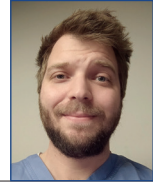# Reproductive success in goats: A review of selected impacting factors

J. Šavorić, V. Stevanović, S. Vince, I. Matić, J. Grizelj, M. Lojkić, N. Maćešić, M. Samardžija, T. Karadjole and B. Špoljarić*

Abstract

Dairy goats are a very successful form of livestock farming in developing countries, with functional products for human consumption, which makes their breeding attractive. Breeding efficiency is determined by successful reproductive parameters. Several parameters can be used as indicators of reproductive success, such as the number of kids born, age at first kidding, kidding interval, percentage of kids born and weaned, abortion rate, body weight of kids at birth and at weaning, and the length of the goat's reproductive life. Due to the seasonality of reproduction and multiple possibilities of controlling the sexual cycle in goats (hormonal and non-hormonal methods), it is difficult to standardise parameters that could be systematically used to detect suboptimal production, and whose improvement would increase reproductive success. Adequate housing conditions and feeding are inseparable from good breeding and productivity of animals. By meeting these measures with constant observation of reproductive success parameters, high fertility, large litters (2 kids per pregnancy) with a survival rate of 90% until weaning can be expected in goat breeding.

Key words: *goats; kidding; fertility; birth weight; abortion*

Introduction

According to the last Croatian 2022 Annual Report for sheep, goat, and small animal breeding (Anonymous, 2023), the number of small ruminants during 2022 decreased. However, the 2020 Annual Report (Anonymous, 2021), showed an increasing five-year trend in the number of goats, but a decrease in the number of breeders, indicating an intensification of breeding. In the Republic of Croatia, the largest number of goats in the north-western parts of the country, in Međimurska County, with a dominance of the Alpine breed (Anonymous, 2023). According to Luo et al. (2019), dairy goats are a very successful form of livestock farming in

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developing countries, with functional products for human consumption (milk and dairy products, but also meat), which makes their breeding attractive. The success of goat breeding is defined by a good reproductive programme. Regardless of the mating method, natural breeding or the use of artificial insemination, certain management factors should be respected if good goat fertility is to be ensured. The basic condition is a good herd, from both the veterinary and reproductive point of view (Niyigena et al., 2022). In addition to a proper reproduction programme, adequate nutrition of the herd plays an important role, with a satisfactory intake of micro- and macroelements, adequate health care with an emphasis on regular maintenance of hooves and deworming. However, breeding efficiency is determined by successful reproductive parameters (Alemayehu et al., 2021). The seasonality of reproduction and the possibility of managing the sexual cycle by different methods (male effect, manipulation of the light regime, use of hormonal and non-hormonal methods of controlling the sexual cycle) provide diversity for displaying reproductive success in goat farming. However, the most widely used indicators of reproductive success are data on the number of kids born, age at first kidding, kidding interval, percentage of kids born and weaned, and abortion rate (Alemayehu et al., 2021), the body weight of kids at birth and at weaning, and the length of the goat's reproductive life (Greyling, 2010). Losses of kids are usually expressed as the percentage of stillbirths and the percentage of kids that die before weaning (Mellado et al., 2006; Song et al., 2006). This paper aims to give an overview of factors that are used as indicators of goat reproduction success and their influence on reproduction success.

Reproductive characteristics of goats

Goats are seasonally polyoestrous animals, with seasonality related to short days. The start and duration of the season depend on many variables. Both genetic and non-genetic parameters (Vlahek et al., 2023), such as the breed, climate, geographic latitude, photoperiod, physiological state of the individual, influence of the male, breeding system, and forage availability (Luo et al., 2019) influence season duration of goats. In the northern hemisphere, anoestrus occurs mostly during spring (April, May). The sexual cycle lasts 20-21 days, oestrus lasts 24-36 hours, with ovulation occurring near the end of oestrus (Mellado, 2016; Grizelj et al., 2022a, 2022b). Goats ovulate 1 to 3 oocytes during oestrus (Greyling, 2010; Luo et al., 2019). Pregnancy lasts 149 days (144-150.8 days), goats usually give birth to more than one kid, usually in the spring, when the availability of food is naturally highest, and the outside temperature is suitable.

