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SI FAT TAILED SHEEP

Awassi sheep reproduction and milk production: review

Abdelsalam Q. Talafha · Mohammed M. Ababneh

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Abstract Awassi is the local breed of sheep in Jordan and is the most important breed in the semi-arid regions of the near east countries. Awassi ram and ewe lambs reach puberty at around 8 and 9 months of age, respectively. The breeding season of Awassi ewes starts as early as April and lasts through September. After puberty, Awassi rams are sexually active throughout the year. The normal estrous cycle in Awassi ewes is 15–20 days (average 17 days). Estrus ranges from 16–59 h (average 29 h) during the breeding season. The reproductive performance of unimproved Awassi sheep has been low while improved Awassi has the highest fertility and milk production and are the heaviest among all Awassi populations. The gestation length varies from 149 to 155 days (average 152 days). Hormones that are commonly used for induction and synchronization of estrus in Awassi ewes include progestins, gonadotropins and PGF2α. An Awassi ewe produces 40–60 and 70–80 kg of milk per 150-day lactation period under traditional and improved production systems, respectively, in addition to the suckled milk left for lambs until weaning. The improved Awassi has the highest milk production among all Awassi populations and may reach 506 L over 214-day lactation period. The objective of this review is to summarize the reproductive pattern and milk production of Awassi sheep in the Middle East region.

Keywords Awassi · Breeding season · Estrous cycle · Milk production · Puberty · Reproductive performance · Sexual behavior

A. Q. Talafha (✉) · M. M. Ababneh
Department of Veterinary Clinical Sciences, Faculty of Veterinary Medicine, Jordan University of Science and Technology,
P.O. Box 3030, Irbid 22110, Jordan
e-mail: talafha@just.edu.jo

Introduction

Awassi is the most common breed of sheep in the Middle East countries and the only native breed in Jordan. The breed is used for meat, milk, and wool production and has been introduced into more than 30 countries in all continents of the world (Galal et al. 2008). Awassi sheep posses good characteristics such as resistance to diseases and parasites, ability to walk long distances for grazing, strong flock instinct, well adaptation to management fluctuations, and tolerance to harsh environmental conditions, especially those related to scarcity of feed availability and high ambient temperatures (Gürsoy 2005; Kridli et al. 2007c). Awassi sheep, however, is a low prolific breed (Abdullah et al. 2002) and reach puberty at a later age than other breeds (Al-Molla and Kridli 2003). The improved Awassi of the breed has the highest milk production among all Awassi populations (Galal et al. 2008).

Photoperiod is the main environmental factor affecting sheep reproduction (Chemineau et al. 1992). Awassi ewes breeding season starts as early as April and lasts through September (Zarkawi 1997). The mating activity is concentrated during late June through early September (Abu Zanat et al. 2005). Seasonality in sexual activity of rams corresponds roughly to the breeding activity of the females of the same breed (Dufour et al. 1984). However, Awassi rams can be used for breeding any time of the year and can be considered non-seasonal due to the non-significant changes in semen quality throughout the year (Salhab et al. 2003; Tabbaa et al. 2006).

Reproductive performance is one of the main factors that determine the efficiency of sheep flock production especially in countries in which sheep industry is important (Ibarra et al. 2000). Factors that can affect the reproductive activity in sheep include season, photoperiod, breed, age, nutrition,

diseases, stress, management, environment, and male factors (Amer and Hazzaa 2009; Ozyurtlu et al. 2010).

The use of hormones to manipulate the reproductive processes offers many advantages that are difficult to attain without their use. Hormones are used to induce estrus and ovulation; thus, they facilitate early breeding of ewe lambs, out-of-season breeding, and increase productivity (Keisler 2007).

Early pregnancy diagnosis is considered an important management practice to avoid unnecessary delay in rebreeding and improves the overall economic return of the flock. Milk and meat are important products from Awassi sheep and many consumers in the Middle East region prefer them over any other breed and species.

Awassi sheep genetic improvement and selection programs have resulted in the development of improved Awassi and Assaf breeds and Afec-Awassi and Afec-Assaf strains. The improved Awassi is characterized by producing the highest amount of milk, having highest fertility and twinning rate, and heaviest body weight among all Awassi populations (Galal et al. 2008). The Assaf breed was developed from a cross between the Awassi with East Friesian breeds. It is considered a high-producing dairy and mutton breed and well adapted to the intensive management system. It has an average milk yield of 334 L during 173-day lactation, 1.34 lambings per ewe per year with an average lambing interval of 272 days (Pollott and Gootwine 2004). Introducing the FecB Booroola gene into the Awassi and Assaf breeds resulted in the formation of the Afec-Awassi and Afec-Assaf strains with prolificacy of about two lambs born per ewe lambing (Gootwine et al. 2001).

