambs in terms of the flocks are given in Table 1. The average live weight of lambs was 26.78 kg at weaning (approximately 125 days) or day of ultrasonic measurement.

The statistics for ultrasonic measurements of the eye muscle properties and weaning weights of lambs are given in Table 2. The coefficient of variation for backfat thickness indicated a higher variation for the trait. It should be noted that the fat levels are very low with a mean of only 1.4 mm. Some of this variation may stem from measurement error.

The analyses have indicated significant effects on weaning weight of flock, sex and birth type of lambs ($p<0.01$) except dam age and lamb age as covariate ($p>0.05$). Mean weights of lambs in Flock-2 and Flock-3 were found 7.5 and 6.8 kg heavier than lambs in Flock-1. Male lambs were found to be significantly heavier than the females (28.1 vs. 25.5 kg; $p<0.01$). With respect to lamb birth type, single born lambs were significantly heavier than multiple born lambs (28.5 vs. 25.1 kg, $p<0.01$) (Table 3).

The differences observed between least squares means of flocks were highly significant for eye muscle width and area ($p<0.01$) and significant for backfat thickness ($p<0.05$) but not significant for muscle depth ($p>0.05$). The difference due to sex of lambs was only significant for muscle depth ($p<0.05$). The age of dam and birth type of lamb were not significant sources of variation for the ultrasonic measurements ($p>0.05$). The coefficients for regression of weaning weights on depth, width and the area of the eye muscle were highly significant ($p<0.01$), but not significant on backfat thickness ($p>0.05$) (Table 4).

All correlation were found to be positive and significant ($p<0.001$). The correlation between longissimus muscle area with depth and width of the muscle were highest (0.845 and 0.753, respectively) (Table 5). There were moderate correlations between the weaning weight

Table 1: Mean (±SD) for age of lambs at weaning by flock

| Factors | N | Age of lambs (days) | Min | Max |
|---|---|---|---|---|
| Overall | 90 | 124.6±37.34 | 73 | 189 |
| Flock-1 | 21 | 83.7±7.06 | 73 | 102 |
| Flock-2 | 49 | 119.5±20.45 | 103 | 162 |
| Flock-3 | 20 | 180.1±16.27 | 129 | 189 |

Table 2: Basic statistics for ultrasound measurements of eye muscle properties and weaning weights of lambs

| Traits | N | Mean | SD | Min | Max | CV |
|---|---|---|---|---|---|---|
| Backfat thickness (mm) | 90 | 1.4 | 0.51 | 0.4 | 3.2 | 37.32 |
| Longissimus muscle depth (mm) | 90 | 19.9 | 2.78 | 13.6 | 28.2 | 14.02 |
| Longissimus muscle width (mm) | 90 | 48.6 | 5.06 | 34.2 | 58.4 | 10.42 |
| Longissimus muscle area ($cm^2$) | 90 | 7.06 | 1.448 | 3.88 | 10.11 | 20.52 |
| Weaning weight (kg) | 90 | 28.94 | 4.527 | 18.60 | 39.10 | 15.64 |

Abbreviations: SD: Standard deviation; CV: Coefficient of Variation

Table 3: Least squares means (±SE) for weaning weight of lambs

| Factors | N | Weaning weight (kg) |
|---|---|---|
| Overall mean | 90 | 26.8±0.48 |
| Flock | | ** |
| Flock-1 | 21 | 22.0±1.21 |
| Flock-2 | 49 | 29.5±0.71 |
| Flock-3 | 30 | 28.8±1.39 |
| Sex | | ** |
| Male | 46 | 28.1±0.53 |
| Female | 44 | 25.5±0.64 |
| Age of dam | | ns |
| ≤2 | 10 | 26.3±1.02 |
| 3 | 20 | 26.0±0.85 |
| 4 | 16 | 26.6±0.98 |
| 5 | 19 | 26.4±0.85 |
| ≥6 | 25 | 28.6±0.79 |
| Type of birth | | ** |
| Single | 75 | 28.5±0.47 |
| Twin and triplet | 15 | 25.1±0.93 |
| Linear Regression of | | ns |
| Lamb age (day) | | -0.039±0.020 |