Puberty onset, age, and size of the mother

In intensive breeding, goats should enter puberty at 7 months of age and kid for the first time at the age of 12-14 months, an ideal that must be accompanied by selection and adequate nutrition (Mellado, 2016). Most goats enter puberty at an early age of 6 to 8 months (Smith, 2007), and males should be separated from females at the age of five months (Shelton, 1978). However, photoperiod influences the onset of puberty, so individuals born later in the spring can enter puberty during the second year of life, i.e., when they enter the season for the second time. Individuals born earlier in the year

enter puberty in their first season, i.e., in autumn. The presence of males has a positive effect on the onset of puberty. Nanny does should not be allowed to breed until they reach a minimum of 60-70% of their adult weight (Mobini, 2000; Greyling, 2010; Clune et al., 2021). Premature breeding of later-born individuals results in a smaller body frame, which can affect the prolificacy of the individual during its life, reducing its productivity but also litter size. The relationship between the age of the dam and the birth weight of the foetus has been proven, and kids born from younger dams have a lower birth weight, which can lower resistance and have negative repercussions on the postpartum period of the kid (Gordon, 1997; Kenyon and Blair, 2014). Furthermore, too early introduction of does in breeding can lead to increased incidence of abortion and stillbirth. There are several possible reasons why nanny does miscarry during their first pregnancy. One of the reasons is an insufficiently developed immune system, which makes them more susceptible to infectious diseases that cause miscarriages (campylobacteriosis and toxoplasmosis). Perinatal deaths of kids are more common in litters of young and inexperienced mothers, most often primiparous ones (Nowak et al., 2000; Dwayer et al., 2015; Constable et al., 2017). Although mating later in life reduces the total reproductive potential, delaying reproduction, in terms of waiting until the mother is fully developed, has positive consequences, like increase in the percentage of conception, the frequency of multiple births and ensuring the survival of the kids (Greyling, 2010). However, even in older females, abortions or stillbirths can occur, especially in females over 7 years of age who have previously given birth regularly (Fernandez, 2014a). According to Mellado (2016),

more than 70% of the herd should consist of goats between the ages of 3 and 6, and all those that do not conceive during the season for various reasons (problems with the reproductive system, undernourished goats, goats with problems in maintaining body condition during pregnancy, or a tendency to abortion) should be culled.

Number of kids

Goats often give birth to twins or triplets rather than a single kid, though this depends on the breed (Robertson et al., 2020). The number of kids born depends on the number of ovulated oocytes, which differs between breeds, and is generally higher at the beginning than at the end of the season. Furthermore, factors influencing the number of ovulated oocytes include genotype, and the size, weight and body condition of the female (Greyling, 2010). Also, the number of ovulated oocytes can be influenced by hormonal and non-hormonal methods that improve fertility, including nutrition improvement, especially targeted. Namely, focused feeding has a positive impact on several aspects related to the fertility of both males and females, though in terms of the number of kids, the positive effect of feeding on increasing the number of kids in the litter is achieved by increasing the number of ovulated oocytes, decreasing embryonic mortality, increasing postnatal survival and development, and programming the future productivity of the foetus (Martin et al., 2004). The number of kids is directly related to the number of ovulated follicles, which is usually high, especially for individuals in good condition. On a scale from 1 to 5, the best condition for breeding is considered 3 (Sánchez-Dávila et al., 2014). Poor condition (2), negatively affects both the