The objective of this review is to summarize the reproductive pattern and milk production of Awassi ewes in the Middle East countries.

Breed description

The average body weight of adult Awassi ewe is 45–55 kg while the ram weighs 60–90 kg (Degen and Benjamin 2003; Ozyurtlu et al. 2010). The body is covered with long coarse wool of creamy white color except for the face. The head is long and narrow with a convex forehead profile and predominantly brown but sometimes black in color. Rams usually have long spiral horns (40–50 cm in length) while ewes are polled or have short horns. The tail is characteristically fat in the Awassi breed. On average, the fat tail of Awassi ewe is about 18 cm long, 16 cm wide, and weighs around 6 kg, while in rams, it is about 30 cm long, 25 cm wide, and weighs around 12 kg. The tail emerges from the rump in one stem that hangs down into two lobes that broaden out toward their lower portion. A deep rift divides the lower part of the lobes (Hailat 2005; Galal et al. 2008). The average birth weight of single-born Awassi lambs is about 5.0 kg while twin lambs are about 20% lighter than singles (Zarkawi et al. 1999).

Puberty

Puberty in ewe lambs is attained with occurrence of the first behavioral estrus that is accompanied by ovulation and development of a corpus luteum with a typical lifespan (Kinder et al. 1995). Ram lambs reach puberty when their ejaculate contains a threshold (minimum number) of fertile spermatozoa that are capable of achieving successful fertilization (Senger 2003). The fundamental requirement for pubertal onset is the secretion of gonadotropins (follicle stimulating hormone (FSH) and luteinizing hormone (LH)) at high enough levels to initiate gametogenesis, steroidogenesis, development of reproductive tissues, changes in body conformation, and an increase in sexual desire. Several external factors modulate the timing of puberty in sheep such as breed, husbandry, season during which the lamb is born, the photoperiod that the lamb is experiencing during onset of puberty, growth or nutritional intake, and social cues (Senger 2003). Sheep reach puberty at an average age of 7.5 months with a range of 4 to 15 months. Awassi ewe lambs born in winter reach puberty at around 9 months of age (Al-Molla and Kridli 2003). Awassi ram lambs reach puberty when they are about 243 days old, weigh about 42 kg, have scrotal circumference of 21 cm in diameter, testosterone concentration of 1.9 ng/ml, and have normal spermatozoa in the ejaculate with at least 30% mass motility over two consecutive semen collections 1 month apart (Kridli et al. 2006, 2007b).

The breeding season

Sheep are considered short-day breeders because their seasonal reproduction is regulated by photoperiod through melatonin secretion along with other environmental factors such as temperature, nutrition, and social relationships (Arendt 1998). Sheep breeds derived from the northern hemispheres have a defined breeding season spanning the fall and winter months. In the tropical zones, where variation in day length is less, indigenous sheep tend to breed throughout the year. Awassi sheep are considered seasonal breeders although their breeding season tends to be long. The breeding season starts as early as April and lasts through September (Zarkawi 1997). The natural breeding season of Awassi rams is concentrated between late June through early September, which allows ewes to lamb between late November and early February (Abu Zanat et al. 2005). The breeding season in improved Awassi flocks begins 1 or 2 months earlier than in the flocks of unimproved Awassi (Epstein 1985). The distribution of lambings in improved

adult and yearling Awassi ewes, with one lambing a year, occurs in the months of December and April, respectively.

