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CAUSES AND REMEDIES FOR NON-INFECTIOUS INFERTILITY IN SHEEP AND GOATS

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ABSTRACT

Non-infectious infertility is particularly critical for sire rams/bucks, as seasonal breeders. This seasonal heavy use of males may lead to sexual exhaustion such that the regular semen production, libido, ejaculation, and litter yield can be seriously impaired. In severe cases, the reproductive processes may stop completely. For avoiding infertility risk, management and feeding should firstly be arranged with a flock-based approach. In reproductive management, the issues of using teaser ram/buck, male/female ratio, weekly mating number, exercise, and experience need attention. Also, inbreeding and using old breeders should be avoided. In oestrus synchronisation, necessary precautions against extremely hot/arid climatic conditions should be considered together with a sufficient number of rams/bucks used rotationally. For sustainable sheep/goat breeding, protective-preventive measures are preferred to problem-solving approaches. In enterprises where female breeder welfare is a priority, sustainable individual yield increases. Further, only the comfort level of males used heavily in season allows the expected libido and fertility to occur. In small ruminants, the necessary interest and responsibility in production provide convenience in the ideal solution with the opportunity of early interventions against undesirable fertility problems in breeders. Undoubtedly, it is vital to consider sustainable animal health and welfare for profitable breeding and husbandry in sheep/goats.

Key words: feeding, infertility, management, reproduction, small ruminant

ABSTRAK

Infertilitas non-infeksi sangat penting untuk pejantan. Penggunaan pejantan secara berlebihan pada musim kawin dapat menyebabkan kelelahan seksual sehingga menurunkan produksi semen, libido, ejakulasi, dan jumlah anak. Pada kasus yang berat, proses reproduksi bisa berhenti total. Untuk menghindari risiko infertilitas, manajemen dan pemberian pakan harus diatur dengan pendekatan berbasis kelompok. Dalam manajemen reproduksi, masalah penggunaan pejantan, rasio jantan/betina, jumlah kawin per minggu, aktivitas, dan usia pejantan perlu mendapat perhatian. Inbreeding dan penggunaan hewan tua harus dihindari. Dalam sinkronisasi estrus, kondisi iklim yang sangat panas/kering dan rotasi jumlah domba jantan yang cukup digunakan harus dipertimbangkan bersamaan. Untuk pembiakan domba/kambing yang berkelanjutan, tindakan protektif-preventif lebih disukai dibandingkan pendekatan pemecahan masalah. Pada perusahaan yang memprioritaskan kesejahteraan induk betina, produksi akan meningkat. Pada level pejantan, diperlukan pejantan yang memiliki libido dan fertilitas yang tinggi. Pada ruminansia kecil, diperlukan perhatian untuk meningkatkan produksi dengan intervensi lebih dini terhadap masalah-masalah fertilitas yang tidak diinginkan. Tidak diragukan lagi, sangat penting untuk mempertimbangkan kesehatan dan kesejahteraan hewan yang berkelanjutan untuk produksi menguntungkan pada peternakan domba dan kambing.

Kata kunci: pakan, infertilitas, manajemen, reproduksi, ruminansia kecil

INTRODUCTION

Although there are many factors affecting fertility in small ruminants (Aytuğ *et al.*, 1990; Elmas, 2013), we can divide them into two groups, as infectious and non-infectious factors. Since the subject of infertility due to infectious causes (brucellosis, tuberculosis, agalactia, maedi, blue tongue) (Arthur *et al.*, 1993; Sönmez, 2012; Elmas, 2013) is out of the scope of this review, only the "non-infectious" infertility in sheep and goats will be discussed herein.

Non-infectious infertility is an important reproductive problem that occurs due to other reasons, regardless of any pathogenic microbial factors (Arthur *et al.*, 1993; Sönmez, 2012). It is characterized by poor performance and/or spermatological disorders of the male in the flock, and the decrease or termination of the fertility of the female. Indeed, in this infertile period, the reproductive process may be disrupted or completely stopped as a result of delayed puberty, oestrus disorders, early embryonic death, difficult lambing/kidding, and abortion in females (Uçar *et al.*, 2004; Polat *et al.*, 2009). In males, in addition to delayed puberty, decreased libido and mounting/mating performance (Öztürkler *et al.*, 2002; Uçar *et al.*, 2007), as well as deterioration or complete loss of conventional (volume, density, mass movement-motility, morphology, and dead/live ratio) (Öztürkler *et al.*, 2002) and functional (acrosome reaction, IVM/IVF, thermoresistance, freezability, DNA damage) spermatological characteristics, may be observed (Uçar and Parkinson, 2003; Sönmez, 2012).

As factors affecting fertility in general, a) environmental (management-feeding) (Uçar *et al.*, 2004; Polat *et al.*, 2009; Uçar *et al.*, 2011; Uçar *et al.*, 2020) and b) other reasons come to mind (Ptaszynska, 2001; İleri, 2007; Gökçen, 2008). Factors for special (non-infectious) reasons may be classified as; a) animal b) maintenance-nutritional (Uçar *et al.*, 2005; Uçar *et al.*, 2007) c) reproductive management d) environmental and e) other factors causing infertility in sheep and goats (Elmas, 2013; Koyuncu and Taşkın, 2016; Dwyer, 2020; Yarsan, 2020).

CAUSES OF GENERAL INFERTILITY

General causes of infertility in sheep and goats can be divided into two groups mainly as environmental (care-management and feeding) and other (genetic, hygiene and climate) factors (İleri, 2007).

