# Reproductive characteristics of Awassi ewes mated artificially or naturally to Jordanian or Syrian Awassi rams

**M.J. Tabbaa[1,3], M.A. Alnimer[1], M. Shboul[2], H.H. Titi[1]**

[1]Dept. of Animal Production, University of Jordan, Amman, Jordan.
[2]National Center for Agricultural Research and Technology Transfer, Baquah, Jordan.

## Abstract

A total of 586 Awassi ewes of varying ages were mated to 11 Jordanian and 11 Syrian Awassi rams either naturally or artificially during the normal breeding season to evaluate reproductive performance of Awassi sheep and compare the local Awassi rams to Syrian rams. The length of the estrous cycle was longer ($P < 0.01$) during June to July (28.6 $\pm$ 0.9 d) than August to September (17.8 $\pm$ 0.7 d). Syrian-sired matings resulted in a greater lambing rate to the first mating within breeding season than Jordanian-sired matings ($P < 0.05$), but not for the second, third, or fourth mating. The cumulative lambing rate after the fourth mating tended to be greater ($P < 0.1$) using Jordanian compared to Syrian sires. The number of single lambs per ewe lambing was significantly ($P < 0.001$) greater than multiple births. Birth, weaning, and marketing weights and average daily gain before weaning were significantly greater in single ($P < 0.001$) and male-lamb ($P < 0.05$) pregnancies than in twins and females. An increase ($P < 0.01$) in the average daily gain during the lambing season was observed in November and December compared to January, February, or March. The overall mortality rate was 21%, and there was a decrease ($P < 0.001$) from 1 to 3 yr of age and an increase ($P < 0.01$) from November to March. Jordanian and Syrian rams yielded similar reproductive characteristics except for the lambing rate of first mating. Lambs born early in the season had better ($P < 0.01$) average daily gain and lower ($P < 0.001$) mortality than those born later.

**Keywords:** Awassi, sheep, reproductive characteristics, artificial insemination, natural mating, sire.

## Introduction

Awassi is a fat-tail breed of sheep utilized for meat, milk, and wool production. It is the common breed in Jordan and most Middle Eastern countries (Zarkawi *et al.,* 1999; Tabbaa *et al.,* 2001). Awassi produce good quality meat and milk and respond to genetic improvement through selection (Mavrogenis, 1996). It is also known for its ability to walk long distances and ability to cope with harsh environmental conditions such as long periods of drought and high temperatures; therefore, it has been introduced in several countries (Jaber *et al.,* 2004).

Variations in reproductive characteristics are expected among different breeds of sheep; within-breed variations are also found (Bradford and Berger, 1988). In Awassi sheep, differences in productive and reproductive characteristics are found in the Mediterranean area (Epstein, 1985). Productivity among farm animals, especially sheep, is limited by sexual seasonality, which in turn is regulated by photoperiod (Zuniga *et al.,* 2002). Breeding seasons usually start during the summer or early autumn for most sheep breeds (Rosa and Bryant, 2003). Awassi sheep have a long breeding season with mating activity concentrated between late June through early September, which allows ewes to lamb between late November and early February (Abu Zanat *et al.,* 2005). Ewes produce about 1.05 lambs per ewe lambing and 40 to 60 kg of milk per 150-day lactation under extensive conditions (Degen and Benjamin, 2003). The main question in concern was if there are differences among Awassi sheep of different origins when were raised under similar conditions.

Natural mating in sheep is practiced in all parts of the Middle East, unlike artificial insemination (AI) which is not very popular. This is mainly due to the requirement of greater knowledge of the technology, availability of frozen semen, and the anatomical structure of the ovine cervix. Factors including locating the cervical opening, the time required penetrating cervical canal, and the experience of the inseminator can have a marked effect on the outcome of AI technique (Halbert *et al.,* 1990). Implementing this technique on a commercial scale is unlikely because only experienced inseminators can achieve acceptable cervical penetration rate (Buckrell *et al.,* 1992). Lambing rates for AI ewes varied from 9% to 53% (Godfrey *et al.,* 1999). The wide range in these lambing rates may be due to the fact that the inseminator acquired experience in the latter trials.

The objectives of this study were to characterize the reproductive performance of Awassi sheep and comparing the local Awassi rams with Syrian rams using natural service and artificial insemination.

