Reproductive characteristics of Awassi ewes under Cornell alternate month accelerated lambing system

Sabri Güll, Mahmut Keskin
Animal Science Department, Mustafa Kemal University, Hatay, Turkey

Abstract

We investigated the reproductive responses of Awassi ewes under Cornell alternate month accelerated lambing (CAMAL) system. Ewes were randomly allocated to two experimental groups. The first group (control group) consisted of 20 ewes exposed to rams in September under conventional management system, while the second group (CAMAL) was divided into four sub-flocks containing each 20 ewes exposed to rams to obtain three lambing in two years with different breeding and lambing months. In CAMAL ewes, oestrus was synchronized using intra-vaginal sponges with progesterone and Pregnant Mare Serum Gonadotropin (PMSG) administration. The results obtained revealed that within CAMAL group, the percentage of animals in heat, onset of oestrus, litter size, birth weight and weaning weight were affected by mating months. September and November were the most appropriate months for oestrus ratio (97.5%) and litter size (1.18 and 0.98, respectively). Lambs of control group were heavier at birth and litter size (1.10-1.20) of litter size and 380 kg milk yield (Galal et al., 2008).

The present study was designed to investigate the appropriateness of Awassi sheep to CAMAL system, to improve lamb yield and some reproductive characteristics in different season of year. Traits related to ewe prolificacy were studied, such as time from PMSG administration after withdrawn of progesterone sponge and onset of oestrus, fertility, fecundity and litter size, birth and weaning weights.

Materials and methods

This study was carried out at the Research and Training Farm of Mustafa Kemal University, Hatay province, Turkey. One hundred, 4-years-old Awassi ewes were allocated into two groups. The first group (control group) consisted of 20 ewes that were exposed to rams in September without any hormonal treatment, while the second group (CAMAL) was divided into four sub-flocks containing 20 ewes each, which were exposed to rams to obtain three lambing in two years with different breeding and lambing months (Table 1). In CAMAL group, mating was started in September 2003 in sub-flock A and finished in July 2004 in sub-flock D.

At the beginning of the experiment, ewes were ranked according to their body weights, and each treatment group contained animals with similar weight. All ewes in each group/sub-flock were weighed at each own mating period. In CAMAL group, rams were isolated from ewes during the year, except for breeding date. Ewes in each sub-flock were inserted progesterone sponges for 14 days before their own mating date. After this period the sponges were withdrawn and 500 U PMSG was administered (Zeleke et al., 2005). Ewes were checked for oestrus at least three times a day, and were considered to be in heat when they stood for mounting by a ram. Oestrus date and time were recorded for each ewe in the sub-flocks and one ram was allowed to mate maximum 5 ewes during joining. Reproductive traits were calculated using the following formulas:

- Fertility1 = (Ewes lambing in 2 years/Ewes in groups) \times 100
- Fertility2 = (Ewes lambing in 2 years/Ewes in groups) \times 100
- Fecundity1 = (Lambs born in 2 years/Ewes in groups) \times 100
- Fecundity2 = (Lambs born in 2 years/Ewes in groups) \times 100
- Litter size1 = (Lambs born in 2 years/Ewes lambing in 2 years) \times 100
- Litter size2 = (Weaned lambs in 2 years/Ewes lambing in 2 years) \times 100
- Lamb survival1 = (Weaned lambs in 2 years/Lambs born in 2 years) \times 100

Animals were housed in semi-open sheds under semi-intensive conditions. Lambs were weaned at 60 days of age. All ewes in each group/sub-flock were fed ad libitum 600 g/head/day of concentrate, 16% crude protein.
and 2500 kcal metabolic energy (ME) per kg dry matter, and grazed at 1500 da of pasture during lactation (Karabulut and Canbolat, 2005).

Lambs were weighed at birth and weaning, fed lamb starter concentrate, 18% high protein (HP) and 2800 kcal ME per kg dry matter, during suckling period. To discard the effect of sex and birth type on these weights, their live weights were adjusted to the means. Also, weaning weight was corrected using birth weight as a covariate. Milk yields of dams until weaning were recorded with 30-d interval to calculate the milk amount fed by lambs. During these control periods, milk was given to lambs using feeding bottle.

One-way ANOVA procedure was used for statistical analysis of quantitative data and χ² test was performed for non-parametric data in SPSS program (SPSS 13.0 for windows).