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Environmental Infertility Factors

Maintenance-management

Maintenance has the highest share (40%) in offspring yield (İleri, 2007). In this context, all kinds of managerial activities in the process starting with animal supply and continueing with the sale of meat, milk, fleece/mohair, breeder, and lamb/kid, make the most important contribution to the operating revenues (Yarsan, 2020). However, serious negligence in the care and management of animals will naturally cause the greatest damage to the enterprise (Uçar *et al.,* 2020). For example, vaccination, hoof care, shearing, weighing, ram training, milking timing, manure management, consultancy/medical services, and professional knowledge and experience are among the maintenance-management issues (Aytuğ *et al.,* 1990; Elmas, 2013; Yarsan, 2020).

Feeding

Ideal nutrition has a net second (30%) contribution (İleri, 2007) to breeding initiation (Uçar *et al.,* 2007; Uçar *et al.,* 2008; Sönmez, 2012) and sustainability (Uçar *et al.,* 2004; Uçar *et al.,* 2008; Koyuncu and Nageye, 2020) as well as to offspring yield (Uçar *et al.,* 2005; Elmas, 2013). The fact that maintenance and feeding, having an 'environmental' effect of 70% on the offspring yield (İleri, 2007), is critical in terms of flock health, productivity, and profit in all enterprises (Yarsan, 2020). However, malnutrition (especially during mating, advanced pregnancy, post-partum, and early lactation periods) or overproduction (dairy Saanen goats and sheep breeds with high twinning rates, such as Chios and Romanovs) are more critical especially in underdeveloped/developing regions/ countries (Uçar *et al.,* 2004; Uçar *et al.,* 2008; Elmas, 2013). While the malnutrition of ewes and rams during the breeding period adversely affects oestrus, libido, follicle/semen, and lamb yield (Yildiz *et al.,* 2002; Uçar *et al.,* 2005, 2008), it is known that additional feeding (flushing) for energy and protein (Aytuğ *et al.,* 1990; Sönmez, 2012; Elmas, 2013), especially in twin lambing breeds, is known to have positive contributions to offspring yield (Tekerli *et al.,* 2002).

Other Infertility Factors

Apart from management and feeding (Sönmez, 2012; Elmas, 2013; Yarsan, 2020), other factors affecting fertility include genetics, hygiene, and climate (İleri, 2007; Koyuncu and Nageye, 2020; Tüfekci and Çelik, 2021).

Genetics

Endangered Chios sheep, known for their poor adaptability and low flock keeping, are famous for their long breeding season (4 months), twins, and high milk yield (Ceyhan *et al.,* 2007; Ertuğrul *et al.,* 2009). The Saanen goat breed, suitable for intensive breeding, is known for its high milk yield (Elmas, 2013; Yarsan, 2020). In generally speaking, the genetic trait has a 15% effect on offspring yield (İleri, 2007). Although the yield levels of indigenous goats and sheep are low compared to culture breeds, they are expected to experience fewer fertility problems because of their higher resistance to all conditions. On the other hand, although culture breeds are high-yielding (lamb/kid, milk, fleece/mohair), stress levels due to high production are also high (Dwyer, 2020, Uçar *et al.,* 2020). Considering that especially the initial adaptation ability may be low (such as in Chios sheep breed) (Tekerli *et al.,* 2002), it is important to follow the fertility rates of males and especially females from such culture breeds. The cases of infertility due to excessive stress can be seen more frequently in dairy breeds with twinning characteristics and adaptation sensitivity (Elmas, 2013).

Hygiene

Generally speaking, water (drinking and disinfection), feed, semen, insemination, milking, and foot hygiene can affect fertility. Hygiene is 10% effective on offspring yield (İleri, 2007). In this context, especially hoof care and udder hygiene are extremely important (Elmas, 2013). Teat disinfection (by dipping) before and after milking is critical with regular foot/body baths (Yarsan, 2020). Especially shelter and litter cleaning, mating/insemination, udder and birth hygiene, suckling hygiene are all important issues. In this context, care and cleanliness are essential during regular monitoring of hoof health, protection of udder health (teat disinfection-teat dipping, subclinical mastitis follow-up, teat injuries risk) especially in dairy ruminants (Chios and Saanen), use of teaser rams (belt hygiene), vaginal examination, sponge application, semen collection, mating/insemination and assistance with lambing/kidding and cesarean section (Aytuğ *et al.,* 1990; Arthur *et al.,* 1993; Sönmez, 2012; Elmas, 2013; Yarsan 2020). Also, water and food hygiene (risk of algae, mold, frostbite, rotting) are important (Koyuncu, 2017; Çokadar, 2020).

Climate

Long/severe cold or extremely hot/dry summer seasons can adversely affect fertility (Uçar and Parkinson, 2003; Uçar, 2006; Sönmez, 2012; Manstny, 2015; Sejian *et al.,* 2021; van Wettere *et al.,* 2021). Keeping breeding animals in a sheltered place in extreme cold/heat in shady cool environments has a positive effect on fertility (Edwards-Callaway *et al.,* 2021). Otherwise, the risk of libido suppression and spermatological disorders in males, or oestrus disorders in females may become more apparent. Generally, the effect of climate on the offspring yield is at the level of 5% (İleri, 2007; Koyuncu, 2017). Especially in dry seasons, both hard ground and dried high grass/stubble fields require attention in terms of feet and udder health. In addition, lung, nail, and udder health may be at risk under heavy rains, while lung, ear, and teats may suffer from extreme cold (Aytuğ, 1990; Elmas 2013). Therefore, extreme climatic conditions (excessive hot, cold, or even rain) should be avoided so that the reproductive performance of animals is not interrupted (Sejian *et al.,* 202; van Wettere *et al.,* 2021).