## Materials and Methods

The study was conducted at the Smaiah Research Station of the Jordan Cooperative Corporation in the Mafraq province northeast of Jordan. The flock

[3]Corresponding author: MJTabbaa@JU.Edu.Jo
Received: September 27, 2007
Accepted: February 1, 2008

was assembled from ewes collected from several farms in various parts of Jordan. Rams were obtained from farmers in Jordan and from the Governmental Station in Syria. It is understandable that the rams used for the two-sub-breeds cannot be claimed to be representative of the whole breed, as this would require larger numbers across the whole industry. A total of 586 Awassi ewes of varying ages (2 to 6 yr) weighing 57.8 $\pm$ 2.2 kg with a body condition score (BCS) of 2.5 to 3.5 (scale = 0 lowest to 5 highest). Ewes were mated to one of 11 Jordanian Awassi or 11 Syrian Awassi rams 2 to 5 yr old with an average weight of 57.3 $\pm$ 0.6 and 58.2 $\pm$ 0.7 kg and a BCS of 3.0 to 4.0, respectively, either naturally or artificially during the normal mating season of Jordan. Animals were housed in an open system with access to grazing from January to April, resulting in an estimated intake of nearly 18 MJ ME per head per day (Harb MU, 2007; personal communication). During the rest of the year, 800 g of concentrate feed was provided to dry ewes. The feed supplement increased to 1.2 kg concentrates and 0.3 kg alfalfa hay during flushing (2 weeks before mating), the last 6 weeks of gestation and lactation. The concentrate consisted of barley grain (73%), wheat bran (15%), soybean meal (10%), limestone (1%), and salt (1%). Rams were offered 1.0 kg of concentrate raised to 2.0 kg starting 2 weeks before mating season, and alfalfa hay was given ad libitum.

The rams were trained for semen collection via artificial vagina, and the semen was examined under the microscope. Rams possessing low motility and abnormal semen were replaced with another ram. A maximum of two daily ejaculates were collected per ram depending on the number of ewes observed in heat daily.

Detection of estrus was performed every 6 h for 5 d per week. Estrus was detected by using three vasectomized rams and breeding marks. Detection of estrus was repeated until the fourth mating. The length of estrous cycle for AI ewes was calculated using the interval between successive estrus periods (Bathaei, 1996). Females that showed standing heat in the morning (between 5 to 7 AM) were penned and inseminated in the evening (between 5 to 7 PM), and those detected in the evening were inseminated in the next morning (Berg, 1989). The ewes were not inseminated twice because a second insemination in the same heat period does not increase conception significantly (Berg, 1989). Ewes that returned to estrus were re-inseminated until the fourth cycle.

Mating was performed randomly between June 22 to October 5. For natural mating (NM), ewes were divided into groups of twenty-five ewes, and each group was sired by one tested ram. For AI, deposition of semen was made inside the first ring of the cervix using 0.2 ml fresh semen. The inseminated females were checked twice daily for those that failed to conceive using the same marker rams previously used starting 14 d after the first insemination. The results of mating were evaluated according to lambing data. After lambing, body weight at birth and weaning weight at 2 months and 5 months of age (market age in Jordan) were taken for each lamb. The study was terminated by the end of May.

Analysis of variance was used to analyze birth weight (BW), average daily gain to weaning (ADGW), weaning weight (WW), ADG to 5 mo (ADGM) and marketing weight (MW). Lambing rate was calculated as number of lambs born per ewes mated from the first (up to 155 days following June, 22), second (from 155 to 170 days), third (from 170 to 185 days), fourth (from 185 to 200 days from insemination), and cumulative lambing. Mortality rate (MR) was calculated as the number of mortalities prior to weaning per number of lambs born. A general statistical model included the fixed effects of sire strain (Jordanian or Syrian), mating type (Natural or AI), parity of ewe (1, 2, 3, or more), birth or rearing type (single or twin), sex of lamb (female or male), month of birth (November, December, January, February, or March), and residual error (GLM; SAS, 1998). Age was initially considered in the model but was not significant in the presence of parity; therefore, it was removed. All possible interactions were tested and found not significant. Backward stepwise removal was performed on non-significant differences. Where factors were significantly different, least-square means for different groups were compared using the *t*-test ($P < 0.05$). All means are reported as least-square means $\pm$ SEM.

