**Genetic Characteristics and Improvement Strategies of Awassi and Assaf Sheep Farming in Palestine**

1. **Introduction**

The genetic improvement of Awassi and Assaf sheep farming in Palestine is critical for enhancing agricultural productivity and promoting economic resilience and sustainability. Agriculture plays a significant role in Palestinian livelihoods, contributing approximately 7% to the gross domestic product and providing employment for 13.4% of the labor force (Agricultural Statistics, 2018/2019). In this context, sheep farming is particularly vital, representing a notable segment of agricultural revenue and contributing to food security (Food and Agriculture Organization, 2023). The Awassi and Assaf breeds, which are well-suited to the region's semi-arid climate, are integral to this sector due to their resilience, high fertility rates, and substantial milk production capabilities (Salman et al., 2024a). While genetic strategies aimed at improving traits such as growth rates, milk yield, and disease resistance show theoretical promise (Molotsi et al., 2017), empirical evidence from localized breeding programs in Palestine remains limited, thereby weakening assertions regarding their immediate impact. Furthermore, improvements in farm management practices and enhanced community support can significantly strengthen the resilience of sheep farming operations (Khalil et al., 2016).

However, socio-economic barriers, including fragmented land ownership, limited access to veterinary services, and fluctuating fodder prices, present significant challenges that must be addressed in future literature. A comprehensive examination of the socio-economic challenges confronting farmers, along with potential solutions, would enhance the practical applicability of genetic improvement. These barriers are crucial for contextualizing the feasibility of genetic strategies. By implementing effective breeding programs and deploying advanced genetic techniques, Palestinian farmers can enhance their livestock management practices, thereby improving livelihoods and contributing to the long-term sustainability of agricultural systems in the region (Ghafouri-Kesbi et al., 2011). Moreover, overcoming socio-economic barriers can create a more favorable environment for the adoption of such genetic strategies, as highlighted in the current state of challenges facing the sector (World Bank, 2024; Economic crisis worsens in Occupied Palestinian Territory, 2024).

1. **Main Sheep Breeds and Genotypes in Palestine**

Sheep farming in Palestine is primarily characterized by two main breeds: the indigenous Awassi and the recently developed Assaf. Historical records indicate that the Awassi breed has traditionally been the primary choice for generations in Palestine. The introduction of the Assaf breed, developed through crossbreeding between the Awassi and East Friesian breeds, represents a notable advancement in Palestinian sheep farming practices (Salman et al., 2024b). According to research documented by Atalla (2018), the native Awassi sheep remained the predominant breed until the Assaf hybrid began to gain prominence. This crossbreeding effort has combined local adaptability with enhanced productivity traits, marking a significant milestone in the evolution of sheep farming in the region.

* 1. ***Awassi***

The Awassi sheep breed is widely recognized for its exceptional adaptability to diverse environments, ranging from arid steppes to intensive agricultural systems. It is predominantly employed for the production of meat, milk, and wool and stands as the most prevalent breed in Palestine while also being common across many Middle Eastern countries (Ahmed, 2010). During a 150-day lactation period, Awassi sheep typically produce 60 to 80 liters of milk, with Palestinian ewes yielding an average of 92.9 kg over approximately 86.6 days (Ahmed & Abdallah, 2013). Awassi lambs are particularly valued for their high-quality meat and reach a market weight of 35–45 kilograms within 4 to 6 months.

The breed exhibits moderate reproductive efficiency, with ewes commonly giving birth to a single lamb per season, although twins are possible under optimal conditions (Jawasreh et al., 2017). However, small-scale farmers face significant challenges in fully realizing the breed’s productivity potential. Limited access to quality feed and veterinary services negatively impacts the flock’s performance, a situation exacerbated by socio-economic constraints such as restricted financial resources and inadequate extension services for smallholders. In addition, inbreeding poses a major risk to genetic diversity, while diseases such as mastitis and parasitism further reduce overall flock health and milk yields (Abdallah & Abo Omar, 2017).