number of kids born and the duration of the reproductive season, and influences occurrence of the irregular oestrous cycles (Rekik et al., 2014). However, focused feeding increases the ovulation rate in goats with poor body condition (Sánchez-Dávila et al., 2017). The use of the "flushing method" is known, where goats are given either energy-rich or protein-rich feed before the beginning and during the mating season, to positively influence the ovulation rate and consequent prolificacy (Sánchez-Dávila et al., 2014). It is also possible to enrich the feed for the first 10-15 days after mating, to improve the success of embryo implantation and consequently to reduce embryonic mortality. On the other hand, increased nutrition immediately after fertilisation can have a negative impact on the early development of the embryo, and therefore, these methods can only be used for a short time in a specific period of the reproductive process (Martin et al., 2004). Research has shown that goats with a body condition of 2 or less respond better to such nutritional enrichment. Namely, assessing and monitoring body condition is a good and simple way to monitor stored body fat reserves, especially in energy-demanding periods, in underfed individuals or during stressful periods. Body condition should be assessed one month before the planned start of the season (Mellado, 2016). A higher body condition score (3 or more) also has a poor effect on fertility, as it increases the risk of reduced milk production, and health and reproductive problems, such as difficult births and fatty liver.

Insufficient nutrition of the mother has an impact on the development of the foetus, which is sometimes manifested later during postnatal life, even after sexual maturity; this is called foetal programming. Martin et al. (2004) summarised possible consequences of insufficient nutrition of the mother during pregnancy, especially from 60 to 120 days, including the consequences on insufficient meat quality (McCoard et al., 1997; Greenwood et al., 2000), slower oocyte development in female foetuses (Borwick et al., 1997; Rae et al., 2001) and the reduction of life-long reproductive capacity (Rhind et al., 1998). The long-term effect on prenatal ovaries is questionable, because if it exists, this implies the possibility of limiting the ovulation rate later during life (Martin et al., 2004). Paradoxically, according to Hales and Barker (1992), poorer nutrition of mothers allows foetuses to better prepare and survive postnatally in conditions of reduced nutrition, which should not happen in controlled breeding systems.

It should be considered that the increase in the potential for the birth of a larger number of offspring must be accompanied by the improvement of zoohygiene measures and conditions that will ensure the survival of an increased number of kids (Martin et al., 2004).

In goats, a nearly 100% conception rate is expected (Diskin and Morris, 2008; Robertson et al., 2020), depending on the season, nutrition, age and breed of goats. Matings out of season result in a suboptimal conception rate (Restall, 1992).

Embryonic and foetal mortality

In goats, embryonic mortality can cause significant problem, though not as much as in sheep, with the usual percentages of 18% for embryonic deaths in double and 40% in triple and more ovulations (Diskin and Morris, 2008). Most often, pregnancy loss is the result of insufficient nutrition, especially in the later stages of pregnancy, and amounts to 53% (Urru-

tia-Morales et al., 2012) and 70% (Mellado et al., 2004) of pregnancy losses. Also, a poor body condition score during mating increases losses to 20% in goats with a body condition score of 2, compared to up to 7% of foetal deaths in goats with a body condition of 3 at the time of mating (Mellado et al., 2004).

Abortions

Goats are corpus luteum-dependent animals for pregnancy maintenance. Therefore, any factor that threatens the survival of the corpus luteum represents a potential threat for termination of the pregnancy (Heath et al., 2007). The causes of abortion are generally divided into infectious and non-infectious ones, and in the case of non-infectious, environmental causes are often those that can be improved (or whose effect can be reduced) by good animal hygiene measures. These are primarily extreme weather conditions (temperature, rainfall, wind), ingestion of toxic plants, predators, and other causes of stress. Most abortions due to stress occur between 90 and 110 days of pregnancy (Shelton, 1978). The cause of non-infectious abortions of other aetiologies is often unknown and it is mainly a question of a toxic effect on the foetus or a deficiency of substances important for the proper foetal growth (Edmondson and Shipley, 2021). Inadequate nutrition can cause miscarriages with an incidence of over 50% (Mellado, 2016). Abortions of infectious aetiology can be divided into bacterial, viral, protozoal or mycoplasma origin (Edmondson and Shipley, 2021). The most common bacterial causative agents are *Brucella* spp., *Campylobacter* spp., *Chlamydophila* spp., *Francisella tularensis*, *Leptospira* spp., *Listeria monocytogenes*, *Listeria ivanovii*, *Salmonella spp.*. The most important viral agents are goat herpesvirus 1, bluetongue, bovine viral diarrhoea virus, Cache Valley virus, Rift Valley virus, Akabane virus and Nairobi virus. *Coxiella brunetti* is the causative agent of Q-fever, which causes abortion in small ruminants, and toxoplasmosis, sarcocystosis, and neosporosis is a protozoal infection that results in abortion in small ruminants (Chase *et al.*, 2017). Compared to other farm animals, both goats and sheep, have a more frequent occurrence of abortions, and a frequency of up to 5% per year is considered normal, less than 5% good and less than 2% an excellent result (Tempesta et al., 2004; Menzies and Miller, 2007; Givens and Marley, 2008).