## Results

Least-square means for the effects of parity and month on the length of the estrous cycle for Awassi ewes are shown in Table 1. Both parity and month affected the length of the estrous cycle. The interval between estruses were recorded for ewes during the first (31.0 $\pm$ 3.2 d) and three more parities (23.6 $\pm$ 0.7 d) and was longer ($P < 0.05$) than that for ewes in the second parity (17.8 $\pm$ 3.1 d). The length of the estrous cycle for ewes during June to July (28.6 $\pm$ 0.9) was longer ($P < 0.01$) than during August to September (17.8 $\pm$ 0.7).

Table 1. Least-square means ($\pm$ SEM) for the effects of parity and month on the length of the estrous cycle for artificial insemination of Awassi sheep.

| Effects | Length of estrous cycle (days) |
|---|---|
| Parity | * |
| 1 | 31.0 $\pm$ 3.2$^a$ |
| 2 | 17.8 $\pm$ 3.1$^b$ |
| ≥3 | 23.6 $\pm$ 0.7$^b$ |
| Month | ** |
| June to July | 28.6 $\pm$ 0.9$^a$ |
| August to September | 17.8 $\pm$ 0.7$^b$ |

*$P < 0.05$, **$P < 0.01$.

$^{a,b}$Means with different letters within effect are different ($P < 0.05$).

Lambing rate, which was affected by sire strain, mating type, birth type, and lambs per ewe lambing, is shown in Table 2. Lambing rate was significantly affected (P < 0.05) by sire strain; the Syrian (42.6%) had a greater lambing rate for the first mating within the breeding season than Jordanian (34.7%) sires, but not for the second, third, or fourth matings. The cumulative lambing rate after the fourth mating tended (P < 0.10) to be higher for the Jordanian (63.3%) than Syrian (58.8%) sires. Lambing rate following either AI or natural mating was similar between the first, second, and third estrous cycle but was significantly (P < 0.01) greater for AI ewes in the fourth (41.7%) and cumulative lambing (72.1%) than natural-service ewes in the fourth (9.2%) and cumulative lambing (62.2%). The number of single lambs born per ewe lambing was significantly (P < 0.001) greater than twins (Table 2). On the other hand, the number of lambs per ewe lambing was similar during different months of the lambing season. In addition, no significance effects of sire strain, ewe parity, or mating type were observed. The number of lambs born per ewe mated was similar between Jordanian (0.86 ± 0.03) and Syrian (0.85 ± 0.02) strains and between AI (0.84 ± 0.03) and natural mating (0.87 ± 0.02).

Table 2. Effects of sire strain, mating type, birth type, and number of lambs per ewe on lambing rate of Awassi sheep.

| Effect | Lambing rate (%) | | | | |
|---|---|---|---|---|---|
| Mating | First | Second | Third | Fourth | Cumulative |
| Sire strain | * | | | | # |
| Jordanian | 86/248 (34.7) | 35/162 (21.6) | 7/127 (5.5) | 29/120 (24.2) | 157/248 (63.3) |
| Syrian | 144/338 (42.6) | 47/194 (24.2) | 4/147 (2.7) | 41/143 (28.7) | 236/338 (58.8) |
| Mating type | | | | ** | ** |
| AI[1] | 106/290 (36.6) | 42/184 (22.8) | 3/142 (2.1) | 58/139 (41.7) | 209/290 (72.1) |
| Natural | 124/296 (41.9) | 40/172 (23.3) | 8/132 (6.1) | 12/124 (9.7) | 184/296 (62.2) |
| Birth type | *** | *** | *** | *** | *** |
| Single | 212/230 (92.2) | 73/82 (89.0) | 11/11 (100.0) | 65/70 (92.9) | 361/393 (91.9) |
| Twins | 18/230 (7.8) | 9/82 (10.9) | 0/11 (0.0) | 5/70 (7.1) | 32/393 (8.1) |
| Lambs/ewe | 1.08 ± 0.02 | 1.11 ± 0.03 | 1.00 ± 0.00 | 1.07 ± 0.03 | 1.08 ± 0.01 |

[1]Artificial insemination.
[#]P < 0.1, *P < 0.05, **P < 0.01, ***P < 0.001.