Further, global climate change (dry and hot summer seasons, dry spring and autumn, rapid loss of snow cover due to short winter) and excessive carbon emission (Aksay *et al.,* 2005; Çokadar, 2020; Nanas *et al.,* 2021), as likely to caused by exhaust gases and environmental pollution, also carries the risk of highly stressed animals due to excessive heat and thirst. These undesirable environmental changes (warming and water scarcity) may cause disruption in reproductive activities in sheep and goats, mainly as a result of excessive energy consumption and weakening, due to mandatory individual adaptation to extreme conditions (Sejian *et al.,* 2021). Hence, the awareness of protecting the environment (Koyuncu and Taşkın, 2016; Koyuncu and Nageye, 2020), animal and human health (Dwyer, 2020) against unfavourable effects (Wakayo *et al.,* 2015; Nanas *et al.,* 2021; Sejian *et al.,* 2021; van Wettere *et al.,* 2021) of global warming and climate changes (Manstny, 2015; Çokadar, 2020) is very critical for sustainable animal production.

CAUSES OF SPECIAL (NON-INFECTIOUS) INFERTILITY

The main infertility factors affecting lamb/kid productivity in sheep and goats are; a) animal factors (genetics, breed, anatomy, age), b) management-feeding factors (breeder/farmer problems, BCS, temperature stress, shearing, number of animals, diseases), c) reproductive management factors (weekly mating, teaser ram/buck, male-female ratio, inexperience, inactivity), d) environmental factors (season, geography) and e) others (Aytuğ *et al.,* 1990; Elmas, 2013; Yarsan, 2020).

Animal Factors

Genetics

Inbreeding can occur both in artificial insemination (AI) in cattle and the presence of sire rams and bucks kept within the same flock for a long time (Aytuğ *et al.,* 1990; Arthur *et al.,* 1993; Sönmez, 2012; Elmas, 2013). As in Europe, after the usage of male breeders for up to 2-3 years, the sires must be changed or sent to another flock (Elmas, 2013). Otherwise, especially in rural areas, cases of congenital anomalies may be observed as a result of the risk of a greater combination of lethal or sublethal genes due to the long-term presence of a small number of males within the flock. In addition, it may threaten the income status of the enterprise, as the resistance to diseases will decrease in addition to the loss of yield in such inbred flocks. Hence, sire males have to be followed very strictly and regularly (with Pedigree and Progeny tests, if possible) (Sönmez, 2012) in the enterprises, so that inbreeding can be avoided realistically.

Breed

Due to other environmental factors, apparent differences can be observed between cultured (high-yielding) and indigenous breeds in terms of care-feeding and infertility. Comparing dairy and beef breeds, the former may suffer more from metabolic and udder problems, while the latter may have more nail and mating problems (Arthur *et al.,* 1993). Differences in fertility are also possible among indigenous breeds (Aytuğ *et al.,* 1990; Elmas, 2013; Yarsan, 2020).

It can be said that twin lambing Chios and Romanov breeds are more prone to pregnancy toxemia (Sönmez, 2012; Elmas, 2013). High-yielding but vulnerable breeds may encounter fertility problems more often than low-yielding (Aytuğ *et al.,* 1990) but resistant indigenous breeds, such as Morkaraman sheep and Hair goat. The main reason for the increase in infertility is that the necessary precautions are not taken enough against the decrease in animal welfare as the productivity increases (Uçar *et al.,* 2020; Dwyer, 2020). For example, in intensive dairy farms, high-yielding female breeders that are not properly managed and fed may encounter problems such as hoof, udder, and gastrointestinal problems, as well as early culling, infertility, pregnancy toxemia, and abortus cases (Aytuğ *et al.,* 1990; Arthur *et al.,* 1993; Elmas, 2013).

In addition, due to heavy weight (overfeeding and/or tail weight), dirty bedding and hard ground, hoof problems, low libido, and difficulty in mating, infertility may be seen more frequently in fat-tailed (Akkaraman, Morkaraman, Awassi) sheep than those with thin tails (Kivircik and Merino) (Elmas, 2013; Yarsan, 2020).

Anatomy

A thin-tailed ram may not easily mate with fat-tailed ewe due to the presence large tail that may prevent mating. This may result in male-male mating due to high testosterone hormone (Yildiz *et al.,* 2002). To prevent this, AI may be preferred to natural breeding in cross-breeding of the fat-tailed ewe (Elmas, 2013). In addition, such problems are not encountered when breeding fatty or thin-tailed sheep among themselves (with similar tail fatness).

Age

The active period of using male and female breeders is between 2-6 years old (Aytuğ *et al.,* 1990; Ptaszynska, 2001; Elmas, 2013). Male sires should be removed from breeding after using them up to 4-5 years. Also, early age breeders may lead to mating failure (inexperience) in males or infertile mating (poor follicular development) in females. Further, while spermatological disorders increase in older males, infertility rates may also increase in females with advanced age (Arthur *et al.,* 1993). In addition, adult males prefer more adult females for mating. Therefore, young females should be placed apart from adult females according to age grouping. It has been observed that using young ram-lambs (8-10 months) for breeding, insufficient fertilisation (*in vitro* acrosome reaction) in males (Finn Dorset, Suffolk, Charolais) (Uçar and Parkinson, 2003) or very low lambing yield (early embryonic death, low twins, small offspring) in young (10 months) ewe-lambs (Tuj) may occur (personal observation).

Maintenance-Nutritional Factors

Breeder issues (management)

Breeders (farmers) are one of the main factors that determine the reproductive performance and profit level in sheep and goat husbandry (Aytuğ *et al.,* 1990; Elmas, 2013). Ideal animal husbandry cannot be discussed as long as the lack of knowledge, ignorance, and poor levels of culture and education of breeders persist (Aydın and Keskin, 2018; Uçar *et al.,* 2020; Kumala *et al.,* 2021). Although many health and reproductive problems appear in animals (Arthur *et al.,* 1993), the main source is often humans. The presence of wild (native) pastures and/or meadows is effective to some extent in animal husbandry culture (Uçar, 2006; Elmas, 2013; Kumala *et al.,* 2021). For an ideal and profitable livestock organisation, the breeders have to provide comfort level (animal welfare) to the breeding animals under all circumstances (Dwyer, 2020; Uçar *et al.,* 2020).