Table 1. The mating schedule for CAMAL group is depicted as following over two years.

| Month | S O N D J F M A M J J A | 1st Year | 2nd Year |
|-------|-------------------------|----------|----------|
| F-A   | M                       | M        | L        |
| F-B   | L*                      | L*       | M        |
| F-C   | M                       | M        | L        |
| F-D   | L*                      | L*       | M        |
| CAMAL | M                       | L*       | M        |

Letters in month line shows the month sequence of year, the first being September (S); F-A, F-B, F-C and F-D shows sub-flocks; CAMAL: Cornell alternate month accelerated lambing; M: mating; L: lambing; L*: lambing of the sub-flocks after their 3rd mating.

Table 2. Some reproductive characteristics of Awassi ewes under two different lambing systems.

| Variables                              | CAMAL group | Control group |
|----------------------------------------|-------------|---------------|
|                                        | F-A         | F-B           | F-C         | F-D         | Total          | P1 | P2 |
| Number of ewes in groups               | 20          | 20            | 20          | 20          | 80             |    |    |
| Number of ewes in groups in 2 years    | 59          | 60            | 60          | 60          | 239            |    |    |
| Number of ewes mated in 2 years        | 54          | 55            | 56          | 54          | 219            |    |    |
| Number of ewes lambing in 2 years      | 44          | 43            | 45          | 40          | 172            |    |    |
| Number of lambs born in 2 years        | 51          | 48            | 50          | 45          | 194            |    |    |
| Number of weaned lambs in 2 years      | 49          | 46            | 47          | 40          | 182            |    |    |

Some reproductive characteristics, %

| Characters                  | CAMAL group | Control group |
|-----------------------------|-------------|---------------|
| Fertility1                  | 74.6        | 71.7          | 75.0        | 66.7        | ns             | 72.0 | 97.5 | * |
| Fertility2                  | 220.0       | 215.0         | 225.0       | 200.0       | ns             | 215.0 | 195.0 | ns |
| Fecundity1                  | 86.4        | 80.0          | 83.3        | 75.0        | ns             | 81.1 | 115.0 | * |
| Fecundity2                  | 255.0       | 240.0         | 250.0       | 225.0       | ns             | 242.5 | 230.0 | ns |
| Litter size1                | 115.9       | 111.6         | 111.1       | 112.5       | ns             | 112.8 | 117.9 | ns |
| Litter size2                | 111.4       | 106.9         | 104.4       | 100.0       | ns             | 105.8 | 112.8 | * |
| Lamb survival               | 96.1        | 95.8          | 94.0        | 88.9        | ns             | 93.8 | 95.7 | ns |

F-A, F-B, F-C and F-D: sub-flocks; P1: statistical significance of the differences among CAMAL sub-flocks; P2: statistical significance of the difference between CAMAL and control group; * P<0.05.

Results and Discussion

Some reproductive characteristics of the ewes under two different lambing system performances in the present study are given in Table 2. Table 3 shows the influence of mating months on body weight, some oestrus characteristics and litter size.

Body weight and weaning weight of lambs and milk yield during suckling period are given in Tables 4 and 5. As shown in Table 2, reproductive characteristics of the control group are better than those of CAMAL group as calculated on ewes’ number per year basis (fertility1, fecundity1) (P<0.05). This might be resulted from forcing on biology and physiology of CAMAL ewes to aim of one time more lambing in two years. Also, it may be affected by mating months of CAMAL ewes that one or two serving of sub-flocks occurred at out of oestrus season. It is known that conception rate and litter size are varied by season (Abegaz et al., 2002). On the other hand, the other reproductive performance of CAMAL ewes was similar to control group (P>0.05), as calculated based on the number of ewes in groups (fertility2, fecundity2 and lamb survival). This is a contradictory result, as producing a lamb crop every 8 months results in an increase of 33-49% of lambs born per ewe per year (Aboul-Ela et al., 1987; Rawlings et al., 1987; Sormunen-Cristian and Suvela, 1999).

Also, Keskin et al. (2005) reported higher lambing for Awassi managed under accelerated lambing than those under one lambing in one year.

As reported in Table 3, interval of oestrus onset after PMSG administration differed due to the mating months (P<0.05). This duration was the shortest in autumn and winter months, the longest in spring and summer months. This might be caused by variation in
the ambient temperature in different months of the year. It is known that thermal stress has significant effect on the interval of oestrus onset (Naqvi et al., 2004). The reason for this delayed onset might be due to an alteration in the pulsatile release of LH and decrease in oestrogen secretion. The normal GnRH release patterns are reduced by exposure to the thermal stress (Dobos and Smith, 2000).