Sexual behavior

Sexual performance is highly variable among rams, irrespective of season. Both sexual inactivity and homosexual behavior have been described and approach an incidence of 10–20% in populations of rams (Roselli et al. 2004). After puberty, Awassi rams are sexually active throughout the year. However, their activity is higher in summer and fall compared to spring (Kridli et al. 2007a). The ram approaches a ewe in a low stretch position with the head angled to the side. Often, the ram contacts the flank of the female, strikes out at the female with one front leg before attempting to mount her. Rams display the flehmen response to ewes in estrus after sniffing the anogenital region. The presence of fat tail in Awassi ewes acts as a barrier to the spread of genital secretions and traps urine odors which may partially overpower the females' sexual odor, thus reducing the sniffing behavior of rams (Kridli et al. 2008). In addition, the fat tail causes mating difficulties especially when using sexually naïve rams or when mating Awassi ewes with exotic rams (Kridli and Said 1999). At the time of mating, the ram must raise the ewe's tail for successful copulation. An experienced Awassi ram stands to the ewe's side and pushes her fat tail with his foreleg upwards and sideway while mounting. If the fat tail is too heavy to be moved with the leg, the ram dismounts and uses his chest to lift the ewe's tail up (Epstein 1985). Preventing copulation may increase aggressiveness of rams (head butts) toward the estrus ewes due to frustration (Price et al. 1993). Some rams will mount several times before ejaculation, and others may service a ewe during the first mount. Virgin rams exhibit an improvement in sexual performance after frequent exposure to estrus females to a level comparable to that of experienced males (Price et al. 1991). Most easily noticed sign of estrus in Awassi ewes is standing quietly as the ram conducts his investigative courtship. As estrus approaches, the vestibule becomes hyperemic and the vulva slightly swells with copious cloudy or clear secretion accumulated around the external os of the slightly dilated cervix. As the estrus period progresses, this secretion becomes less copious and more viscous, which indicates the approach of ovulation. Awassi ewes may have a loss of appetite when they are in estrus (Epstein 1985).

Estrous cycle

The length of the normal estrous cycle in Awassi ewes is between 15 and 20 days (with an average of 17 days). An excessively longer recurrent estrus that varied from 20 to 77 days has been reported (Epstein 1985). However, such a wide period could be due to early pregnancy loss and undetected estruses due to silent heats. Estrus in Awassi ewes lasts an average of 29 h, but may range from 16 to 59 h during the breeding season (Epstein 1985).

At the ovarian level, the estrous cycle can be divided into the follicular phase covering the 2–3 days in which ovulatory follicles grow and produce their ova and the luteal phase which lasts about 12–14 days and dominated by one or more corpora lutea on the ovary (Lindsay 1991). Transrectal ultrasonography has allowed description of follicular dynamics (follicles with diameter >2 mm) in the ewe (Bartlewski et al. 1999). Ovarian follicular development in ewes is a progressive and recurring process, with three to four waves of follicular growth occurring each cycle. During the estrous cycle, one to three antral follicles emerge or grow from a pool of follicles of 1 to 3 mm in diameter, approximately every 4 to 5 days. The ovulatory follicle (6 to 7 mm in diameter) emerges around day 11 of the cycle and grows over a period of 4 days at a growth rate of 1.2 mm per day. The largest nonovulatory follicles grew at the same rate as ovulatory follicles and regressed over a period of 2.6 days at a rate of 1.2 mm per day (Ravindra et al. 1994). Large antral follicle life span in the ewe consists of a 2- to 4-day growing phase, a static phase (no apparent change in size, 1–4 days), and regressing phase (1–5 days) (Rawlings and Bartlewski 2007).

In the cyclic ewe, transient increases in estradiol and peak FSH serum concentrations are associated with the follicular wave emergence. Serum concentrations of estradiol peak at the end of the growth phase of the largest follicle of the wave (about day 16 of the cycle) (Bartlewski et al. 1999). Although mean serum FSH is greatest at wave emergence, FSH pulse frequency increases during the follicle growth phase of follicle waves (Bartlewski et al. 2000). The LH is released from the pituitary gland in episodic pattern for most of the luteal phase. Estradiol from large antral follicles, along with gonadotropin-releasing hormone, stimulates the release of preovulatory LH surge which occurs about 10 h after the onset of estrus, and then, both LH and estradiol concentrations fall rapidly (Ward 1986). The resultant LH surge induces final development of the ovulatory follicles, ovulation, luteinization, and maturation of the primary oocyte to a secondary oocyte (Scaramuzzi et al. 1993). Ovulation typically occurs from 12 h before to 8 h after the end of estrus, with an average occurrence within an hour after end of estrus. In Awassi ewes with long estrus periods, ovulation tends to precede the end of estrus, while in ewes with shorter estrus periods, ovulation usually occurs after the end of estrus (Schindler and Amir 1972). After ovulation, the corpus luteum grows rapidly and starts to produce significant amount of progesterone from day 3 of diestrus. Progesterone concen-

trations remain elevated until day 13. If viable embryos are not present in the uterus on day 13 of the estrous cycle (day of estrus=day 0), pulses of oxytocin from the corpus luteum and the posterior pituitary, on days 10–12 of the cycle, initiate prostaglandin F2α secretion from the endometrium between days 14 and 17 of the estrous cycle. PGF2α causes regression of the luteal tissue and diminishes progesterone secretion to less than 1.0 ng/ml by the last 2 days of diestrus (Pineda 2003; Rawlings and Bartlewski 2007).