Nutrition (body condition score/BCS)

Breeding animals should be fed regularly with quality feeds (not moldy, frozen, rotten, or wet) according to their periodic physiological needs (Aytuğ *et al.,* 1993; Uçar *et al.,* 2004; Uçar *et al.,* 2008; Elmas, 2013). The risk of infertility increases as a result of physical injuries of scrotal skin and testicles (mainly myiasis, itching, and thermoregulation due to testicular oedema) in rams grazing in high stubble or thorny fields in the summer. In summer pastures, feeding mostly of green meadow and pasture grass is sufficient for animals, while roughage (silage, dry clover/grass) and grain (barley, corn) or concentrated feed should be given together in semi-intensive and intensive farms (Elmas, 2013). In the case of feeding mostly with roughage (hay), the risk of oestrus disorders (prolonged oestrus) and early embryonic death or anomaly due to ovum aging increases (Uçar *et al.* 2004, 2008). During the mating season, females should be given additional energy and protein supplements (250 grs corn and barley, 300-600 gr barley or 500 gr mixed feed, either), as a flushing diet, for 1-2 months to support reproductive activities (Aytuğ *et al.,* 1990; Elmas, 2013). Care should be taken for breeding males to be fed with high-quality grass with vitamin-mineral support (Uslu *et al.,* 2017) and concentrated feed (Aytuğ *et al.,* 1990; Elmas, 2013). However, excessive feeding (fattening) of breeding rams and bucks should never be allowed (Uçar *et al.,* 2008). Otherwise, low libido, fatigue, and hoof problems may be encountered more frequently. Salt, mineral (calcium, phosphorus, iron, copper, zinc, selenium) and vitamin (A-D-E) needs (especially mating, milking, pregnancy, and growth periods) should be met regularly and adequately (Uçar *et al.,* 2011; Sönmez, 2012; Ömür *et al.,* 2016; Uslu *et al.,* 2017). Nutritional disorders (weakening and gatro-intestinal foreign bodies such as wool balls or bezoars) can be seen both in sheep and goats (Figure 1). Animals should not be fed in closed places, and maximum utilisation of the pasture should be pursued as far as conditions permit. Finally, precautions should be taken -in terms of ration energy support- against the risk of pregnancy toxemia (Sönmez, 2012) due to twin/triple litters especially seen in Chios and Romanov ewes (Elmas, 2013; Yarsan, 2020). In addition, it is extremely important to provide additional feeding (at least 2-3 months) during the lactation period in both twin-lambing ewes and dairy Saanen does (Aytuğ *et al.,* 1990). Otherwise, the risk of weakening or growth retardation in lambs and kids both, and the risk of metabolic disorders and reproductive disease in the mother may increase (Uçar *et al.,* 2004; Uçar *et al.,* 2008). In this case, the entry to the new breeding season may be delayed or even stopped due to extreme weakness or long-lasting disorders (Elmas, 2013). In breeding rams, poor libido, impaired spermatogenesis, and low fertility may be seen due to malnutrition (Sönmez, 2012). 'Moderate' body condition in both males and females (2.5-3.0 units in females, 3.0-3.5 units in males, 1-5 scale) is suitable for ideal performance (Uçar *et al.,* 2008). The BCS level is one of the predominant factors determining the number of lambs born (litter size). Although individuals with BCS 2 levels show signs of oestrus, the litter size decreases markedly (Uçar *et al.,* 2005).

Figure 1. Bezoars, wool-based gastro-intestinal stones (with quite a hard surface and mostly regular-round in shape), is mainly occurring due to malnutrition in a goat in the mountainous province of Erzurum-TR (by Dr. Ö. Uçar)

Heat stress

The breeding process is disrupted in extremely hot/dry seasons or crowdy/stuffy shelter conditions (Aytuğ *et al.,* 1990; Elmas, 2013). Under these peculiar conditions, libido is suppressed, spermatological parameters deteriorate, and abnormal sperm count increases in males, while delayed or irregular oestrus, early embryonic death, or even abortion can be observed in females (Wakayo *et al.,* 2015). It is appropriate to have a shade (Koyuncu, 2017; Edwards-Callaway *et al.,* 2021) and walking opportunity during resting (Figure 2a, Figure 2b). Especially less sunny (cloudy) and/or tolerable cool night hours are preferred for grazing, while in extreme cold animals are sheltered in an air-conditioned (little warm) place. In cold winter or hot summer months, attention should be paid to the temperature of artificial vagina used to keep the filling

(a)

(b)

Figure 2. Shade and walking areas for different breeds of a) sheep and b) goat barns, in the hot-seaside province of Mugla-TR (by Dr. Ö. Uçar)

water temperature stable during semen collection (Uçar and Parkinson, 2003; Sönmez, 2012). In a hot environment, poor motility and/or high dead sperm are seen predominantly, while in cold the presence of low sperm motility and tail anomalies become noteworthy. Therefore, heat stress (extreme heat or cold) should be avoided for normal fertility in male and female sires (Joy *et al.*, 2020; Narayan *et al.*, 2021; Sejian *et al.*, 2021).

Shearing

In sheep/goats, long wool/hair causes heat stress in males (Figure 3) and females in extreme heat or a closed environment. So, spring or summer months are the best time for shearing. Sometimes, second shearing may be needed in the fall season (Elmas, 2013). In males, careful cleaning of testicular hair is important in preventing scrotal heat stress so that 'summer infertility' (rams) can be prevented effectively (Aytuğ *et al.*, 1990; Elmas, 2013). Compliance with the rules of mastership and hygiene at shearing facilitates possible parasitic cleansing (Yarsan, 2020). Otherwise, hoof and mounting problems may occur due to heavy and dirty wool/hair. In addition, maximum hygiene and avoidance of using rusty utensils (scissors, shaving devices, etc.) during shearing can provide effective protection against the risk of local injuries, especially tetanus.