Least-square means for BW, ADGW, WW, ADGM, MW, and MR, significantly affected by sire strain, mating type, ewe parity, birth type, sex, and month of birth, are presented in Table 3. The overall BW observed over the lambing period was 4.2 ± 0.04 kg for Awassi lambs. There were no differences in BW among lambs of different sire strains, mating type, or parity of dam; however, BW was greater (P < 0.001) in singles and male lambs than in twins and female lambs. There was a tendency (P < 0.1) for an effect of month of birth (Table 3). The overall mean ADGW was 0.19 ± 0.003 kg with no differences among sire strains, mating type, or parity. However, a greater (P < 0.001) ADGW was found in single and male lambs than in twins and female lambs. In addition, a greater (P < 0.01) ADGW was observed in November and December than in January, February, or March months of birth (Table 3). The overall WW was 15.5 ± 0.2 kg for all Awassi lambs. Similarity was observed in lamb WW among Jordanian and Syrian sires, born from artificially and natural mating, and different parity of dams; however, there were differences (P < 0.001, P < 0.05) in lamb WW according to birth type, sex, and month of birth. Average daily gain to 5 mo and MW were similar among sire strains, mating types, and parity of dams; differences (P < 0.10 to P < 0.01) were observed for birth type, sex, and month of birth.

The overall MR was 21.3% (Table 3). Significant (P < 0.001) differences in MR were observed for lambs according to mating type, parity of dam, and month of lambing. Mortality rate was lower for lambs of AI-mated (10.8%) than natural-mated dams (31.5%). Mortality rate of lambs decreased (P < 0.01) as parity of their dams increased from the first to more than three. Mortality rate was the least during November and significantly (P < 0.01) increased as month of birth proceeded to March (Table 3).

Table 3. Least-square means (± SEM) for the effects of sire strain, mating type, parity, birth/rearing type, sex, and month of birth on production parameters of Awassi lambs

| Effect | BW[1] (kg) | ADGW (kg) | WW (kg) | ADGM (kg) | MW (kg) | MR (%) |
|---|---|---|---|---|---|---|
| Overall mean | 4.2 ± 0.04 | 0.19 ± 0.003 | 15.5 ± 0.2 | 012 ± 0.01 | 27.9 ± 0.5 | 21.3 |
| Sire strain | | | | | | |
| Jordanian | 3.8 ± 0.08 | 0.17 ± 0.007 | 14.0 ± 0.4 | 0.13 ± 0.01 | 25.5 ± 1.2 | 22.8 |
| Syrian | 3.9 ± 0.08 | 0.18 ± 0.007 | 14.7 ± 0.4 | 0.13 ± 0.01 | 27.0 ± 1.1 | 19.8 |
| Mating type | | | | | | ** |
| AI[2] | 3.8 ± 0.08 | 0.18 ± 0.007 | 14.3 ± 0.4 | 0.11 ± 0.01 | 24.7 ± 1.1 | 10.8 |
| Natural | 3.9 ± 0.08 | 0.17 ± 0.007 | 14.3 ± 0.4 | 0.15 ± 0.01 | 27.8 ± 1.4 | 31.3 |
| Parity | | | | | | ** |
| 1 | 3.8 ± 0.12 | 0.17 ± 0.013 | 14.1 ± 0.8 | | | 57.7 |
| 2 | 3.8 ± 0.11 | 0.18 ± 0.009 | 14.7 ± 0.5 | 0.12 ± 0.01 | 26.1 ± 1.4 | 17.1 |
| ≥3 | 3.9 ± 0.06 | 0.17 ± 0.005 | 14.1 ± 0.3 | 0.13 ± 0.01 | 26.3 ± 1.1 | 12.1 |
| Birth type | *** | *** | *** | | * | |
| Single | 4.3 ± 0.06$^a$ | 0.19 ± 0.005$^a$ | 15.8 ± 0.3$^a$ | 0.12 ± 0.01$^a$ | 27.8 ± 0.8$^a$ | 20.1 |
| Twin | 3.4 ± 0.10$^b$ | 0.16 ± 0.009$^b$ | 12.8 ± 0.6$^b$ | 0.14 ± 0.02$^b$ | 24.7 ± 1.7$^b$ | 22.9 |
| Sex | *** | *** | *** | # | *** | |
| Female | 3.7 ± 0.08$^b$ | 0.16 ± 0.007$^b$ | 13.4 ± 0.4$^b$ | 0.12 ± 0.01$^b$ | 24.4 ± 1.2$^b$ | 21.5 |
| Male | 4.0 ± 0.08$^a$ | 0.19 ± 0.007$^a$ | 15.2 ± 0.4$^a$ | 0.14 ± 0.01$^a$ | 28.0 ± 1.1$^a$ | 21.9 |
| Month of birth | # | ** | * | ** | *** | ** |
| November | 3.7 ± 0.16$^b$ | 0.22 ± 0.013$^a$ | 17.1 ± 0.8$^a$ | 0.15 ± 0.016$^a$ | 29.9 ± 1.7$^a$ | 0.0 |
| December | 4.0 ± 0.09$^{ab}$ | 0.20 ± 0.008$^b$ | 15.8 ± 0.5$^a$ | 0.14 ± 0.010$^a$ | 27.7 ± 1.0$^a$ | 8.2 |
| January | 4.0 ± 0.10$^a$ | 0.16 ± 0.009$^c$ | 13.5 ± 0.6$^b$ | 0.10 ± 0.014$^b$ | 21.0 ± 1.5$^b$ | 14.1 |
| February[3] | 3.8 ± 0.10$^b$ | 0.16 ± 0.009$^c$ | 13.2 ± 0.6$^b$ | | | 16.1 |
| March | 3.8 ± 0.09$^b$ | 0.14 ± 0.009$^c$ | 12.1 ± 0.5$^b$ | | | 44.6 |

