Chapter 12

Problems and Advanced Techniques in Herd Management Practices in Small Ruminants

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Abstract

Small ruminant farming, particularly through sheep and goat breeds, plays a strategic role in rural development, food security, and sustainable animal production. This production model offers advantages such as biodiversity conservation, low input requirements, adaptability to challenging environmental conditions, and support for economic and ecological sustainability, particularly in mountainous and semi-arid regions. However, multiple structural and technical problems observed in its field negatively impact the sector's productivity and animal welfare. Ineffective utilization of genetic resources, inadequate breeding programs aimed at protecting and improving native breeds, seasonal fluctuations in feed supply, and a lack of quality forage increase production costs and limit animal performance. Furthermore, regional inequalities in health services make early diagnosis and control of diseases difficult, and substandard housing conditions threaten animal welfare and production sustainability. In addition to these problems, limited access to information by breeders, lack of technical training, and climatic variability reduce the sector's adaptive capacity.

Climate change is another critical factor directly impacting small ruminant farming. Rising temperatures, depleting water resources, and pasture degradation threaten both forage production and animal health. In this context, protecting indigenous breeds resilient to environmental stressors and developing climate adaptation strategies are vital for the future of the sector. Significant challenges also exist in terms of marketing and the value

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chain. Producers struggle to deliver their products directly to the market and earn low incomes in a system dominated by intermediaries. Effective cooperatives, the use of digital marketing tools, and local branding strategies are among the potential solutions that can increase producers' incomes. Finally, digitalization and data-based management systems have the potential to increase productivity in small ruminant farming. Innovative approaches such as animal tracking systems, health and production monitoring through mobile applications, and artificial intelligence-supported decision-making mechanisms both guide breeders and facilitate the production of scientific data. This study aims to develop sustainable and innovative solutions by addressing the current problems of small ruminant farming with a multidimensional approach. Improvements at both the technical and socioeconomic levels will ensure the sector achieves a resilient and competitive structure.

1. Introduction

Herd management is the proper execution of all animal husbandry-related tasks to create a healthy and long-lived herd. Housing animals in an environment that meets their natural behavioral needs, providing a balanced diet, ensuring access to clean and adequate water, combating diseases and pests, and timely and correct intervention are the most important factors affecting animal health and productivity. The goal of herd management is to ensure that all tasks related to animal husbandry are carried out in a timely and orderly manner. A profitable livestock enterprise is only possible through herd management. Increasing production efficiency is one of the most important concepts that contribute to competitive advantage. Consequently, agricultural enterprises engaged in livestock farming must focus on modern and professional husbandry.

Achieving good and high-quality yields in sheep and goat farming operations, as well as the continuation of the herd, depends on well-organized herd management. The concept of herd management refers to maximizing the income generated by a sheep-goat enterprise and all practices that will or should be implemented regarding the herd.

Herd management practices involve the following processes: first, all operations within the farm are defined. Second, decisions are made and implemented. Then, the farm's development is monitored, and finally, future plans are made (Öz and Bilgen, 2002). The primary goal of herd management is to manage the flock professionally, taking into account the comfort and well-being of the animals raised. Regardless of the number of animals in these farms, information on various yields obtained from these animals is collected and evaluated according to their purpose, and decisions are made and implemented for the farm. This cycle continues, repeating itself annually. The decisions of the herd management manager regarding goals, resource allocation, planning, implementation, evaluation, and review will determine the success of the farm (Göncü, 2023).

The systematic use of herd management practices minimizes the physical and psychological burden on the farmer, increases the farm's success, reduces risks, ensures the most efficient use of farm resources, ensures the highest level of adaptation of all input elements to the needs of the animals, provides human support in herd management and early diagnosis of diseases, minimizes medication use through early diagnosis and preventative measures, maximizes the use of individual animals' potential (Bergfeld, 2006; Bewley, 2008), utilizes more reliable data in animal selection, generates herd projections, and enables more accurate planning for future periods. This study aims to highlight the challenges encountered in herd management practices in small ruminants and highlights the importance of these issues.