Figure 3. Indigenous (fat-tailed) breed of Tuj ram with long fleece, in the mountainous province of Kars-TR (by Dr. R. Kulaksiz)

Number of animals

Large flocks, the presence of close neighbouring flocks, and very small/large size of farm/enterprise are important in terms of potential infertility. In crowded flocks, there is a risk of an increase in the number of infertile matings as a result of excessive effort consumption due to active persistent follow-up for seeking potentially oestrous females and frequent mating as well as high challenging competition between male breeders. This situation carries the risk of mating failure or neglecting females with normal oestrus. The presence of neighbouring flocks is another source of stress due to grazing competition and the potential distraction of the flock. In large enterprises, active follow-up and controlled-mating (Sönmez, 2012) are important for effective flock management (Aytuğ *et al.*, 1990) towards sustainable productivity (Koyuncu and Taşkın, 2016; Dwyer, 2020; Koyuncu and Nageye, 2020).

Diseases

In general, oestrus, libido, and mounting symptoms can be seriously impaired in sick animals (permanent lameness, fracture, blindness) (Sönmez, 2012). In synchronisation, sick individuals may not respond to treatment. As a result, the reproductive process maybe stopped completely, especially in severe and chronic diseases (Arthur *et al.*, 1993; Dwyer, 2020; Yarsan, 2020). In cases of pain and fever diseases (poisoning, snake/scorpion stings, horn injury), the reproductive process might be disrupted totally. In long-horned goat breeds (Figure 4), it was observed that a buck with a horn break has not mated during the breeding season along with suffering from serious depression (personal observation) neighbouring flocks.

Figure 4. Long-horned indigenous kil (hair) goat, in a large lake-side province of Van-TR (by Dr. B.A. Uslu)

Reproductive Management Factors

Number of mounting per week

As a weekly mounting number, every other day or 3 times a week is appropriate (Aytuğ *et al.,* 1990; Sönmez, 2012; Elmas, 2013). If good care-feeding is done, a maximum of two inseminations per day can be allowed in male breeders. Frequent sperm collection, leading to insufficient sperm maturation within the epididymis, brings along spermatological (sperm mid-piece) disorders (Sönmez, 2012). This situation (especially the presence of excessive protoplasmic droplets) carries the risk of adversely affecting fertility (Aytuğ *et al.,* 1990).

Searching (teaser) ram/buck

Before the breeding season (anoestrus or transition period), it is very important to use a search (teaser) ram in enterprises that aims to get early lambs with synchronisation, which requires effective oestrus monitoring (Aytuğ *et al.,* 1990). If intense matings/inseminations are not controlled during the synchronisation process, infertile mating/insemination cases can be frequently encountered as a result of unsuccessful/false mounting. In this case, either the individual does not give any semen or the number of abnormal/dead spermatozoa increases by decreasing the volume of semen given with a limited amount (Sönmez, 2012). If the excessive use of males results in decreased libido (and fertility) due to fatigue, adequate mating with estrous females may be reduced or eliminated. In this sense, the limited number of valuable male breeders will not be wasted and exhausted if the necessary measures are taken in the enterprises. In addition, by doing so, estrous females can successfully conceive with a sufficient number of inseminations (Elmas, 2013).

Male-female ratio

As with the use of search rams, the male-to-female ratio is particularly critical in the pre-season oestrus synchronisation process. In this case, both male and female breeders are successfully mated or inseminated in sufficient numbers in a short period, as desired. For this purpose, one ram/buck to 5-10 females (5 if synchronised, or 10 if in season) in case of synchronisation, and one ram/buck to 10-15 females in the normal case should be allocated for breeding (Aytuğ *et al.,* 1990; Ptaszynska, 2001; Elmas, 2013). In adjusting young/adult male or female, both possible poor performance of young males in particular and the stiation of young females that are not preferred by adult males should be kept in mind for mating.

Inexperience

Inexperience can be a problem on its own, especially for male breeders (Aytuğ *et al.,* 1990; Sönmez, 2012). Incorrect mounting can lead to false ejaculation or mating failure. Therefore, young/inexperienced males watching the mating individuals in the flock make it easier for them to gain mating experience. Breeding individuals gain the necessary experience with the advancing age. In this context, it is recommended that breeding individuals are to be at least 12 months (or preferably 12-18 months) of age (Aytuğ *et al.,* 1990; Elmas, 2013).

Inactivity

Regular exercise is important not only for libido and body conditioning but also for hoof health and animal welfare (Sönmez, 2012; Dwyer, 2020). Especially rams and bucks should have enough space for movement, and they should be allowed to move actively, not being kept in closed areas outside the mating season. In addition, in the passage of flock or breeding males from the places where the wire fences are located, especially in the summer, the flabby testicles and the scrotum (especially during mating season) and preputium may cause orchitis, decreased libido, and deterioration in semen quality. Wire fences may also lead to udder injuries and mastitis problems in dairy females (Chios ewe, Saanen doe) (Figure 2a, Figure 5) (Elmas, 2013). On the other hand, peculiar cases such as injuries, fractures, abortion, or even sudden death can occur in mudguards and wetlands, as a result of slipping or getting bogged down. So, flock management during shipment to and from the pasture is quite important (Aytuğ *et al.,* 1990).