Reproductive performance

The minimal fecundity or prolificacy for the ewe is the production of a crop of one lamb per ewe per year and is referred to as a 100% lamb crop. Sheep producers seek a prolificacy average of at least 1.5 lambs per ewe (Pineda 2003). A fertile ewe is capable of producing at least one lamb per pregnancy. The reproductive performance of Awassi ewes has been low in the semi-arid regions of the near east countries (Hamadeh et al. 2001; Husein and Kridli 2002). Under normal conditions, less than 10% of Awassi ewes lamb twice a year (Lafi et al. 2009). A study was conducted by Kridli et al. (2007c) on 3- to 6-year-old pluriparous Awassi ewes (n=56) bred during June and July reported 60.7% (34/56) pregnancy rate, 91% (31/34) single birth rate, 9% (3/34) multiple birth rate, 90% lambing rate (number of lambs born per ewe mated), and 1.08 fecundity (number of lambs born per ewe lambing). The lambing rates from first mating ranged from 33% to 35% (Abdullah et al. 2002). The twinning rate in Awassi ewes ranged from 4% to 20% (Epstein 1985).

The positive effect of supplying energy and protein in excess of requirements (flushing) few days prior to mating improves Awassi sheep fecundity. A strong correlation was found between females weighing more than 50 kg at the time of mating and a fertility rate of 100% in Awassi sheep (Thomson and Bahhady 1988). An increase in lambing percentage of 0.3 to 1.3 (Kassem et al. 1989) and ovulation rate of 2% (Smith 1985) were reported for each kilogram increase in body weight before mating.

Husein and Haddad (2006) reported that the gestation length for 2–6-year-old Awassi ewes (n=14) weighing 52±1.5 kg was 149±0.6 days. The gestation length during the normal breeding season in about 1-year-old Awassi ewes (n=16) weighing in average 37.4±4.9 kg (range, 29.5–44.0 kg) varied from 149 to 155 days with an average of 152±2.3 days (Zarkawi 1997). The duration of pregnancy was not affected by either the type of birth (146±6.0 to 153.6±3.6 days for singles, 148.7±1.2 to 153.3±4.4 days for twins, and 144 to 146.5±0.5 days for triplet) or the sex (152.1±1.4 days for males and 151.0±1.5 days for females). In addition, estrous synchronization programs during or outside the breeding season have no effect on the duration of pregnancy in Awassi ewes (Al-Merestani et al. 1999; Turk et al. 2008).

Control of the reproductive cycle

Effective hormonal therapies to control the estrous cycle in ewes are essential for successful breeding, increasing the number of pregnant females (Motlomelo et al. 2002) and allowing ewes to be bred and lamb a more uniform lamb crop within a short period (Titi et al. 2010). It should be pointed out that hormonal control of the reproductive processes should never substitute good management practices. Hormones that are commonly used for induction and synchronization of estrus in Awassi ewes include progestins, gonadotropins, and PGF2α.

The most widely used program for out-of-season breeding is a combination of progestin given for periods 9–16 days and pregnant mare serum gonadotropin (also known as equine chorionic gonadotropin) administered at the time of progestin removal or within 48 h prior to removal. The controlled intravaginal drug-releasing device and the progestin-impregnated vaginal pessary are the most commonly used progestin delivery systems. Administering PGF2α 24 h before progestin removal and introduction of a teaser ram 24 h after progestin removal further tighten estrus synchrony (Keisler 2007). Estrus can be expected about 24–48 h after removal of the progesterone source.

Administration of PGF2α is the preferred method for synchronizing estrus and ovulation in cycling ewes. PGF2α induces regression of the corpus luteum, reduces progesterone concentrations, and allows for a new follicular wave to start within 2–3 days (Alnimer et al. 2005). One dose of PGF2α results in 60% to 70% of the cycling ewes in the flock to exhibit estrus within 30–60 h. A two-treatment method involving a second injection 9 to 11 days after the first one results in the tightest estrus synchrony in almost all ewes (Keisler 2007).