Litter size of control group (110.5-112.8%) is accepted in normal level for Awassi sheep. For Awassi sheep in Syria, Kassem (1988) informed that the mean number of lambs born per ewe lambed ranged between 1.11±0.014 and 1.19±0.017. There is a similar report for Awassi sheep in different literatures (Galal et al., 1996).

The mean litter size during the studied period ranged from 0.55 to 1.20% over successive six lamb crops during two years. The greatest performance was obtained in the September mating followed by the November mating; their performance was the poorest in the May mating (Table 3). It was previously determined that August, September and October are favourable months for Awassi sheep (Kaynakç and Sinmez, 1996). There is a general agreement that the number of lambs born after spring or summer mating is lower than those after autumn or winter mating (Schoeman and Burger, 1992; Maria and Ascaso, 1999; Notter, 2000; Mukasa-Mugerwa et al., 2002; Keskin et al., 2005). Lewis et al. (1996) reported that fertility was higher for mating in favourable season than for those in unfavourable season. Prolificacy tended to be higher for ewes bred in favourable season in present study. Similar seasonal effects on litter size were also reported by different researchers (Aboul-Naga et al., 1991; Sormunen-Cristian and Suvela, 1999; Notter, 2000). Brown and Jackson (1995) investigated the seasonal effect on some reproductive parameters of St. Croix sheep, which lambing percentage was lowest for spring breeding, resulting in lower number of lamb born and weaned per ewe exposed and lower litter size and weaning weights per ewe exposed. In our study, the litter size declined by 0.55 lambs between May and September showing a similar sensitivity of the ewes to changes in day length during the breeding season, as reported by Sormunen-Cristian and Suvela (1999). This might be caused by the effect of season correlated with photoperiod on oestrus activity and conception rate. As reported by different researchers, frequency of oestrus and conception rate associated with season is highest in autumn (Mukasa-Mugerwa et al., 2002; Sormunen-Cristian and Suvela, 1999).

Some mating period of different sub-flocks, such as May mating of the sub-flock A, January mating of the sub-flock C, etc., has got high ratio of ewes in heat with low litter size (Table 3). Sormunen-Cristian and Suvela (1999) informed that the season of maximum conception rate do not correspond to the season of maximum litter size. Thus, high temperature and poorer feeding management in summer time may increase embryonic mortality and decrease litter size (Huston, 1983). Besides, reproductive characteristics of male, such as exhibition of libido and semen quality, are the best in autumn and they have influences on litter size (Derycke et al., 1990). In our study, the ewes were individually hand-mated without problems in libido of rams. Notter and Copenhaver (1980) and Fogarty et al. (1984) also asynchronous in prolificacy and fertility in pure and composite breeds allowed to lamb three times in two year. In their studies, fertility and prolificacy were higher at mating during the normal breeding period (August and either November or December) than those during the anoestric period (April). However, within the normal breeding period, months of maximum fertility and prolificacy did not correspond. The highest prolificacy was observed at August mating by Fogerty et al. (1984) but at November mating by Notter and Copenhaver (1980). Thus, seasonal influences cause variability in reproductive rate in frequent lambing systems that seems linked to the management calendar and breed chosen.

Birth weight and weaning weight of lambs were also affected by the systems (Tables 4 and 5). We also detected milk yield differences during different suckling periods; among 24.7±1.33 kg in December birth and 49.9±3.07 kg in April birth.

In addition to litter size, birth weight and weaning weight were also observed to evaluate the lamb yield performance. These might be regarded as important parameters to

---

Table 3. Effect of mating months on body weight, time interval to onset of oestrus after PMSG administration, rate of ewes in heat and litter size in CAMAL group.