Figure 5. Dairy Saanen doe (large udder) and kid, in a semi-intensive barn, form a lowland province of Ankara-TR (by Dr. R. Kulaksiz)

Environmental Factors

Season

In small ruminant breeding, males and females are mostly housed in areas (semi-intensive or intensive) away from pasture in autumn and winter, especially in Central and Eastern Anatolia. For sheep, the mating season is June-July months in Western Anatolia and the temperate coastal areas, while in Central and Eastern Anatolia it starts in August-September (Elmas, 2013). Goats enter the breeding season 1-2 months later than the sheep (Aytuğ *et al.,* 1990). Especially when mating in the shelter, young-old separation, grouping, and hand-mating (controlled breeding) are recommended for females. In sheep and goat breeding where open (extensive) fattening is normally based on pasture, the summer season mainly coincides with the anoestrus period. Since the females before this period have given lamb/kid before, intensive grazing is carried out during

and after the lactation period (Elmas, 2013). Therefore, the sheep are grazed for fattening to increase BCS and body weight (Aytuğ *et al.,* 1990; Uçar *et al.,* 2008) especially in the dark (night) or early morning times.

Geography

Mountainous lands (Eastern Anatolia) or slope (Black Sea, Mediterranean regions) structure, precipitation condition (Black Sea region), coastline, temperature level (Northeast, Southeast Anatolia), border length, and plateau existence/distance related to the location of the flock and the enterprise may have all an impact on fertility potential (Aytuğ *et al.,* 1990; Elmas, 2013).

Other Factors

Undesirable environmental conditions such as the presence of noise in the environment (airport, railway, highway, bridge), high voltage lines (power plant), excessive wind (peak, slope), and heavy smoke (factory, heating chimneys) may have all the potential to adversely affect both general animal health and fertility (Aytuğ *et al.,* 1990; Sönmez, 2012; Elmas, 2013).

DISCUSSION

Necessary precautions against the non-infectious low fertility, management-feeding in particular (Uçar *et al.,* 2004; Uçar *et al.,* 2008; Uçar *et al.,* 2020) should be considered not only with individual follow-up and struggle but also on a flock basis for ideal offspring yield (Uçar *et al.,* 2005; Elmas, 2013). It should not be forgotten that high meat, milk, lamb/kid-yielding breeds are more vulnerable than the local breeds with poor yield. Further, udder health, hoof care, good adjustment of ration energy level, ram/buck effect, male-female ratio (Elmas, 2013) as well as effective struggle against heat stress (Koyuncu and Nageye, 2020; Joy *et al.,* 2020) and taking necessary intensive/extensive measures according to open/closed breeding system (Aytuğ *et al.,* 1990) are all important. In a critically important breeder ratio, periodic feeding is also important especially during the mating and post-partum periods (Elmas, 2013).

To achieve high success in natural mating and AI in sheep and goats, maximum attention should be paid to the rules of semen collection, vaginal examination, sponge application, mating/insemination and shearing (Aytuğ *et al.,* 1990; Uçar and Parkinson, 2003; Uçar *et al.,* 2005; Sönmez, 2012). The use of alternating rams/bucks in natural breeding, 5-10 females per male in synchronisation applications or 10-15 females per male in normal cases are suitable (Aytuğ *et al.,* 1990; Elmas, 2013). It is recommended to use search ram/buck for effective breeder use, especially in large flocks where the number of males is limited or during the anoestrus period. In AI after synchronisation, the ideal protocol should be selected first. The use of progesterone sponge, gonadotropin-releasing hormone (GnRH), and Prostaglandin (Bayşu-Sözbilir *et al.,* 2006; Kulaksız *et al.,* 2013a; Kulaksız *et al.,* 2013b; Kumala *et al.,* 2021) and pregnant mare serum gonadotropin (PMSG) in-season, and melatonin, progesterone, and PMSG in the off-season (Ucar *et al.,* 2005; Uslu *et al.,* 2012; Kaya *et al.,* 2013; Yadav *et al.,* 2020) are recommended. In addition to the breeder ratio (Elmas, 2013), melatonin can also be applied for high performance from males outside the breeding season (Uslu *et al.,* 2012).

In an effective struggle against diseases, vaccination should be the priority, consultancy and medical services should not be interrupted, and normal 'animal welfare' (Dwyer, 2020) should be taken as a basis before animal health (Aytuğ *et al.,* 1990; Elmas 2013; Yarsan 2020). Against the risk of infertility or any disease, careful management-feeding approaches according to the normal level of welfare are required for ideal production, not only for health protection but also for disease management in all animals (Sönmez, 2012; Uçar *et al.,* 2020). Finally, choosing an animal breed (Yarsan, 2020) suitable for the breeding purpose (Elmas, 2013) can markedly increase the level of fertility success and operating profits by reducing operating costs and health problems of the flock (Koyuncu and Taşkın, 2016).

CONCLUSION

In conclusion, for sustainable small ruminant breeding, protective and preventive measures are to be preferred to problem-solving approaches. In enterprises where candidate mothers' welfare is a priority, their sustainable individual reproductive yields increases. Further, only the comfort level of seasonally heavily used males allows the normal breeder performance to occur. Undoubtedly, it is vital to combine sustainable animal health and welfare for achieving profitable animal breeding and husbandry.

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REFERENCES

Aksay, C.S., O. Ketenoğlu, and Kurt, L. 2005. Küresel ısınma ve iklim değişikliği. **SÜ Fen Ed. Fak. Fen Derg.** 25:29-41.

Arthur, G.H., D.E. Noakes, and H. Pearson. 1993. **Veterinary Reproduction and Obstetrics** (6th ed.). Bailliere Tindall, London.

Aydın, M.K. and M. Keskin. 2018. Muğla ilinde küçükbaş hayvan yetiştiriciliğinin yapısal özellikleri. **Mediterr. Agric. Sci. 31(3):** 317-323.

Aytuğ, C. N., E. Alaçam, Ü. Özkoç, H. Gökçen, and H. Türker. 1990. **Koyun-Keçi Hastalıkları ve Yetiştiriciliği.** TÜM VET. Hayvancılık Hizmetleri Yayını. No. 2, TEKNOGRAFİK Matbaası, İstanbul, Turkey.