[1]BW, birth weight; ADGW, average daily gain to weaning; WW, weaning weight;, ADGM, average daily gain to marketing age; MW, marketing weight at 5 mo; and MR, mortality rate.
[2]Artificial insemination.
$^{\#}$P < 0.1, *P < 0.05, **P < 0.01, ***P < 0.001. $^{a,b,c}$Means with different letters within effect are different (P < 0.05).

## Discussion

Sheep are important animals in Jordan and in many tropical and subtropical countries. In subtropical areas, ewes are generally bred during the summer to lamb during the winter, thus increasing the need at parturition for milk production (Degen and Benjamin, 2003). Jordan Badia is characterized by a hot summer, cold winter, and feed scarcity. Therefore, the current study helped elucidate some reproductive characteristics as a continuation for previous work on Jordanian Awassi sheep (Kridli *et al.,* 2006; Tabbaa *et al.,* 2006).

An effect of month on the length of the estrous cycle for Awassi ewes was observed in this study. Estrous cycles were longer during the period of June to July while they returned to the regular length during August to September. This result is similar to the findings of Epstein (1985), who reported that estrous cycles of Awassi ewes reached a peak of regularity during August and September with an interval of 14 to 19 d and the excessively longer recurrent estruses varied from 20 to 77 d. However, such a wide period could be due to early pregnancy losses and undetected estruses due to silent heats. In another study, Zarkawi (1997) found that cyclicity in Awassi sheep is initiated towards the end of June, peaks during the first half of August, and declines by the first week of October. In Chios sheep however, Papachristoforou *et al.* (2000) reported that the interval between successive cycles was in some cases extended to 3 to 6 wk before September and after that, all ewes exhibited regular cyclicity. In Menz sheep, Mukasa-Mugerwa and Kassi-Lahlou (1995) reported that estrous activity declined from June to September due to an increase in silent ovulations. The lack of seasonality in estrous behavior of tropical sheep has been reported (Mittal and Ghosh, 1980) in which seasonal variation has often been associated with changes in feed supply (Molokwu and Umunna, 1980).

In the present study, estrous cycle length for ewes in the first parity was apparently longer than that for ewes in later parities. This could be due to the fact that younger ewes exhibited a greater number of multiple estrous events, indicating a higher incidence of silent estruses. In fat-tailed Mehraban ewes, Bathaei (1996) found that young ewes showed more frequent multiple estrous events that extended between 27 and 57 d than that for older ewes. Moreover, Davies and Beck (1993) reported that younger ewes had a higher incidence of embryonic loss that may be related to deficiencies in plasma progesterone and LH concentrations.