The ram effect is widely used to manipulate reproduction in ewes. Continuous exposure of ewes to rams advances puberty in ewe lambs, shortens the period of anestrous about 2 months, and advances ovulation relative to the onset of estrus by advancing the preovulatory LH surge (Rosa and Bryant 2002). However, to evoke a ram effect response, ewes need to be isolated from the sight, sound, and smell of rams prior to ram introduction. Although reports in the literature vary greatly in the duration of isolation, Keisler (2007) suggested the duration to be approximately 30 days.

Light manipulation to alter the natural ratio of light to dark and administration of exogenous melatonin to supple-

ment the endogenous release can also be used to advance the breeding season in ewes.

Detailed description of the various methods of controlling the reproductive processes in Awassi sheep is beyond the scope of this article.

Pregnancy diagnosis in Awassi sheep

Early pregnancy diagnosis, determination of the fetal numbers and stage of gestation, and recognition of the abnormalities of pregnancy are important reproductive herd health management practices because of the impact of reproductive performance on the economic return from the flock. The real-time B-mode ultrasonography is the preferred method of pregnancy diagnosis for small ruminants. Generally, scanners with sector, linear, and convex probes at frequencies of 3.5 to 7.5 MHz are used for pregnancy diagnosis in sheep. Linear array transducers are suitable for both transabdominal and transrectal scanning, while sector transducers are preferred for transabdominal pregnancy diagnosis. Pregnancy diagnosis in Awassi sheep utilizes the same principles and findings as in other sheep breeds. A positive diagnosis of pregnancy requires the identification of the embryo, fetus, or placentomes. The embryo appears as an echogenic mass surrounded by anechoic fluid within the uterine lumen on about day 30 until day 45. By day 45, fetal skeletal structures are sufficiently dense to reflect most of the ultrasound waves. As pregnancy progresses, the fetus continues to develop and specific structures become more easily identifiable (Bazer et al. 2007). Placentomes could be detected by transrectal ultrasonography (5 MHz) on day 32 of gestation and, by day 42, appear as small gray C- or O-shaped structures around the edges of the fluid-filled vesicle (Doize et al. 1997). Transrectal ultrasonographic scanning can be used to diagnose pregnancy as early as day 18 and as late as day 120 of pregnancy. Transabdominal ultrasonography can be used to accurately detect pregnancy as early as day 35 of gestation, and it is the preferred approach during the second half of pregnancy since larger portion of the pregnant uterus can be easily visualized (Kähn 2004). Transrectal ultrasonography is mainly used as a research tool to study, for example, embryonic death and follicular dynamics (Kähn 2004; Bazer et al. 2007). Under field conditions, transrectal ultrasonography is not of practical use since it requires animal handling and time. On the other hand, up to 250 ewes can be scanned transabdominally per hour with high accuracy (Bazer et al. 2007).

The correlation between placentomes size and gestational age in ewes is controversial. Kelly et al. (1987) found a significant quadratic relationship between ultrasonographic placentomes diameter and square root transformation of day of pregnancy. In contrast, Doize et al. (1997) and Gonzalez et al. (1998) found poor correlation due to great variations in the size of placentomes in the same observations. Ababneh et al. (2000; unpublished data) found the relationship between the size of placentomes determined by transabdominal ultrasonography and gestation age in 3–6-year-old pluriparous Awassi ewes (n=13) carrying singles and which had an average pregnancy duration of 152 days is best fitted in the following equation: $Y=4.16X-3.62$, where Y is the gestational age in days and X is the placentomes size in millimeter. Analysis of this equation demonstrated that the size of the placentomes increased about 1 cm every 40 days of gestation.

Awassi ram reproduction

Seasonality in the ram can be measured by the changes in the diameter of the testes and the level of reproductive hormone secretions. These changes correspond roughly to the breeding activity of the females of the same breed (Dufour et al. 1984). The mean weight of the testes of unimproved Awassi rams is 140 g and of the epididymis is 23 g (Epstein 1985). In a study conducted by Tabbaa et al. (2006) to evaluate monthly changes in scrotal circumference (SC) and some semen characteristics of ten Awassi rams (five matures of 2 to 6 years old and five yearlings of 12 to 18 months old) starting in May for an entire year found that SC was affected by age and month of the year. Mature rams had greater SC (33.5±0.8 cm) than yearlings (29.6±1.3 cm) throughout the year. The highest SC values were observed during August, September, and October before declining from November throughout January. Semen characteristics reported for the yearling versus mature Awassi rams were as follows: ejaculate volume (milliliter) (0.87±0.2 vs. 1.0±0.1), mass motility (percent) (65.3±6.0 vs. 72.7±3.8), forward motility score (score 1–4) (3.38±0.2 vs. 3.48±0.1), sperm concentration (10^9/ml) (2.21±0.5 vs. 2.91±0.3), abnormal sperm (percent) (18.1±2.0 vs. 16.39±1.2), and normal sperm concentration (10^9/ml) (1.85±0.4 vs. 2.48±0.3). These semen characteristics are not affected by ram age and month of the year. However, Salhab et al. (2003) found that ejaculate volume (average, 1.2±0.5 ml) and spermatozoa concentration (average, $4\pm1.6\times10^9$ sperm/ml) collected from 11-month-old Awassi rams (n=14) increased significantly over the next 20 months despite monthly variations while progressive motility (average value, 75±10%) was similar throughout the study period. Epstein (1985) reported similar average semen characteristic of Awassi rams to those reported by Tabbaa et al. (2006). Results of Salhab et al. (2003) and Tabbaa et al. (2006) studies showed that Awassi ram semen is not affected by the