Bayşu Sözbilir, N., Ş. Maraşlı, Y. Öztürkler, and Ö. Uçar. 2006. Effects of double injections of $PGF_{2\alpha}$ at different intervals on some reproductive traits in Tuj ewes. **Turk. J. Vet. Anim. Sci.** 30:207-211.

Ceyhan, A., İ. Erdoğan, and T. Sezenler. 2007. Gen kaynağı olarak korunan Kıvırcık, Gökçeada ve Sakız koyun ırklarının bazı verim özellikleri. **Tekirdağ Ziraat Fak. Derg.** 4(2):211-218.

Çokadar, S.N. 2020. İklim değişikliği ve küresel ısınma. İNSAMER. **https://insamer.com/tr/iklim-degisikligi-ve-kuresel-isinma_3464.html**.

Dwyer, C.M. 2020. Can improving animal welfare contribute to sustainability and productivity?. **BSJ Agri.** 3(1):61-65.

Edwards-Callaway, L.N., M.C. Cramer, C.N. Cadaret, E.J. Bigler, T.E. Engle, J.J. Wagner, and D.L. Clark. 2021. Impacts of shade on cattle well-being in the beef supply chain. **J. Anim. Sci.** 99(2):1-21.

Elmas, M. 2013. **Koyun-Keçi El Kitabı**. Billur Yayınevi, Konya, Turkey.

Ertuğrul, M., G. Dellal, İ. Soysal, C. Elmacı, O. Akın, S. Arat, İ. Barıtçı, E. Pehlivan, and O. Yılmaz. 2009. Türkiye yerli koyun ırklarının korunması. **U.Ü. Ziraat Fak Derg.** 23(2):97-119.

Gökçen, H. 2008. **İneklerde İnfertilite**. Nobel Tıp Kitabevleri, İstanbul, Turkey.

İleri, İ.K. 2007. Suni tohumlama ve gebelik şansını artırıcı uygulamalar. **IV. Ulusal Reprodüksiyon ve Suni Tohumlama Bilim Kongresi**. Manavgat-Antalya, Türkiye. Sayfa 22-26.

Joy, A., F.R. Dunshea, B.J. Leury, I.J. Clarke, K. DiGiacomo, and S. S. Chauhan. 2020. Resilience of small ruminants to climate change and increased environmental temperature: A review. **Animals.** 10(5):867.

Kaya, S., C. Kaçar, D. Kaya, and S. Aslan. 2013. The effectiveness of supplemental administration of progesterone with GnRH, hCG and $PGF_2\alpha$ on the fertility of Tuj sheep during the non-breeding season. **Small. Rum. Res.** 113(2-3):365-370.

Koyuncu, M. 2017. Küresel iklim değişikliği ve hayvancılık. **Selcuk J. Agr. Food Sci.** 31(2):98-106.

Koyuncu, M., and Nageye, F.İ. 2020. İklim değişikliğinin sürdürülebilir hayvancılığa etkileri. **J. Anim. Prod.** 61(2):157-167.

Koyuncu, M., and M. Taşkın. 2016. Ekolojik koyun ve keçi yetiştiriciliği. **Hayvansal Üretim.** 57(1):56-62.

Kulaksız, R., Ö. Uçar, and A. Daşkın. 2013a. Effects of FGA sponge and Ovsynch based protocols on reproductive performance of fat-tailed ewes during breeding season. **Kafkas Üniv. Vet. Fak. Derg.** 19(4):629-633.

Kulaksız, R., Ö. Uçar, and A. Daşkın. 2013b. Effects of oestrus synchronisation by double FGA-sponge or split eCG administrations upon the reproductive traits in Angora goats during the breeding season. **Ata. Üniv. Vet. Bil. Derg.** 8(1):1-8.

Kumala, S., W. Asmarawati, Ismaya, S. Bintara, R. N. Aji, and D. T. Widayati. 2021. Estrogen hormone profile and estrus response and thin tailed ewes synchronized with controlled internal drug release. **J. Kedokt. Hewan.** 15(3):71-75.

Manstny, L. 2015. **Dünyanın Durumu–Sürdürülebilirliğin Önündeki Gizli Tehditlerle Yüzleşmek**, Worldwatch Enstitüsü. Hotinli G (Çevirmen), (*State of the World 2015- Confronting Hidden Threats to Sustainability*), Türkiye İş Bank. Kültür Yayınları. I. Baskı, Ayhan Matbaası, Ekim, İstanbul, TURKEY.

Nanas, I., T.-M., Chouzouris, E. Dovolou, K. Dadouli, K. Stamperna, I. Kateri, Barbagianni, M., and G. S. Amiridis. 2021. Early embryo losses, progesterone and pregnancy associated glycoproteins levels during summer heat stress in dairy cows. **J. Thermal Biol.** 98:102951.

Narayan, E., M. Barreto, G.-C. Hantzopoulou, and A. Tilbrook, 2021. A retrospective literature evaluation of the integration of stress physiology indices, animal welfare and climate change assessment of livestock. **Animals.** 11:1287.

Ömür, A. D., A. Kırbaş, E. H. Aksu, F. M. Kandemir, E. Dorman, Ö. Kaynar, and O. Ucar. 2016. Effects of antioxidant vitamins (A,D,E) and trace elements (Cu, Mn, Se, Zn) on some reproductive and metabolic profiles in dairy cows during transition period. **Polish J. Vet. Sci.** 19(4):697-706.

Öztürkler, Y., Ö. Ucar, S. Yildiz, and İ. Kaya. 2002. The effect of nutritional supplements upon reproductive traits of pre-pubertal fat-tailed Tushin rams. **Reprod. Domest. Anim.** 37:244 (Abstract).

Polat, B., A. Colak, M. Kaya, and O. Ucar. 2009. Stimulation of delayed puberty in heifers by using a PRID regime. **Rev. Med. Vet.** 160(3):149-153.

Ptaszynska, M. 2001. **Compendium of Animal Reproduction**. (6^{th} Revised ed.), INTERVET Int. bv, Netherland.