| Sub-flocks | Mating months with order | Body weight, kg per ewe | Interval to onset of oestrus, h | Ratio of ewes in heat, % | Litter size |
|------------|--------------------------|------------------------|-------------------------------|-------------------------|------------|
| Sub-flock A | September | 55.0±2.34 | 41.9±2.14 | 100.0 | 1.20±0.12 |
| May        | 54.7±2.15 | 50.9±3.10 | 95.0 | 0.65±0.13 |
| January    | 56.9±2.47 | 43.1±2.15 | 75.0 | 0.81±0.10 |
| P          | ns         | *           | ns              | **                      | **         |
| Sub-flock B | November  | 53.9±2.15 | 36.8±2.40 | 100.0 | 1.15±0.13 |
| July       | 53.6±2.52 | 40.2±2.20 | 95.0 | 0.75±0.10 |
| March      | 57.1±2.09 | 38.6±2.50 | 80.0 | 1.00±0.00 |
| P          | ns         | **          | ns              | *                       |           |
| Sub-flock C | January   | 50.1±2.32 | 35.6±2.44 | 100.0 | 0.80±0.12 |
| September  | 50.6±2.53 | 39.5±2.41 | 95.0 | 1.15±0.11 |
| May        | 58.7±2.68 | 43.1±2.58 | 85.0 | 0.55±0.11 |
| P          | ns         | *           | ns              | **                      | **         |
| Sub-flock D | March     | 46.7±2.66 | 46.6±2.45 | 80.0 | 0.72±0.14 |
| November   | 52.2±2.35 | 41.1±2.67 | 95.0 | 0.80±0.14 |
| July       | 56.3±2.19 | 33.5±3.22 | 85.0 | 0.84±0.14 |
| P          | ns         | *           | ns              | ns                      | ns         |

Total | | | | | |

 Effects of mating months upon 2 years

|                    | January | 53.8±1.74 | 38.8±1.77 | 87.5 | 0.81±0.08 |
|---------------------|---------|-----------|-----------|------|-----------|
| March               | 56.7±1.72 | 42.6±1.87 | 80.0 | 0.82±0.09 |
| May                 | 53.4±1.76 | 47.2±2.12 | 90.0 | 0.68±0.09 |
| July                | 53.0±1.69 | 41.8±2.39 | 90.0 | 0.79±0.08 |
| September           | 54.9±1.66 | 40.7±1.80 | 97.5 | 1.18±0.08 |
| November            | 51.9±1.86 | 38.9±1.80 | 97.5 | 0.98±0.10 |
| P                   | ns       | *         | ns       | ***   |           |

PMSG, Pregnant Mare Serum Gonadotropin; *= with the different superscript indicate significant difference in the same column; P: statistic significance; *P<0.05; **P<0.01; ***P<0.001.
describe the productivity of the ewes. As shown in Table 4, lambs produced by traditional lambing system have got higher birth and weaning weight than the CAMAL group (P<0.001). This is an expected result because of the season effect correlated with pasture condition and ewes milk yield that also affects weaning weight. Thus, in traditional group all lambs were born in February or March, as these months are more suitable for lamb growing. In addition, physiology of ewes in CAMAL group was forced for more than one time lambing. On the other hand, lambing month affected lamb survival (P<0.05), although the highest values were detected in June births and the lowest in December ones. In the study of Lewis et al. (1996), about 82% of lambs born were weaned, with lamb survival values of 86% in March and 74% in June. They also informed that weaning weights were heaviest for January and October matings. In their study, conception rates were higher in autumn and winter (October through January) and lower in spring (March and June). Such reduced conception rates during spring mating have consistently been reported for different sheep breeds (Rosa and Bryant, 2003; Gordon, 1997; Iniguez et al., 1986; Lewis et al., 1996). Fahmy (1990) reported that mortality at birth was not affected by season and ewes mated in winter and autumn had larger litters than those mated in spring. In CAMAL group, lamb birth weights were not differed by lambing season (P>0.05) but weaning weight were affected (P<0.01) (Table 5). This might be caused by pasture condition of the farm. We know that feeding of animal during the last two months of gestation and the time after birth has effects on birth and weaning weight (Kaya and Öztürkcan, 2005). In the present study, lamb mortality until weaning was similar for all months. This result is in line with study of Maria and Ascaso (1999), who reported that lambing season did not affect lamb mortality for different sheep breeds under accelerated lambing system.

Conclusions

It is concluded that three lambing in two years did not increase lamb number produced, since the mating season could affect negatively fertility, fecundity and litter size in Awassi ewes. This might be due to the fact that, like other seasonal breeds, at least one or even two matings occurred in anoestrus season. On the other hand, time intervals to onset of oestrus after hormonal administration, litter size, birth weight and weaning weight were affected by the mating months.

References

Abegaz, S., Duguma, G., Negussie, E., Gelmesa, U., Terefe, E., Rege, J.E.O., 2002. Factors effecting reproductive performance and estimates of genetic parameters of litter size in Horro sheep. J Agr Sci. 139:79-85. Aboul-El, M.B., Aboul-Naga, A.M., Shalaby, T.H., Majala, K., 1987. Physiological responses to climate changes in Finnish Landrace ewes imported to Egypt and their half-sibs raised.