2. Genetics and Breed Selection

Genetic diversity in small ruminant farming is crucial for the continuity of animal food production and the preservation of biodiversity. One of the most effective strategies for protecting small ruminant genetic resources is the "conservation through use" approach. Rational utilization of indigenous breeds that demonstrate high adaptability to local environmental conditions significantly contributes to both strengthening food security and the environmental sustainability of agricultural production. The use of these breeds reduces dependence on external inputs, enabling the establishment of lower-cost production systems, particularly in terms of feed supply and health management. Therefore, the integration of indigenous genetic resources into production systems has the potential to increase the economic profitability of small-scale livestock enterprises (Kosgey et al., 2006). Intra-breed selection is a selection strategy frequently employed in genetic improvement programs and applied within a given population. This method aims to increase the average genetic merit (genetic merit) of a population by assessing phenotypic and genetic variation among individuals within the same breed. Intra-breed selection practices are often based on measurements and evaluations of production traits (e.g., milk yield, growth rate, reproductive performance) and contribute to sustainable genetic progress (Kosgey et al., 2006). Lack of knowledge and widespread record keeping among small ruminant breeders are among the factors that complicate selection practices. Farm size can influence the acceptance of selection practices. It is hoped that assessing the socio-economic status of small ruminant breeders in the implementation of breeding programs will influence their success (Kosgey et al., 2006).

2.1. Breeding Stock and Inbreeding

In small ruminant farming, breeding stock is sourced from within the herd, neighboring herds, or markets. Prolonged use of breeding stock within the herd can lead to problems stemming from inbreeding. Controlling breeding stock use and monitoring the duration of breeding stock within the herd are important for ensuring the sustainability of small ruminant farming. Problems arising from inbreeding are more common in small herds (Kosgey et al., 2006). In a study aimed at defining the population structure of Romanov sheep raised in the Czech Republic and assessing the impact of inbreeding on offspring production, the average inbreeding coefficient was 5.5% and the annual inbreeding rate was 1%. The same study reported a decrease in genetic diversity and the emergence of inbreeding depression (Vostry et al., 2018). This suggests that genetic variation will continue to decline unless changes are made to current breeding strategies. In a separate study, inbreeding levels and genetic diversity trends in six different purebred sheep breeds (Belclare, Charollais, Galway, Suffolk, Texel, and Vendeen) were analyzed to guide breeding programs. Based on pedigree data from a total of 472,612 individuals, the analysis revealed effective population sizes ranging from 116.0 (Belclare) to 314.8 (Charollais). The Charollais population has the highest genetic diversity, with the largest number of effective founders, effective ancestors, and effective founder genomes, while the Belclare population has the lowest values for these parameters, representing the most limited genetic diversity. Inbreeding has been reported to increase between 0.05% (Charollais) and 0.17% (Belclare) per year (Rafter et al., 2022). It has been stated that current breeding strategies are generally sufficient to maintain genetic diversity, but monitoring and intervention are still necessary, particularly for low-diversity populations (Rafter et al., 2022). Monitoring these parameters is critical, as a decrease in genetic diversity can have negative effects on both sustainable genetic progress and performance (inbreeding depression) (Bahrami et al., 2020; Cortellari et al., 2022).

3. Feeding and Feed Management

Livestock production occurs in a variety of system types, which can vary greatly. Some systems are pastoral or pasture-based, while others exist in more intensive systems where livestock can be raised on smaller plots (Herrero et al., 2012). One of the biggest challenges in these livestock systems is the high cost of animal feed. Feed costs in livestock production systems have been reported to account for up to 70% of total costs (Alqaisi et al., 2017). This significant financial burden highlights the need for more sustainable approaches to livestock production. A promising solution lies in the availability of grazing land, which offers farmers the opportunity to develop extensive livestock production. By utilizing grazing pastures, farmers can reduce their reliance on purchased feed for livestock production. Furthermore, improving livestock productivity without using additional land can be achieved through improved grazing management and pasture production practices (Thornton et al., 2010; Webb and Erasmus, 2013). Consequently, understanding the economics of various grazing management and pasture production strategies is important, particularly as their feasibility can vary significantly depending on the costs associated with implementation (Godfray et al., 2010). Furthermore, techniques such as cultivated pastures and effective grazing management systems can help reduce feed costs on farms.