Sejian, V., M.V. Silpa, M.R. Reshma Nair, C. Devaraj, G. Krishnan, M. Bagath, S.S. Chauhan, R.U. Suganthi, V.F.C. Fonseca, S. König, J.B. Gaughan, F.R. Dunshea, and R. Bhatta. 2021. Heat stress and goat welfare: Adaptation and production considerations. **Animals.** 11(4):1021.

Sönmez, M. 2012. **Reprodüksiyon, Suni Tohumlama ve Androloji Ders Notları**. Fırat Üniversitesi Veteriner Fakültesi, Elazığ, Turkey.

Tekerli, M., M. Gündoğan, Z. Bozkurt, and A. Akcan. 2002. Akkaraman, Dağlıç, Sakız ve İvesi koyunlarının Afyon koşullarındaki verim özelliklerinin belirlenmesi I: döl verimi ve yaşama gücü. **Lalahan Hayvan. Araşt. Enst. Derg.** 42(2):29-36.

Tüfekci, H. and H.T. Çelik. 2021. Effects of climate change on sheep and goat breeding. **BSJ Agri.** 4(4):137-145.

Uçar, Ö. 2006. Kafkas Üniversitesi Veteriner Fakültesi Dölerme ve Suni Tohumlama Anabilim Dalına getirilen hayvanların bireysel özellikleri, geliş zamanları ve uygulama yaklaşımları yönünden değerlendirilmesi. **Atatürk Üniv. Vet. Bil. Derg.** 1(3-4):39-50.

Uçar, Ö. and T.J. Parkinson. 2003. In vitro induction of the acrosome reaction in ovine spermatozoa by calcium ionophore A23187. **Acta Vet. Hung.** 51(1):103-109.

Uçar, Ö.T. Bülbül, and M. Saatci. 2020. The effects of insufficient management and nutrition on reproductive performance in dairy cows: struggle between modern and traditional breeding. ICABGEH (**IV. International Congress on Domestic Animal Breeding, Genetics and Husbandry**) (Oral). Abstract No: ICABGEH-2020-012. August 12-14. İzmir-TURKEY.

Uçar, Ö., Y. Ünal, and S. Yıldız. 2004. Ruminantlarda yetersiz beslenmenin sindirimsel ve metabolik adaptasyonlar ve üreme üzerine etkileri (Çeviri). **Kafkas Üniv. Vet. Fak. Derg.** 10:227-241.

Uçar, Ö., S. Özkanlar, M. Kaya, Y. Özkanlar, M.G. Şenocak, and H. Polat. 2011. Ovsynch synchronisation programme combined with vitamins and minerals in underfed cows: biochemical, hormonal and reproductive traits. **Kafkas Univ. Vet. Fak. Derg.** 17(6):963-970.

Uçar, Ö., M. Çenesiz, M. Kaya, and S. Yıldız. 2008. Koyunlarda vücut kondisyon skorunun üreme üzerine etkileri (Derleme). **Bültendif Vet. Bülten.** 29**:**2-5.

Uçar, Ö., Y. Ünal, M. Kaya, D. Blache, and S. Yıldız. 2007. Kuzularda üre-melas mineral blok yemiyle beslenme sonrası uygulanan telafi besisinin hormonal ve reprodüktif parametreler üzerine etkileri. **IV. Ulusal Reprodüksiyon ve Suni Tohumlama Kongresi** sf. 124-125. Manavgat-Antalya, 25-28 Ekim.

Ucar, O., M. Kaya, S. Yildiz, F. Onder, M. Cenesiz, and M. Uzun. 2005. Effect of Progestagen/PMSG treatment for oestrus synchronization of Tuj ewes to be bred after the natural breeding season. **Acta Vet. Brno.** 74:385-393.

Uslu, B.A., L. Mis, F. Gülyüz, B. Comba, A. Comba, V. Kosal, S. Sendag, and O. Ucar. 2017. Is there a relationship between serum minerals (Ca, Mg) and trace elements (Cu, Fe, Mn, Zn) at mating and pregnancy rates in fat-tailed Morkaraman sheep?. **Indian J. Anim. Res.** 51(2):256-262.

Uslu, B. A., I. Tasal, F. Gulyuz, S. Sendag, O. Ucar, S. Goedrick-Pesch, and A. Wehrend. 2012. Effects of oestrus synchronisation using melatonin and norgestomet implants followed by eCG injection upon reproductive traits of fat-tailed Morkaraman ewes during suckling, anoestrus season. **Small Rum. Res.** 108:102-106.

van Wettere, W.H.E.J., K.L. Kind, K.L. Gatford, A.M. Swinbourne, S.T. Leu, P.T. Hayman, J.M. Kelly, D.O. Kleeman, and S.K. Walker. 2021. Review of the impact of heat stress on reproductive performance of sheep. **J. Anim. Sci. Biotech.** 12(1):1-18.

Wakayo, B.U., P.S. Brar, and S. Prabhakar. 2015. Review on mechanisms of dairy summer infertility and implications for hormonal intervention. **Open Vet. J.** 5(1):6-10.

Yadav, V., R.K. Chandolia, R. Dutt, A. Bisla, G. Saini, G. Singh, and L.C. Ranga. 2020. Effect of ovsynch estrus synchronization protocol on fertility in crossbred ewes. **J. Anim. Res.** 10(4):543-549.

Yarsan, E. 2020. **Koyun ve Keçi Hekimliği**, Güncellenmiş 2. Baskı. Güneş Tıp Kitabevleri, Ankara, Turkey.

Yildiz, S., M. Uzun, M. Cenesiz, O. Ucar, M. Kaya, and F. Onder. 2002. Effects of sexually-activated rams or ewes on pulsatile LH secretion in anoestrous sheep. **Acta Vet. Brno.** 71:297-302.