*p<0.05; **p<0.01; ns: non significant

Table 4: Least squares means (±SE) and standard errors for ultrasound measurements of backfat thickness and depth, width and area of longissimus muscle of lambs at weaning

| Factors | N | BFT (mm) | LMD (mm) | LMW (mm) | LMA ($cm^2$) |
|---|---|---|---|---|---|
| Overall mean | 90 | 1.2±0.08 | 19.6±0.35 | 48.1±0.61 | 6.91±0.157 |
| Flock | | * | ns | ** | ** |
| Flock-1 | 21 | 1.0±0.15 | 20.4±0.67 | 50.4±1.17 | 7.76±0.300 |
| Flock-2 | 49 | 1.5±0.10 | 19.8±0.47 | 49.3±0.81 | 7.10±0.209 |
| Flock-3 | 20 | 1.2±0.12 | 18.6±0.52 | 44.5±0.91 | 5.86±0.234 |
| Sex | | ns | * | ns | ns |
| Male | 46 | 1.3±0.08 | 19.0±0.36 | 48.1±0.62 | 6.83±0.160 |
| Female | 44 | 1.2±0.11 | 20.2±0.49 | 48.0±0.86 | 6.98±0.220 |
| Age of dam | | ns | ns | ns | ns |
| ≤2 | 10 | 1.2±0.15 | 19.5±0.70 | 46.4±1.22 | 6.82±0.315 |
| 3 | 20 | 1.3±0.13 | 20.3±0.60 | 50.1±1.04 | 7.27±0.268 |
| 4 | 16 | 1.3±0.15 | 19.8±0.67 | 48.8±1.17 | 7.05±0.300 |
| 5 | 19 | 1.1±0.13 | 19.3±0.59 | 48.1±1.03 | 6.85±0.265 |
| ≥6 | 25 | 1.2±0.11 | 19.2±0.51 | 47.0±0.89 | 6.55±0.228 |
| Type of birth | | ns | ns | ns | ns |
| Single | 75 | 1.3±0.07 | 19.9±0.31 | 48.0±0.54 | 7.05±0.140 |
| Twin and triplet | 15 | 1.1±0.15 | 19.3±0.68 | 48.1±1.18 | 6.76±0.303 |
| Linear Regression of | | ns | ** | ** | ** |
| Weaning weight | | 0.0003±0.0016 | 0.036±0.007 | 0.053±0.013 | 0.193±0.032 |

BFT: Back Fat Thickness; LMD: Longissimus Muscle Depth; LMW: Longissimus Muscle Width; LMA: Longissimus Muscle Area; *p<0.05, **p<0.01, ns: non significant

Table 5: Correlation coefficients between ultrasound measurements and weaning weight (n = 90)

| Traits | BFT | LMD | LMW | LMA |
|---|---|---|---|---|
| LWW | 0.362*** | 0.608*** | 0.581*** | 0.649*** |
| BFT | | 0.406*** | 0.368*** | 0.427*** |
| LMD | | | 0.562*** | 0.845*** |
| LMW | | | | 0.753*** |

LWW: Lamb Weaning Weight; BFT: Backfat Thickness; LMD: Longissimus Muscle Depth; LMW: Longissimus Muscle Width; LMA: Longissimus Muscle Area; ***p<0.001

of lamb and the measurements of longissimus muscle depth, size and the area but the correlation of weaning weights with backfat thickness was lower.

## DISCUSSION

In this study, average lamb weight was approximately 27 kg and the average age ranged from 83-180 days, depending on flock membership. Animal age at time of measurement is important, as variation may exist between genetic evaluation programs which are based on ultrasonic measurements, if these scan measurements are ascertained at different time periods. Australia's genetic evaluation and performance testing program, LAMBPLAN, allows ultrasonic measurement for lambs to be taken over a wide range of ages, 5 to 18 months (Gilmour *et al.*, 1994). Others, such as Suffolk sire-reference schemes in Canada (Gallivan and Hosford, 1997) and Britannia (MLC, 1987) target measurement at 100 and 147 days of age, respectively.

With respect to lamb weight and environmental factors, the results observed here were close to common expectations. However, the effect of dam and lamb age were some surprising. With respect to dam age, the effect of oldest females appeared superior, whilst other age groups were in keeping with each other. This observation can be explained in terms of animal husbandry: animals which perform well (ewes have high milk yields) are maintained in flocks longer, in an effort by breeders to increase their farm production value. On the other hand the regression coefficient of lamb age (days) on the weaning weight of lambs was not significant and was negative. Daily age effects were compounded with flock effects due to the large variation of lamb ages across the three flocks, compared to the limited variation within flocks. As was expected, male lambs were higher performing than their female counterparts, as was the case with single born lambs when compared to twins and triplets. The effects of dam age, birth type, rearing type and lamb age on the live weights of lambs was shown to be significant in a study by Gilmour *et al.* (1994) using the Poll Dorset breed. Similar trends were observed in this experiment.