Table 4. Effect of lambing systems on birth weight, weaning weight and milk yield during sucking period.

| Lambing system | Birth weight | Weaning weight | Milk yield for suckling period, kg |
|----------------|--------------|----------------|-----------------------------------|
| CAMAL          | 3.2±0.06     | 12.9±0.22      | 38.5±1.15                         |
|                | (194)        | (182)          |                                   |
| Control        | 3.7±0.08     | 14.6±0.37      | 53.7±7.00                         |
|                | (46)         | (44)           |                                   |
| P              | ***          | ***            | ***                               |

P, statistic significance; ***P<0.001.

Table 5. Effect of lambing months on birth weight, weaning weight, suckled milk and lamb survival in CAMAL group.

| Group | Lambing month in two year with order | Birth weight, kg | Weaning weight, kg | Suckled milk | Lamb survival, % |
|-------|--------------------------------------|-----------------|-------------------|--------------|------------------|
| A     | February                             | 3.3±0.16        | 15.5±0.51         | 47.8±3.73    | 100.0            |
|       | October                              | 2.7±0.15        | 12.3±0.48         | 40.2±3.54    | 93.3             |
|       | June                                 | 2.6±0.12        | 12.6±0.24         | 27.7±2.26    | 92.3             |
|       | P                                    | **              | **                | **           | **               |
| B     | April                                | 3.8±0.19        | 15.4±0.99         | 53.6±4.02    | 95.7             |
|       | December                             | 2.7±0.17        | 12.8±0.40         | 27.1±1.64    | 93.3             |
|       | August                               | 3.1±0.33        | 10.6±0.91         | 30.1±1.85    | 100.0            |
|       | P                                    | ***             | ***               | ***          | ns               |
| C     | June                                 | 3.7±0.25        | 13.9±0.60         | 32.8±3.85    | 100.0            |
|       | February                             | 3.3±0.16        | 11.4±0.53         | 29.3±2.15    | 91.3             |
|       | October                              | 3.4±0.16        | 12.5±0.52         | 31.2±3.07    | 90.9             |
|       | P                                    | **              | **                | **           | ns               |
| D     | August                               | 3.2±0.22        | 12.8±0.40         | 35.5±3.10    | 84.6             |
|       | April                                | 2.8±0.21        | 11.2±0.51         | 44.5±4.53    | 93.8             |
|       | December                             | 3.1±0.15        | 10.0±0.40         | 21.7±1.97    | 87.5             |
|       | P                                    | **              | **                | **           | ns               |

Effects of lambing months upon 2 years

| Month | Birth weight, kg | Weaning weight, kg | Suckled milk | Lamb survival, % |
|-------|-----------------|-------------------|--------------|------------------|
| February | 3.3±0.11        | 13.5±0.48         | 38.4±2.39    | 95.7             |
| April  | 3.4±0.16        | 13.7±0.71         | 49.9±3.07    | 94.9             |
| June   | 3.2±0.18        | 13.3±0.38         | 30.3±2.43    | 96.6             |
| August | 3.2±0.19        | 11.8±0.53         | 22.2±2.00    | 91.3             |
| October| 3.0±0.13        | 12.4±0.35         | 36.9±2.60    | 92.3             |
| December | 2.9±0.12       | 11.4±0.39        | 24.7±1.33    | 90.3             |

P, statistic significance; ""P<0.01; """"P<0.001; digits in parenthesis show the number of lambs in each group.