In an era of high-cost inputs, pasture-based livestock production systems offer an effective way to maintain soil and plant integrity while promoting ruminant growth. In recent years, significant research has focused on the interactions between ruminants and pasture vegetation (Dickhoefer et al., 2010; Ogel and Gul, 2018). Rangeland productivity is typically assessed by measuring animal yield per acre or per capita during the grazing season. This productivity reflects the combined effects of forage growth and the efficiency with which animals convert forage into animal products. Investments in rangelands have primarily aimed to increase livestock production by increasing forage availability and grazing area (DelCurto et al., 2023). Pasture rental, feed costs, and insufficient grazing are among the problems seen (Ogel and Gul, 2018; Tüfekci, 2020; Acıbuca and Bostan Budak, 2021; Tozlu Çelik and Tüfekci, 2024).

3.1. Different Physiological Periods

The proper development of the fetus and newborn lambs and kids in the womb requires adequate transport of nutrients to the placenta and mammary gland. Approximately two-thirds of a developing fetus's birth weight is gained in the last six weeks of gestation. Therefore, a balanced diet in late pregnancy is crucial for fetal development and survival at birth. The diet must contain sufficient energy and protein, which influence the development of pregnant sheep, embryonic and fetal growth, the maintenance of metabolic processes, mammary gland growth, colostrum, and milk production. Adequate transport of nutrients to tissues also affects fetal ovarian development, postnatal growth, reproductive performance, and metabolism (Mahoub et al., 2013).

The nutrition of sheep and goats from pregnancy to birth is known to be a crucial factor in the health and survival of lambs (Hinch and Brien 2014; Rooke et al., 2015). Nutrition in sheep and goats directly affects birth weight, milk yield, the establishment of the mother-offspring bond, postpartum lamb growth, and sheep mortality. Rooke et al. (2015) reported that maternal malnutrition during the last third of pregnancy is critical, with maternal malnutrition affecting calf birth weight and survival rate from weaning to 50-85%. It has been reported that the nutrition of small ruminants during the breeding season also affects the physiology and behavior of lambs and kids (Kleemann et al., 1993). It has been reported that undernourished animals during this period give birth to smaller, less active lambs and kids.

Other side effects of undernourishment in sheep and goats include decreased udder development and decreased colostrum production and quality. Feeding supplements during mid- or late pregnancy can be used to reduce calf mortality by increasing lamb and kid birth weight, colostrum, and milk production. Furthermore, feeding sheep and goats throughout pregnancy affects maternal behavior at birth. Undernourished animals take longer to interact with their calves, exhibit more aggression, spend less time licking their calves, and spend more time feeding after birth (Nowak and Poindron, 2006).

Seasonal feed resource inadequacy leads to feeding problems, especially during dry periods. Lack of knowledge about ration preparation leads to unbalanced nutrition and production losses. Incorrect ration preparation and seasonal feed shortages in small ruminants reduce production performance. Roughage availability is a critical issue, especially during droughts.

4. Health and Disease Control

Parasitic infections, zoonotic diseases, and epidemics remain a widespread problem. Inadequate preventive veterinary services make early diagnosis and intervention difficult. Parasitic infections and zoonotic diseases are widely reported in small ruminants (Tüfekci, 2020). Regional inequalities in veterinary services make early diagnosis and treatment difficult. Irregular vaccinations and errors in medication use threaten herd health (Yıldız and Aygün, 2021).

Selecting genetically resistant animals is a more reliable option among sustainable parasite control strategies and can yield results when integrated with other strategies such as grazing management and anthelmintic applications (Zvinorova et al., 2016). A study in Ethiopia demonstrated that veterinary and genetic improvement interventions significantly increased the number of sheep and goats offered to market by smallholders. Producers utilizing community-based veterinary services achieved higher economic returns per animal; it was determined that they reached higher levels in terms of purchasing power, annual income, and earnings per animal unit. In the same study, producers participating in the Community-Based Improvement Program were able to offer a higher number of small ruminants to the market and demonstrated a more advantageous economic performance in terms of total income (Kassie et al., 2021). In livestock farms in Greece, quarantine practices, feed analysis, the use of ultrasound for pregnancy control, and the frequency of veterinarian visits were positively correlated with milk production, milk protein content, and calf number (Lianou and Fthenakis, 2021). A study conducted in Nigeria indicated that health management practices were at a low level (Kalu et al., 2021). As awareness of health practices has increased, the number of practices to be implemented in this direction has increased in recent years (Tozlu Çelik and Tüfekci, 2024). In addition to increasing the accessibility of vaccines, encouraging activities to raise public awareness is of vital importance for the effectiveness of strategies for disease prevention and control at the national level (Tüfekci, 2020; Win et al., 2021).