**Figure 1:** Awassi Ewe

* 1. ***Assaf***

The Assaf sheep breed, developed in the 1950s through crossbreeding between the Awassi and East Friesian breeds, blends the adaptability and resilience of the Awassi with the superior milk production traits of the East Friesian (Epstein, 1985). In Palestine, the Assaf breed plays a critical role in intensive farming systems, producing between 300 and 400 kg of milk over a lactation period of 170 to 200 days. However, while the breed is well-suited to meeting market demands, its higher nutritional and hygienic requirements present challenges for farmers with limited technical expertise (Ugarte et al., 2001). For example, a 2023 study conducted in the Hebron Governorate revealed that only 22% of Assaf farmers were able to meet optimal feeding standards due to financial constraints (AbdAllah et al., 2023).

To address these challenges, research has focused on optimizing feeding strategies using locally available ingredients and implementing veterinary interventions to mitigate common diseases (AbdAllah et al., 2023). Although the lack of organized breeding programs poses additional obstacles, the strong growth performance of Assaf sheep underscores their importance to the local livestock sector. Newborn Assaf lambs average 5.6 kg at birth and achieve a weaning weight of 19.5 kg, demonstrating excellent growth potential (Bast et al., 2021). The strategic development of systematic breeding initiatives, including the collection and analysis of relevant data, is essential to further enhancing the productivity of the Assaf breed. Such measures would benefit not only individual farmers but also contribute to the broader agricultural economy in Palestine (Halaweh et al., 2025; Salman et al., 2024b; Milán et al., 2011).



**Figure 1:** Assaf Ewe

*Table 1: Summary of key traits of Awassi and Assaf sheep breeds.*

|  |  |  |
| --- | --- | --- |
| Trait | Awassi | Assaf |
| Adaptability | High | Moderate |
| Milk yield | 60-80 liters | 300-400 kg |
| Average birth weight | 4.16 kg | 5.6 kg |
| Weight | 35-45 kg (Market) | 19.5 kg (at weaning) |

1. **Enhancing Productivity and Economic Sustainability**
   1. ***Enhancing Productivity***

Considering the economic significance of sheep farming, genetic improvement remains a critical area for enhancing livestock productivity and increasing farmer profitability. While heritability estimates for traits such as milk yield and growth rates highlight considerable genetic potential (Salman et al., 2024b), practical implementation in Palestine is hindered by challenges like inconsistent pedigree recording and the limited adoption of genomic tools among small-scale farmers. Research has shown that understanding heritability estimates and genetic correlations enables breeders to design effective selection strategies aimed at improving desirable traits. For instance, studies demonstrate that heritability estimates for early growth traits and reproductive metrics vary significantly between breeds, indicating that targeted breeding programs can optimize these characteristics based on genetic potential (Salman et al., 2024b).

In Palestine, the integration of advanced genetic methodologies, such as genomic selection and artificial insemination, offers a pathway to overcome the constraints of traditional breeding practices. These modern approaches can address some of the limitations posed by smallholder farming systems, which typically depend on accurate pedigree recording and are often challenged by limited resources (Ahmed & Abdallah, 2013). Community-based breeding programs represent a promising alternative but face obstacles, including lower participation rates driven by the unaffordability of feed supplements and skepticism toward centralized initiatives.

To ensure the sustainability of genetic improvement efforts, investments in scientific research and agricultural extension services are essential. These initiatives not only enhance farm-level productivity but also improve resilience to environmental pressures, contributing to the development of sustainable agricultural systems. Additionally, the integration of community-driven breeding programs with cutting-edge technology offers a viable model for livestock improvement in resource-limited settings (Ren et al., 2024; Shi et al., 2024).

* 1. ***Economic Sustainability***

The economic and cultural significance of sheep farming in the West Bank, Palestine, has increasingly gained recognition, given its critical role in supporting local livelihoods and contributing to regional food security. Marzin et al. (2019) highlighted that sheep farming is not merely a source of income but also an integral part of the cultural heritage that connects the Palestinian people to their land. According to a recent report by the Food and Agriculture Organization (2023), 65% of Bedouin households depend entirely on sheep farming for their income, yet 40% of these households are indebted due to rising feed costs. Variations in productivity across intensive, semi-intensive, and pastoral sheep farming systems reflect the impact of distinct management practices. A detailed understanding of feeding strategies is essential for improving the financial viability and environmental sustainability of these operations.