Birth weight, perinatal deaths, and the number of weaned kids

Birth weight is an important factor that influences the survival of kids. Although kids with a larger birth body weight are preferred, that weight can have a negative consequence because it predisposes the animal to dystocia if the kid is too large for the birth canal. On the other hand, kids with a lower body weight in the postpartum period have a reduced chance of survival due to a reduced reserve of fat tissue and ensuing problems of sufficient thermoregulation (Fernandez, 2014b). Birth weight is determined by nutrition, the genetic characteristics of the mother, and litter size, which is also determined by the genetic characteristics of the mother. Research has shown a direct connection between the birth weight of kids and the condition and nutrition of the mother in the last third of pregnancy, but also with perinatal deaths (McCoard et al., 2017). Low birth weight is thus one of the most significant reasons of deaths in the perinatal period. In addition to

birth weight, the number of kids in the litter, the sex of the kid and its behaviour are also significant (Dwayer et al., 2015; Constable et al., 2017). Kids born weighing 3 kg or more have a higher chance of survival.

Kids with a higher birth weight have enough energy to maintain body temperature and will get up easier to start suckling. Kids with a lower birth weight are more prone to starvation and hypothermia. Furthermore, kids with a lower birth weight, and those that were lighter on the 25th day of life, were 20 % less likely to conceive as adults, suggesting a long-term genetic or nutritional effect (Mellado et al., 2016). With multiple litters, there is a lower chance of kid survival, given that they have smaller birth weights, with less brown fat tissue, and the distribution of colostrum is uneven. Therefore, in multiple litters, the first month of life is considered critical (Fernandez, 2014a; Fernandez, 2014b; Manirakiza et al., 2020). Perinatal diseases can cause large losses in goat farming. It is estimated that 10–30% of small ruminant offspring dies before weaning, and almost half of these deaths occur on the day of birth. However, the proportion of deaths depends on the way the farm is run and how the herd is kept, and on well-managed farms, only 5 to 10% of all perinatal deaths account for that part (Constable et al., 2017). In addition to late abortions and stillbirths caused by dystocia, the causes of perinatal deaths are also infectious diseases, and other relatively minor causes such as congenital malformations, predators, and accidents (Dwayer et al., 2015).

Considering the care that kids receive in intensive breeding, the number of deaths from birth to weaning is relatively small, and it is realistic to expect that 90% of kids will be weaned from their mothers (Mellado, 2016). A higher percentage of deaths is expected in larger litters, so litters with one kid have a mortality up to 17%, twins up to 13 to 18%, and triplets from 18 to 83% (Lehloenya et al., 2005; Snyman 2010; Aldridge et al., 2015; Nogueira et al., 2016; Robertson, 2020). Most deaths are related to the early perinatal period, within a few days after birth, although later deaths are also possible due to illness. The most common causes are either dystocia or starvation due to a poor connection with the mother (Roberson et al., 2020).

Conclusion

The factors that most affect the profitability of goat farming are the success of reproduction and productivity. Due to the seasonality and multiple possibilities of controlling the sexual cycle, it is difficult to standardise parameters that could be systematically used to detect suboptimal production, and whose improvement would increase reproductive success. Adequate housing conditions and feeding are inseparable from good breeding and productivity of animals. By meeting these measures, high fertility, large litters (2 kids per pregnancy) with a survival rate of 90% until weaning can be expected in goat breeding.

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Ključne riječi: *koze, jarenje, plodnost, porođajna težina, pobačaj*