\(^{a,b,c}\)With the different superscript indicate significant difference in the same column; P, statistic significance; **P<0.01; ***P<0.001; digits in parenthesis show the number of lambs in each group.
in Finland. Livest. Prod. Sci. 17:179-185.
Aboul-Naga, A.M., Mansour, H., Aboul-Ela, M.B., Almahdy, H., 1991. Breeding activity of two subtropical Egyptian sheep breeds under accelerated lambing system. Small Ruminant Res. 4:285-292.
Brown, M.A., Jackson, W.G., 1995. Ewe productivity and subsequent preweaning lamb performance in a. Coix sheep bred under different times during the year. J. Anim. Sci. 73:1258-1263.
Dobson, H., Smith, R.F., 2000. What is stress, and how does affect fertility? Anim. Reprod. Sci. 60:743-752.
Fahmy, M.H., 1990. The accumulative effects of Finnsheep breeding in crossbreeding schemes: ewe productivity under an accelerated lambing system. Can. J. Anim. Sci. 70:967-971.
Fogarty, N.M., Dickerson, G.E., Young, L.D., 1984. Lamb production and its components in pure breeds and composite lines. I. Seasonal and other environmental effects. J. Anim. Sci. 58:285-300.
Halal, S., Gurol, O., Shaat, I., 2008. Awassi sheep as a genetic resource and efforts for their genetic improvement. Small Ruminant Res. 79:99-108.
Gordon, I., 1997. Controlled Reproduction in sheep and goats. CAB International, Wallingford, Oxon, UK.
Hogue, D.E., 1987. Frequent lambing systems. In: I.F. Marai and J.B. Owen (eds.) New Techniques in Sheep Production. Butterworths, London, UK, pp 57-63.
Huston, J.E., 1983. Production of fine-wool ewes on yearling rangeland in West Texas. II. Effects of supplemental feed and breeding frequency on reproductive rate. J. Anim. Sci. 56:1277-1281.
Iniguez, L.C., Quasas, R.L., Van Vleck, L.D., 1986. Lambing performance of Morlam and Dorset ewes under accelerated lambing system. J. Anim. Sci. 63:1769-1778.
Karabulut, A., Canbolat, O., 2005. Yem degerlendirmelerini. Ziraat Fakultesi, Uludağ Universitesi, Bursa, Turkey.
Kasse, R., 1988. The Awassi sheep breeding project in Syria. In: E.F. Thomson and F.S. Thomson (eds.) Increasing Small Ruminant Productivity in Semi-Arid Areas. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 155-163.
Kaya, Ş., Öztürkcan, O., 2005. Meraya ek olarak verilen kesif yemin Hatay keçilerinde anann performansı, döl ve süt verimine etkileri. pp 113-120 in Proc. Nat. Dairy Goat Congr., İzmir, Turkey.
Kaymakçı, M., Sönmez, R., 1996. İleri koyun yetiştiriciliği. Ege University Press, İzmir, Turkey.
Keskin, M., Biçer, O., Gül, S., Sarı, A., 2005. A study on improving of lamb yield by tree lambing in two years in Awassi sheep. J. Lalahan Livestock Res. Inst. 45:19-24.
Lewis, R.M., Notter, D.R., Hogue, D.E., Magee, B.H., 1996. Ewe fertility in the STAR accelerated lambing system. J. Anim. Sci. 74:1511-1522.
Maria, G.A., Aresco, M.S., 1999. Litter size, lambing interval and lamb mortality of Salz, Rasa Aragonesa, Romanov and FI ewes on accelerated lambing management. Small Ruminant Res. 32:167-172.
Mukasa-Mugerwa, E., Anindo, D., Sovani, S., Lahlu-Kassi, A., Tembely, S., Rege, J.E.O., Baker, R.L., 2002. Reproductive performance and productivity of Menz and Horro sheep lambing in the wet and dry seasons in the highlands of Ethiopia. Small Ruminant Res. 45:261-271.
Naqvi, S.M.K., Maurya, V.P., Gulyani, R., Joshi, A., Mittal, J.P., 2004. Effect of thermal stress on superovulatory response and embryo production in Bharat Merino ewes. Small Ruminant Res. 55:57-63.
Notter, D.R., 2000. Effects of ewe age and season of lambing on prolificacy in US Targhee, Suffolk and Polypay sheep. Small Ruminant Res. 38:1-7.
Notter, D.R., Copenhagen, J.S., 1980. Performance of Finnish landrace crossbred ewes under accelerated lambing. I. Fertility, prolificacy and ewe productivity. J. Anim. Sci. 51:1033-1042.
Rawlings, N.C., Jeffcoate, I.A., Howell, W.E., 1987. Response of purebred and crossbred ewes to intensified management. J. Anim. Sci. 65:651-657.
Rosa, H.J.D., Bryant, B.J., 2003. Seasonality reproduction of Sheep. Small Ruminant Res. 48:155-171.
Schoeman, S.J., Burger, R., 1992. Performance of Dorper Sheep under an accelerated lambing system. Small Ruminant Res. 9:265-281.
Sormunen-Cristian, R., Suvela, M., 1999. Out-of-season lambing of Finnish Landrace ewes. Small Ruminant Res. 31:265-272.
SSI, 2007. State Statistical Institute of Turkey. Home page address: http://www.tuik.gov.tr
Zeleke, M., Greyling, J.P.C., Schwalbach, L.M.J., Muller, T., Erasmus, J.A., 2005. Effect of progestagen and PMSG on oestrous synchronization and fertility in Dorper ewes during the transition period. Small Ruminant Res. 56:47-53.