5. Shelter and Management Conditions

Inadequate shelters in terms of hygiene, ventilation, and space requirements reduce animal welfare. The lack of modernization of herd management techniques reduces labor productivity. The inadequacy of shelters, particularly the lack of humidity and temperature control, is among the primary factors negatively impacting animal welfare. Compared to farming practices in Europe and America, the need for modernization of shelter systems in Turkey becomes evident. It has been determined that adobe pen structures constitute the majority (Yıldız and Aygün, 2021).

Housing conditions are a key parameter affecting the survival of newborn calves in small ruminant farming (Pritchard et al., 2021). Studies have indicated that shelter conditions are inadequate and primitive (Ogel and Gul, 2018). However, in recent years, shelters have been equipped with windows necessary for ventilation and light (Tüfekci, 2020).

Community-Based Breeding Programs (CBBPs) have emerged as a sustainable and participatory approach to breeding indigenous livestock on smallholder farms. Goat CBBP models implemented in Malawi and Uganda demonstrate the potential to achieve the dual objectives of conserving and improving local genetic resources and supporting rural livelihoods. These programs promote and strengthen smallholders' access to feed resources for small ruminants through the sustainable management of existing communal pastures, increasing feed production capacity, and effectively utilizing agricultural residues and by-products (Kaumbata et al., 2021). Housing conditions need to be updated to meet changing climate conditions. Some of the practices that address climate change include ventilation, fans, and cooling devices in the shelters.

6. Access to Education and Information

A study conducted in Malaysia found that the majority of farmers were between 40 and 50 years of age (23.5%). The majority of farmers were male (92.8%), while the female rate was 7.2%. A significant portion of farmers were educated, with 36% having less than five years of professional experience. However, a small proportion of participants (1.2%) exhibited insufficient literacy (Melissa et al., 2016). A recent study reported that 67% of small ruminant farmers in Malaysia were between 21 and 40 years old, and the majority were male (Mazlan et al., 2023). In Nigeria, 68.7% of farmers were between 31 and 50 years of age, and 96.0% were literate (Adetarami et al., 2020). The average age of farmers participating in the study in Şırnak was 49.98. Of the participants, 75.78% were only literate, 23.44% were primary school graduates, and 0.78% were high school graduates. The average professional experience in goat farming was 13.32 years, while this figure was 13.37 years in sheep farming. Access to information and communication technologies was generally low; while all farmers owned a mobile phone, only 31.25% had a computer, and 21.88% had internet access (Ogel and Gul, 2018). In Karaman province, 61.9% of farmers were between the ages of 41 and 55, and primary school graduates constituted the majority (63.5%) (Demirbük, 2021). Various literatures indicate that breeders are, on average, 40 years old or older, and the majority are male (Tüfekci, 2020; Acıbuca and Bostan Budak, 2021; Yıldız and Aygün, 2021; Lianou and Fthenakis, 2021; Kalu et al., 2021; Tozlu Çelik and Tüfekci, 2024).

Breeders' lack of technical knowledge prevents scientific practices from being implemented in the field. Limited extension activities hinder knowledge transfer and the adoption of innovations. Lack of knowledge in small ruminant farming is one of the main causes of application errors. Limited extension activities hinder the transfer of scientific knowledge to the field. Access to and acceptance of information is influenced by breeders' age, region, educational status, and economic opportunities.

7. Climate and Environmental Factors

Environmental stress factors such as extreme heat, humidity, and drought reduce production performance, particularly in breeds with low adaptability. Overgrazing and erosion of pastures threaten sustainable forage supply. In migratory livestock farming, climate variability challenges the adaptability of animals. Extreme heat and drought, in particular, complicate herd management. Overgrazing and erosion of pastures threaten the sustainability of forage resources.

As part of agricultural adaptation strategies for climate change, the use of concentrated feed, promotion of forage crop production, increasing diversity in production patterns, and breeding breeds more resilient to environmental stressors such as disease and drought stand out as key practices. However, the most significant obstacle to climate change adaptation has been identified as a lack of knowledge. Regular communication of climatic impacts on agricultural production and possible future scenarios to producers should be made possible through planned training activities in this context (Demirbük, 2021; Kaygısız et al., 2023). Importance should be given to providing awareness training to growers regarding climate change and to dissemination activities through the media.