For the Kivircik lambs were assessed, the average backfat thickness, depth, width and area of the eye muscle measured by ultrasound were 1.2, 19.6 and 48.1 mm and 6.91 $cm^2$, respectively. The area of the eye muscle was recorded as 8.95, 9.67 and 10.85 $cm^2$ for Manchego, Merinos and Ile de France x Merino lambs, respectively, with a live weight ranging from 22 to 28 kg (Fernandez *et al.*, 1997). The fat thickness for these genotypes was also recorded as 3.28, 3.83 and 4.10 mm, respectively. Similarly, Stanford *et al.* (2001) assayed 90 day old male and female lambs with live weights of

27.3 and 25.3 kg. The loin eye area was recorded as 7.15 and 7.42 $cm^2$ and the fat thickness of these sheep were recorded as 2.74 and 2.96 mm, respectively. The values reported for the fat thickness and the eye muscle in these two studies was higher than the values observed in present study. The low level of backfat thickness in Kivircik lambs makes this breed superior in terms of carcass quality. This issue was supported by similar results obtained by Cemal *et al.* (2005, Personal Communication). In their study, backfat thickness and eye muscle properties of Kivircik and Karya (Sakiz x Kivircik cross) lambs that have a mean age of approximately 157 days (after a 70 day fattening period) are measured on live animals by ultrasound and on their carcasses actually. They found backfat thickness to be 0.32 and 0.27 mm for Kivircik (n = 10) and 0.27 and 0.23 mm for Karya (n = 10) lambs. In that study, the phenotypic correlation between ultrasonic measurements and carcass backfat thickness was estimated as 0.72 ($p<0.001$) using pooled data.

The correlation coefficients obtained in the present study (Table 5) are in the range previously reported in literature (Fernandez *et al.*, 1997; Conington *et al.*, 2001; Safari *et al.*, 2005). Fernandez *et al.* (1997) stated the correlation coefficients of fat thickness with muscle depth and muscle area were 0.31 and 0.34 and the correlation coefficient of muscle area with muscle depth was reported as 0.56. Findings in present study were in agreement with their values. The consistently high correlation observed between longissimus muscle depth and area is the reason only depth measurements are incorporated into breeding programs, such as the Australian LAMBPLAN scheme.

Ultrasonic measurement technology has been used in selection programs to improve growth and carcass traits in sheep (Simm *et al.*, 1987; Larsgard and Kolstad, 2003). The advantage of this method is that it can be used on live animals at relatively low costs (Conington *et al.*, 1995; Larsgard and Kolstad, 2003). In addition, heritability estimates for ultrasonic fat and muscle measurements were moderate to high (Fogarty, 1995; Jones *et al.*, 2004; Safari *et al.*, 2005). The results reported here with Kivircik lambs will be useful for future studies including genetic improvement of meat quality in lambs. In many parts of the world (UK, Australia, New Zeal and Denmark, Finl and Norway) ultrasound measurements are incorporated into national genetic evaluation programs or into selection indices to achieve high quality lamb carcasses (Stanford *et al.*, 1998). The generation of these indices relies on accurate estimates of genetic and phenotypic variances and covariances for the selection criteria and covariances between the criteria and objectives. In the same way, Kivircik breeders will eventually have access to genetic estimate parameters using a database containing more animal materials and pedigree information. Once these parameters are obtained, a selection index may be easily formed to improve carcass quality of lambs according to consumer demands.

## CONCLUSIONS

Lambs are being sent to market at weaning, or a short time thereafter, in most regions of Western Anatolia. It is very difficult to take individual carcass measurements as lambs are generally marketed or slaughtered in small groups or individually in an unplanned manner. Flock sizes are also small. Therefore, ultrasonic scans on live animals may be used in breeding programs, along with weaning or market weight, to increase meat yield and quality of lambs. In this respect, a database generated by AMU-GSBP, an organization supported by many sheep breeders in the vicinity of Aydin, is a first step towards measured genetic breeding gains. This work will be starting point for genetic parameter estimation and breeding value predictions when genetic relationship established. The rate of genetic improvement for growth and carcass characteristics of lambs can be accelerated by a breeding program including ultrasonic measurements along with other records, such as live weights or live weight gains in some periods.

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