Lambing rates were greater for Syrian sires than for Jordanian sires after the first mating but were similar for the second, third, and fourth mating and tended ($P < 0.1$) to be greater for Jordanian than that for Syrian after the fourth mating. The reasons for the difference between Jordanian and Syrian sires are not known. Previous studies using Jordanian ewes demonstrated that lambing rates from first mating ranged from 33 to 35% for either hormone treated or untreated ewes (Abdullah *et al.,* 2002; Alnimer *et al.,* 2005). A similar rate was reported in Syria by Zarkawi *et al.* (1999). In general, pregnancy rate in Awassi ewes following the first mating was low, which could be indicative of embryonic mortality. Early embryonic mortality during the first 3 wk of gestation results in pregnancy rates ranging from 16 to 76% (Beck *et al.,* 1994; Nephw *et al.,* 1994). Although factors causing early embryonic mortality in sheep are not well established, there is some evidence suggesting the involvement of luteal inadequacy (Binelli *et al.,* 2001). Luteal inadequacy, resulting from environmental factors such as heat stress or nutrition, has been shown to be a major cause of embryonic loss in sheep (Binelli *et al.,* 2001).

On the other hand, both AI and natural matings resulted in similar lambing rates for the first, second, and third lambing while AI mating resulted in a greater lambing rate at the fourth insemination. Previous results obtained from AI using fresh semen showed that lambing rates varied from 47 to 60% (Epstein, 1985). Fernandez Abella *et al.* (1992) reported pregnancy rates varying between 54 to 82% using cervical insemination. Variations in results of different researchers maybe due to the AI technician experience. The inseminator experience can have marked effects on the outcome of AI technique as suggested by Halbert *et al.* (1990). In this study, lambing rates tended to be low in both groups, which could be indicative of early embryonic loss. Embryonic losses from luteal inadequacy is a major source of reproductive wastage in ewes (Wilmut *et al.,* 1986). Moreover, heat stress may also have been another contributing factor as the prevalent maximum temperature during mating period ranging from 35 to 45°C. In general, factors such as season of the year, genetics, breed differences, hormonal influences, post weaning management practices, maximum temperature, and nutrition affected sex drive and sexual performance during the natural breeding season, and their effects on reproductive performance have been reported (Mickelsen *et al.,* 1982).

Low twinning rates are expected from Awassi ewes (Degen and Benjamin, 2003; Abu Zanat *et al.,* 2005). Therefore, there were a greater number of ewes that lambed singles than those that produced multiples during this study. Similar results were found in previous studies using Awassi sheep in different countries (Juma and Alkass, 1996; Said *et al.,* 1999; Kridli *et al.,* 2006). Least-square means for BW, ADGW, WW, ADGM, and MW were similar among sire strains, mating types, and dam parities. However, single and male lambs had a heavier weight at birth and grew faster to weaning than multiple and females. Consistent superiority of single and male lambs has been widely reported (Bell *et al.,* 1970; Buvanendran *et al.,* 1992; Burfening and Carpio, 1993; Mavrogenis, 1996; Mukasa-Mugerwa *et al.,* 2000). There is variation in BW, ADGW, WW, ADGM, and MW among lambs born in different months. Greater ADGW was observed in November and December than in January, February, or March months of birth while mortality rate increased as month proceeded. This would mostly be due to the fact that cold weather during December and January reduced the presence of insects and parasites in the pasture when the early-born weaning lambs started to graze. This would allow for better health for those lambs. Although, late-born lambs appeared in good health, their sub-clinical status might be compromised (Alonby, year; personal communication). This would increase the mortality rate and reduce growth. Variations in BW, ADGW, WW, ADGM, and MW for Awassi sheep in Iraq were reported by Juma and Alkass (1996).

The mortality rate recorded in Awassi lambs (Table 3) is within the range reported by other researchers in the subtropics (Beck *et al.,* 1994; Nephw *et al.,* 1994). The mortality rate in Awassi flocks is 15 to 20% during normal years and up to 50% in years of drought or severe winters (Epstein, 1985; Gordon, 1997). Moreover, the decrease ($P < 0.01$) in mortality rate with the increase in parity was observed. This result agrees with the results of Warren and Mysterud (1995), who found a significant effect of age of ewe on lamb mortality. Mortality is a complex trait affected by the lambs' weakness and by dam's rearing ability (Burfening, 1993).

In conclusion, Awassi ewes had regular estrous cycles during August and September. Further studies are needed to evaluate reproductive hormones and more-precisely determine the earliest estrous activity and the best mating time. Syrian sires were only superior to Jordanians for early lambing while Jordanian tended to be greater after the fourth mating. Both AI and natural matings resulted in similar lambing rates for early mating while AI was greater later in the mating season. Lambs born early had greater ADGW than those born later in the lambing season; however, mortality rate increased as month proceeded and decreased with the increase in parity. Therefore, farmers are advised to mate their ewes to lamb as early as possible in the next lambing season. Environmental effects considered in this study are important and need to be taken into consideration for the accurate estimation of breeding values.