Feed resource management has become especially critical, given the effects of climate change on pasture availability. In the Jordan Valley, for instance, pasture degradation resulted in a 25% reduction in grazing land between 2010 and 2020, forcing farmers to rely on expensive imported feed (Palestinian Central Bureau of Statistics, 2021). While sheep farming continues to play a crucial economic role in Palestinian communities, challenges such as rising fodder prices and limited market opportunities undermine its profitability (Abu Shaban, 2014). Recent data from the Palestinian Central Bureau of Statistics indicates that the sheep population in Palestine reached 771,168 in 2021 (92.5% in the West Bank and 7.5% in the Gaza Strip), compared to 567,236 in 2010, representing an increase of 203,932 heads.

To promote sustainable development in sheep farming, it is essential to adopt advanced breeding and management practices, supported by effective recording systems for selection programs (Salman et al., 2024b). A 2022 case study from Hebron demonstrated that cooperative purchasing of feed reduced costs by 20%; however, scaling such initiatives would require robust policy support (Koluman & Paksoy, 2024). Al Baqain and Valle Zárate (2011) emphasized that in Bedouin communities, sheep farming is heavily reliant on the resilient Awassi breed. Nevertheless, herders face economic difficulties due to escalating feed costs and shrinking grazing areas. Beyond its economic importance, sheep farming enriches the social and cultural fabric of these communities by providing meat, milk, and wool. Additionally, traditional farming practices, including the extensive use of family labor, signify the deep cultural ties of shepherding in Palestinian life (Al Baqain & Valle Zárate, 2011).

1. **Studies Related to Genetic Parameter Estimation and Major Genetic Disease in Palestine**
   1. ***Estimation of Genetic Parameters of Milk Traits in Sheep Genotypes in Palestine***

Understanding genetic parameters for milk production traits is essential for improving sheep breeds effectively. Heritability estimates for traits such as total milk yield, milk yield over 120 days, and milk yield over 150 days provide critical insights for breeders (Salman et al., 2024b). Studies have shown that fixed effects, including breed, geographical location, ewe parity, and lambing season, significantly influence milk production (Jawasreh et al., 2018). Furthermore, lactation length has been identified as an important determinant of total milk yield in lactating ewes, with longer lactation periods being associated with higher milk yields (Gootwine & Pollott, 2000). The integration of targeted breeding programs that focus on enhancing the genetic potential for milk traits, combined with optimized management practices, has been highlighted as a key driver for improving productivity in sheep farming systems in Palestine.

For instance, the genetic potential of the Assaf and Awassi breeds for milk production has been emphasized in multiple studies. Findings from Ahmed and Abdallah (2013) and Salman et al. (2024b) suggest that selective breeding strategies focused on these breeds could lead to significant improvements in milk yield. A prior study evaluated genetic parameters for milk yield and prolificacy using 3,682 records from 1,837 ewes of several breeds. Key findings indicated that litter size had no significant effect on milk traits. However, factors such as breed, location, ewe parity, and lambing season showed significant impacts on traits like total milk yield. Heritability estimates for total milk yield ranged from 0.00 to 0.11, with the highest values observed in the Awassi breed. These findings underscore the importance of robust performance recording and pedigree tracking in the effort to enhance sheep breeding practices in the region.

* 1. ***Genetic Parameters for Early Growth Parameters and Kleiber Ratio in Palestinian Sheep Breeds***

Early growth parameters such as birth weight, weaning weight, pre-weaning daily gain, and the Kleiber ratio—are vital indicators of sheep productivity and efficiency. Genetic evaluations of these traits have revealed considerable variability across sheep breeds in Palestine (Salman et al., 2024a). Heritability estimates indicate that traits such as birth weight exhibit moderate to high heritability across breeds, emphasizing their strong genetic basis (Wang et al., 2024). For example, heritability estimates for birth weight in Awassi and Assaf breeds range from 0.30 to 0.60, while the Kleiber ratio demonstrates promising potential for improvement through genetic selection (Salman et al., 2024a; Ghafouri-Kesbi et al., 2011). The relationships among early growth traits are critical for designing effective breeding strategies and programs. Studies have consistently shown that selecting for higher birth weights enhances weaning weights, illustrating the genetic correlations between these traits. Similarly, the Kleiber ratio measuring growth efficiency relative to metabolic body weight is significantly influenced by genetic factors and serves as a valuable metric for selection in breeding programs (Ghafouri-Kesbi, 2013).