season and that both yearling and mature Awassi rams may be employed for breeding at any time of the year while taking in consideration the ram to ewe ratio with respect to ram age.

Awassi ewes milk production

Milk yield of unimproved Awassi ewes shows a wide variation among countries and depends on dam's age and weight at lambing, month of lambing, type of birth, sex of born lamb, the sheep management system, and length of lactation period (Jawasreh and Khasawneh 2007). An Awassi ewe produces 40–60 kg of milk per 150-day lactation period under traditional (extensive) production system (Degen and Benjamin 2003) and 70–80 kg under improved (intensive) production system at government research stations (Hailat 2005). These levels do not include the suckling period when milk is left for lambs. The amount of suckling milk in traditional production system ranged between 68 and 90 kg during a period of 81–93 days (Hailat 2005). The improved Awassi is the second best milk-producing breed of the world and the highest milk-producing breed in Turkey. Milk yield ranging from 97.5 to 360 kg over 95 to 222 days lactation period was reported (Gürsoy 2005). Awassi ewes nurse their lambs for 2 to 3 months, depending on the state of pasture, time of birth, and growth of the lamb. During the suckling period, lambs are isolated from their dams 12 h before morning milking. Awassi ewes are milked twice a day during the first 3 to 4 months of the milking period and only once during the following month until they go dry (Epstein 1985). Ewes are usually milked by hand. Mechanical milking is practiced in some governmental research stations (Hailat 2005). Milk production from 3- to 6-year-old pluriparous Awassi ewes (n=56) was recorded weekly from parturition until weaning at 70 days of age with the aid of milking machine, with lambs being separated from the dams 12 h before the morning milking. The quantity of milk produced was extrapolated over the 24-h period. Milk production increased until reaching a peak at the third week of lactation (567±63 g), after which it began to decline. The percentages of milk dry matter, protein, and milk ash were 14.3%, 5.4%, and 0.83%, respectively. Milk protein percentage increased with advancement of lactation reaching its highest values at the time of weaning (6.3%) (Kridli et al. 2007c). The average specific gravity (SPG) of Awassi milk is 1.0371. Milk specific gravity differs in different months of the year due to variations in the proportions between various constituents, namely fat (SPG 0.93), proteins (SPG 1.346), lactose (SPG 1.666), and ash (SPG 5.5) (Epstein 1985).

Milk production of 1,360 improved Awassi ewes was followed over 3 years. Lambs were removed from the ewes at birth, and milk yield was recorded once a month over 214-day lactation period. These ewes had mean total milk production of 506 L. Maximum secretion potential of the ewes was 3.9 L/day, which resulted in a peak yield of 3.44 L/day at day 45 of lactation. Milk production increased by 62 g/day midway between the start and peak of lactation, and decreased by 16.5 g/day midway between the peak and end of lactation (Gootwine and Pollott 2000).

Conclusion

Awassi is the most common sheep breed in the Middle East countries. It is used for meat, milk, and wool production. The amount of milk produced during the lactation period varies greatly among different studies. The improved Awassi is the second best milk-producing breed of the world. The breed has low prolificacy and reaches puberty at a later age than other breeds. However, it has good adaptability to various managemental and environmental conditions. Awassi ewes have an average interestrus interval of 17 days with the breeding activity starts as early as April and lasts through September. Awassi rams can be used for breeding all year around. Progestins, gonadotropins, and PGF2α are commonly used to control the estrous cycle of Awassi ewes. Pregnancy diagnosis can be performed using transrectal and/or transabdominal real-time B-mode ultrasonography.

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