**Acknowledgments**

The authors thank all Smaiah Research Station staff for taking care of the flock and assisting in data collection.

### References

**Abdullah AY, Husein MQ, Kridli RT**. 2002. Protocols for estrus synchronization in Awassi ewes under arid conditions. *Asian-Austr J Anim Sci*, 15:957-962.

**Abu Zanat MM, Mekdadi HA, Tabbaa MJ**. 2005. Production systems of small ruminants in middle badia of Jordan. *Dirasat,* 32:205-213.

**Alnimer M, Tabbaa MJ, Amasheh M, Alzyoud H**. 2005. Hormonal treatments and the ram effect on synchronized estrus in Awassi ewes at the beginning of the breeding season *NZ J Agric Res,* 48:480-473.

**Bathaei S**. 1996. Breeding season and oestrous activity of Iranian fat-tailed Mehraban ewes and ewe lambs. *Small Rumin Res,* 22:13-23.

**Beck NFG, Peters AR, Williams SP**. 1994. The effect of GnRH agonist (Buserelin) treatment on day 12 post mating on the reproductive performance of ewes. *Br Soc J Anim Prod,* 48:243-247.

**Bell GH, Davison JN, Scarborough H**. 1970. *Textbook of physiology and biochemistry*. Edinburgh, UK: Longman.

**Berg KA**. 1989. [Artificial insemination of sheep using frozen semen. Effects of time of insemination and of 1 or 2 inseminations]. *Tierärztl Umsch*, 44:322-325.

**Binelli M, Thatcher WW, Mattos R, Baruselli PS**. 2001. Antiluteolytic strategies to improve fertility in cattle. *Theriogenology,* 56:1451-1463.

**Bradford GE, Berger YM**. 1988. Breeding Strategies for Small Ruminants in Arid and Semi-Arid Areas. *In*: Thomson EF, Thomson FS (Eds.). *Increasing small ruminant productivity in Semi-Arid Areas.* Allepo, Syria: ICARDA. pp.95-109.

**Buckrell BC, Buschbeck C, Gartly CJ, Kroestsch T, Mccutcheon W, Martin J, Penner WK, Walton JS**. 1992. A breeding trial using a transcervical technique for artificial insemination in sheep. *In*: Proceedings of the 12th International Congress on Animal Reproduction and Artificial Insemination, 1992, The Hague, Netherlands. The Hague: ICAR. pp.1531-1533.

**Burfening PJ**. 1993. Direct and maternal genetic effects on lamb survival. *Small Rumin Res,* 11:267-274.

**Burfening PJ, Carpio PM**. 1993. Genetic and environmental factors affecting growth rate and survival of Junin sheep in the central highlands of Peru. *Small Rumin Res,* 11:275-287.

**Buvanendran V, Makuza SM, Chironga P**. 1992. Phenotypic and genetic parameters of weaning traits in Dorper sheep in Zimbabwe. *Small Rumin Res,* 7:369-374.

**Davies MCG, Beck NFG**. 1993. A comparison of plasma prolactin, LH and progesterone concentrations during oestrous and early pregnancy in ewe lambs and ewes. *Anim Prod,* 57:281-286.

**Degen AA, Benjamin RW**. 2003. Milk intake and growth rate of Awassi lambs sucking ewes grazing on natural pasture in the semiarid Negev. *Anim Sci,* 76:455-460.

**Epstein H**. 1985. *The Awassi sheep with special reference to the improved dairy type.* Rome: FAO. (Animal Production and Health Paper, 57).

**Fernandez Abella D, Abella O, Rodriguez Palma R, Zanotta G**. 1992. [Effect of semen dose, diluent and storage on fertility after cervical insemination]. *Bol Tec Cienc Biol,* 2:21-36.

**Godfrey RW, Collins JR, Hensley EL, Wheaton JE**. 1999. Estrous synchronization and artificial insemination of hair sheep ewes in the tropics. *Theriogenology*, 51:985-997.

**Gordon I**. 1997. *Controlled Reproduction in sheep and goats*. Wallingford, Oxon. UK: CAB International.

**Halbert GW, Dobson H, Walton JS, Sharpe P, Buckrell BC**. 1990. Field evaluation of a technique for transcervical intra-uterine insemination of ewes. *Theriogenology*, 33:1231-1243.