8. Adoption of New Technologies

The potential for integrating precision animal husbandry (HH) technologies into dairy sheep farming systems, particularly those commonly implemented in the Mediterranean region, has been examined. Mediterranean countries (France, Italy, Greece, and Spain) account for approximately 40% of global sheep milk production, and dairy sheep farming is an important production model in these regions, both culturally and economically. In developed countries in the region, dairy sheep farming has evolved into highly specialized systems through improved animal breeding, increased feeding strategies, and increased production intensity. However, extensive systems remain important due to their low input costs and resilience to market fluctuations. HH technologies include components such as electronic identification systems (ear tags, rumen bolus, subcutaneous RFID), on-animal sensors (accelerometers, GPS, activity monitors), and stationary management systems (weight measuring devices, automatic drafting machines, virtual fences, and milking technologies). The suitability of these technologies for integration into widespread dairy sheep production systems has been evaluated. However, adoption of these technologies in small and medium-sized farms remains limited. The high average age of breeders, conservative attitudes toward technological change, limited financial resources, and a low risk-taking tendency are among the main factors slowing this process. However, global trends such as global warming, animal welfare, antibiotic resistance, and changes in European Union agricultural policies are increasing the importance of HH technologies and creating an environment that could encourage their wider adoption in the future. Consequently, the adoption of HH technologies in dairy sheep farming offers significant opportunities in terms of production efficiency, animal welfare, and sustainability. The dissemination of these technologies requires overcoming socioeconomic barriers and developing targeted support policies (Odintsov Vaintrub et al., 2021).

To collect baseline data from New Zealand sheep farmers on lamb tail docking and castration techniques, their perceptions of the level of pain experienced by lambs after these procedures, and their views on the use of analgesia. Methods: Descriptive statistics for quantitative study variables were provided from a cross-sectional survey of New Zealand sheep farmers administered to volunteers. Thematic analysis was conducted using free-text comments. Univariate logistic regression was used to assess factors associated with farmers indicating they would consider using a device that allows analgesia simultaneously with castration and tail docking. Results: There were 432 survey responses with sufficient data for analysis. Of the 340 (77.5%) who always or sometimes castrated ram lambs, 242 (72.2%) used a rubber ring for complete castration, 23 (6.9%) used the short scrotum method for cryptorchid castration, and 75 (22.4%) used a combination of both methods. Of the 423 (97.9%) respondents who reported always or sometimes performing tail docking, 245 (57.9%) used only a hot iron, 148 (35.0%) used only a rubber ring, 26 (5.8%) used both methods, 3 (0.7%) used a surgical blade, and 1 (0.2%) did not provide any response. Less than 2% of respondents always or sometimes used painkillers for these procedures. Of the 432 respondents, 139 (32.2%) and 180 (41.7%) strongly agreed that castration and tail docking, respectively, did not cause enough pain to warrant the use of painkillers. Time and cost were identified as the biggest barriers to providing painkillers. In unadjusted logistic regression analyses, participants who were female, had a higher level of education, had been farming for less than 20 years, believed lambs experienced high levels of pain after the procedures, and believed the pain lasted longer than 6 hours were more likely to express a desire to use pain control devices. Conclusion and clinical relevance: Our findings suggest that very few sheep farmers in New

Zealand provide pain relief to lambs after tail docking or castration. This is likely due to the perception that the procedures are not painful enough to warrant pain relief and to concerns about time and cost. This highlights the need for farmers to be educated about lamb pain and distress after tail docking and castration and the negative impact this can have on animal welfare. Farmers also need pain relief techniques and devices that can be applied simultaneously with these procedures to save time and labor costs (Kongara et al., 2023).

9. Marketing Products

It is crucial that animal products are transported from production areas to the market and safely transferred from producer to consumer. Products derived from small ruminants, in particular, are highly valuable. Due to the increasing demand for natural products in recent years, they must be marketed at a value price.