**Jaber LS, Habre A, Rawda N, Abisaid M, Barbour EK, Hamadeh SK**. 2004. The effect of water restriction on certain physiological parameters in Awassi sheep. *Small Rumin Res,* 54:115-120.

**Juma KH, Alkass JE**. 1996. Awassi sheep in Iraq. *Dirasat,* 23:200-207.

**Kridli RT, Abdullah AY, Momani Shaker M**. 2006. Sexual performance and reproductive characteristics of young adult Awassi, Charollais-Awassi and Romanov-Awassi Rams. *Sheep Goat Res J,* 21:12-16.

**Mavrogenis AP**. 1996. Estimates of environmental and genetic parameters influencing milk and growth traits of Awassi sheep in Cyprus. *Small Rumin Res,* 20:141-146.

**Mickelsen WD, Paisley LG, Dahmen JJ**. 1982. The relationship of libido and serving capacity test scores in rams on conception rate and lambing percentage in the ewe. *Theriogenology* 18:79-86.

**Mittal JP, Ghosh PK**. 1980. A note on annual reproductive rhythm in Marwari sheep of the Rajasthan desert in India. *Anim Prod,* 30:153-156.

**Molokwu ECI, Umunna NN**. 1980. Reproductive performance of the Yankasa sheep of Nigeria. *Theriogenology,* 14:239-249.

**Mukasa-Mugerwa E, Kassi-Lahlou A**. 1995. Reproductive performance and productivity of Menz sheep on the Ethiopian highlands. *Small Rumin Res,* 17:167-177.

**Mukasa-Mugerwa E, Lahlou-Kassi A, Anindo D, Rege JEO, Tembely S, Tibbo M, Baker RL**. 2000. Between and within breed variation in lamb survival and the risk factors associated with major causes of mortality in indigenous Horro and Menz sheep in Ethiopia. *Small Rumin Res,* 37:1-12.

**Nephw KP, Cardenas H, McClure KE, Ott TL, Bazer FW, Pope WF**. 1994. Effects of administration of human chorionic gonadotropin or progesterone before maternal recognition of pregnancy on blastocyst development and pregnancy in sheep. *J Anim Sci* 72:453-458.

**Papachristoforou C, Koumas A, Photiou C**. 2000. Seasonal effects on puberty and reproductive characteristics of female Chios sheep and Damascus goats born in autumn or in February. *Small Rumin Res,* 38:9-15.

**Rosa HJD, Bryant MJ**. 2003. Seasonality of reproduction in sheep. *Small Rumin Res,* 48:155-171.

**Said SI, Muwalla MM, Hanrahan JP**. 1999. Sources of variation and repeatability for litter size, body weight and matured performance of Awassi Ewes. *Turk J Vet Anim Sci,* 23:461-465.

**SAS**. 1998. *SAS/STAT User's guide, version 7*. Cary, NC: SAS Institute Inc.

**Tabbaa MJ, Al-Azzawi WA, Campbell D**. 2001. Variation in fleece characteristics of Awassi sheep at different ages. *Small Rumin Res,* 37:131-135.

**Tabbaa MJ, Kridli RT, Amashe MG, Barakeh FS.** 2006. Factors affecting scrotal circumference and semen characteristics of Awassi rams. *Jordan J Agric Sci,* 2:243-250.

**Warren JT, Mysterud I**. 1995. Mortality of domestic sheep in free-ranging flocks in Southeastern Norway. *J Anim Sci,* 73:1012-1018.

**Wilmut I, Sales DI, Ashworth CJ**. 1986. Maternal and embryonic factors associated with prenatal losses in mammals. *J Reprod Fertil,* 76:851-864.

**Zarkawi M**. 1997. Monitoring the reproductive performance in Awassi Ewes using progesterone radioimmunoassay. *Small Rumint Res,* 26:291-294.

**Zarkawi M, Al-Merestani MR, Wardeh MF**. 1999. Induction of synchronized oestrous and early pregnancy diagnosis in Syrian Awassi ewes, outside the breeding season. *Small Rumin Res,* 33:99-102.

**Zuniga O, Forcada F, Abecia JA**. 2002. The effect of melatonin implants on the response to the male effect and on the subsequent cyclicity of Rasa Aragonesa ewes implanted in April. *Anim Reprod Sci,* 72:165-174.