Small ruminant farming contributes significantly to the rural economy through the production of various animal products, such as meat, milk, wool, and leather. However, despite the strategic importance of marketing these products, the process of marketing them still faces numerous structural problems in Turkey. Disorganized production structures, lack of organization, inadequate marketing channels, and price instability are among the main obstacles directly impacting producers' incomes. Furthermore, the lack of product standardization in line with consumer demands and the lack of branding limit the competitiveness of small ruminant products. In this context, addressing marketing issues from a multifaceted perspective is a critical necessity for both improving producer welfare and the sustainability of the sector.

A study conducted in Şırnak province identified insufficient use of mass media channels. It has been reported that private veterinarians, veterinary consultants, and other breeders are the primary sources of information on sheep farming and marketing. It has been noted that breeders in this region are unable to market their products at value (Ogel and Gul, 2018). Producers struggle to deliver their products directly to the market and earn low incomes in a system dominated by intermediaries. Effective cooperatives, the use of digital marketing tools, and local branding strategies are among the potential solutions that can increase producers' incomes.

10. The Problem of Finding Shepherds

Small ruminant farming plays a critical role in economic sustainability and food security, especially in rural areas. However, this sector has faced serious challenges in accessing a qualified workforce in recent years. The availability of shepherds, in particular, has become one of the main problems directly affecting the continuity of the production process and animal welfare. The aging rural population, the shift of young people to non-agricultural sectors, and the perceived unattractiveness of shepherding due to social status are exacerbating this problem. In this context, examining the effects of a lack of shepherds on small ruminant farming is crucial for increasing sectoral productivity and developing sustainable livestock policies. Various studies have indicated that small ruminant farmers face difficulties finding shepherds (Ogel and Gul, 2018; Tüfekci, 2020; Acıbuca and Bostan Budak, 2021; Yıldız and Aygün, 2021; Tozlu Çelik and Tüfekci, 2024). To ensure the sustainability of small ruminant farming, problems must be addressed not only from a technical perspective but also from a socio-economic perspective. Active participation of farmers in decision-making processes, leveraging local knowledge, and integrating young people into the sector are critical to sustainable production. Difficulties in recruiting shepherds, in particular, directly impact both workforce continuity and animal welfare.

11. Advanced Technology Applications

Manually tracking livestock data is both time-consuming and insecure. This highlights the need for electronically based livestock management systems to quickly and accurately record and back up data and to make future decisions by leveraging previous data when necessary (Tsipis et al., 2022; Ariff et al., 2014).

Flock management in livestock farms is complex, requiring technical knowledge, ensuring animal health and welfare, ensuring quality and product safety, monitoring worker productivity and health, carefully evaluating various data sources within its own logic, and requiring a professional approach to making sound decisions. Therefore, herd management systems, automation, and artificial intelligence applications have gradually begun to be used in livestock farms. These applications are of great importance because they form a never-ending cycle for the continuity and profitability of production in the short and long term (Kopuzlu, 2023). Although farm management may show some differences on a country and regional basis, considering that it serves within a global economic structure, it must know and follow what is happening in different parts of the world, both locally and globally, sectorally. In such farms, every process, from herd management and insemination matching to heat stress and manure management, from udder health to estrus and fertility monitoring, and from animal behavior to animal selection, is carried out digitally. In modern animal husbandry, all types of data related to productivity, behavior, and disease are collected. Electronic identification devices (IRFDs) attached to the ears, ankles, and necks of animals, along with sensors and cameras, record their rumination count, movements, estrus, live weight, calving times, lying and standing times, the amount of factory feed consumed, body condition scores, milk yield and characteristics, length of time spent in the feedlot, body temperature, and many other parameters digitally (Kopuzlu, 2023).

Herd management can transition from a group-level approach to individual-focused herd management thanks to technological applications (Bewley, 2008). Technological applications in herd management allow for the effective use of automatic animal identification, detection, measurement, and information processing technologies to continuously monitor the production process, achieving optimal results in profitability, health, quality, product safety, animal protection, and environmental protection. These systems aim to increase the effectiveness of the production control process and, by doing so, positively impact the management of yield, quality, feeding, health, and reproduction within the farm (Uzmay et al., 2010).

Within the herd management system, records are kept for animals' birth and various life-cycle weights, productivity traits, various health-related data, daily feeding principles, and information on various environmental impacts. These records allow for the creation of a herd projection encompassing health practices, feed supply, feeding programs, animal breeding programs, quality milk production, monitoring worker performance, and operating income and expenses to ensure the continuity of a productive and healthy herd in the future. These systems not only save on labor but also minimize human errors.

Barcodes and tags, found on suitable low-frequency RFID (Radio Frequency Identification) devices, are used for animal tracking and ensure the most efficient and effective tracking. Using RFID antennas, reader modules, and tag technologies, animals are quickly and securely identified. Furthermore, this allows for automated data collection. RFID tags are divided into three groups based on their functions: active, passive, and semi-active (Doğan et al., 2016). Active tags communicate via a built-in battery. They offer excellent reading range but are expensive. Therefore, they are used for identifying and tracking expensive items (Domdouzis et al., 2007). Passive tags lack a power source. Therefore, they derive the necessary energy from readers. The reader sends a radio signal to the antenna. The tag receives this signal via the antennas, providing the power needed to operate the chip. In other words, the tag uses the energy from the signal to perform its function. The communication range is relatively short. They can be used in many systems due to their cost-effectiveness (Roberts, 2006). Semi-active tags, on the other hand, have their own power source, but this source is used only to power the chip. Like passive tags, they can read via electromagnetic fields emitted from the reader, but they cannot broadcast like active tags (Karaca, 2010). If the sole purpose is animal identification or tracking, passive tags are sufficient. However, if sensor-based applications are desired, active or semi-active tags must be used (Chandrud et al., 2008). RFID tags can be injected into the body. Rumen-type tags are more sensitive to external factors but have a relatively more complex structure (Hong, 2012). There is a possibility that injected tags may become contaminated with animal products after slaughter. Alternative electronic tags have been designed to mitigate this risk (Doğan et al., 2016). These tags, called rumen bolus tags, can be made of ceramic or steel (Fallon, 2001). Numerous studies by Hong (2012) and Varese et al. (2008) have demonstrated the superior properties of rumen bolus tags over other tags. Additionally, RFID systems have some drawbacks, such as mechanical damage, environmental damage from dust and extreme heat or cold, difficulty reading tags over time, and problems arising from the effects of other electronic devices in the environment (Mennecke and Townsend, 2005).

Herd management in small ruminants is a complex process that requires coping with challenges such as climate change, antimicrobial resistance, and pathogen control. While traditional methods are valuable for parasite management and disease diagnosis, the integration of modern technologies can provide significant improvements in this process. Innovative tools such as new sensor technologies and smart monitoring systems offer significant opportunities to improve herd health and welfare. These technologies have the potential to increase productivity through applications such as early disease detection, determination of thermal stress through temperature measurements, and monitoring animal behavior. However, the dissemination of these innovations is limited by barriers such as cost and difficulty in collecting accurate data. Providing small ruminant producers with access to these new technologies is critical for the adoption of animal welfare practices and improving overall production efficiency (Tüfekci and Tozlu Çelik, 2024). The effective adoption of a technology in agricultural production systems depends primarily on its compatibility with the needs of farmers and existing production conditions. In this context, proposed technologies should be relatively simple, economically accessible, and present low risks during implementation. The success of breeding programs depends not only on technical parameters but also on a holistic approach to evaluating the production system and integrating producers' traditional knowledge, behaviors, and value systems into the process. Active participation of producers in the planning, implementation, and evaluation of breeding programs increases their sustainability and acceptability. However, as with all innovative initiatives, the possibility of failure in animal breeding programs must be considered. Rather than operating with unrealistic expectations of success, accepting a certain level of failure as a natural part of the development process allows for the development of more flexible and adaptable strategies that support long-term progress (Kosgey et al., 2006).

As a result, the use of innovative technologies in animal production will contribute to animal health and welfare while also contributing significantly to the economic sustainability of animal production through its long-term cost-reducing effect as a result of obtaining more efficient and higher-quality animal products.

12. Conclusion and Recommendations

Small ruminant farming is a production area that provides animal food and income. Identifying the problems faced by small ruminant farmers and developing solutions is crucial for the sustainability of small ruminant farming and ensuring the safe production of the resulting food. Small ruminant farming is a widespread practice in various parts of the world. To address these challenges, training should be provided to farmers to facilitate their needs and adapt to innovations. Planning should consider genetic diversity, regional production areas, herd sizes, and the farmers' opinions when setting short-, medium-, and long-term goals. Evaluating the support provided to small ruminant farmers by considering regional conditions and socioeconomic structures is crucial for sustainability.

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