Understanding the genetic and maternal influences on growth performance is crucial for achieving sustained productivity improvements. Genetic evaluations, incorporating maternal effects, have been strongly recommended, as maternal traits have a substantial impact on lamb growth rates (Mokhtari et al., 2012). By integrating both genetic and maternal factors into selection protocols, meaningful advancements in productivity can be accomplished through targeted breeding. Salman et al. (2024a) conducted a study analyzing data from 4,614 lambs across multiple breeds in Palestine. The results showed that Assaf lambs achieved the highest weaning weight and Kleiber ratio, while Improved Awassi lambs exhibited the highest birth weight and pre-weaning average daily gain. These findings underscore the significant influence of genetic factors on growth performance. Additionally, the study revealed the effects of genotype, mating type, and environmental conditions on early growth traits, highlighting the considerable scope for genetic improvement through selective breeding in Palestinian sheep populations.

Further research by Halaweh et al. (2025) explored the effects of different mating methods and semen preservation techniques on reproductive performance and lamb growth in Palestinian Assaf sheep. Using a sample of 123 ewes divided into three groups based on mating methods (natural mating, fresh semen, and frozen semen), the study found that natural mating yielded the highest fertility rates (71.9%), followed by fresh semen (61.1%) and frozen semen (45.4%). While artificial insemination did not significantly affect prolific lambing rates, it was associated with improved lamb growth metrics, including birth weight and weaning weight. These findings demonstrate the strategic value of artificial insemination in enhancing reproductive and growth performance, reinforcing its utility as a valuable tool for advancing sheep farming efficiency.

* 1. ***Genetic Variability of the Prion Protein Gene (PRNP) in Palestinian Assaf Sheep***

Prion diseases, including scrapie, represent fatal neurodegenerative disorders resulting from the misfolding of the normal cellular prion protein into its pathogenic isoform (Acín et al., 2021). Also referred to as transmissible spongiform encephalopathies, prion diseases are characterized by rapid progression leading to inevitable fatality. Neuropathological indicators of these conditions include spongiform degeneration, neuronal loss, astrogliosis, and the absence of an inflammatory response (Belay, 2008). This group of diseases encompasses disorders such as Creutzfeldt-Jakob disease, kuru, and bovine spongiform encephalopathy—each arising from the post-translational misfolding of glycosylphosphatidylinositol-anchored prion protein into its abnormal pathogenic form. For scrapie in particular, genetic susceptibility is largely determined by polymorphisms in the prion protein gene, with codons 136, 154, and 171 identified as critical loci (Adeola et al., 2023). Understanding the genetic basis of susceptibility is essential for developing strategies aimed at mitigating the prevalence and transmission of this disease. Genetic testing has emerged as a valuable tool in identifying individuals with susceptible genotypes, thereby enabling the implementation of selective breeding programs designed to reduce the spread of scrapie in affected populations (Zeineldin et al., 2024).

Despite advances in genetic screening, historical records document multiple instances of scrapie outbreaks in Palestinian sheep populations. The first documented outbreak occurred in 1993 in northern Palestine, necessitating the culling of the entire infected flock as a control measure. Subsequent incidents were reported in 1996, 2002, and 2005, with similar interventions being required (Alsayed, 2019). In Europe, extensive studies have investigated the association between polymorphisms at codons 136, 154, and 171 and varying levels of scrapie susceptibility. Differences in amino acid composition at these loci result in common alleles such as ARR, AHQ, ARQ, and VRQ, which confer varying degrees of resistance or vulnerability to scrapie (Eiríksson et al., 2024). Within the Assaf breed in Palestine, limited studies have been conducted to evaluate prion protein gene variability and its implications for scrapie resistance. Available findings reveal that the ARQ allele, associated with intermediate susceptibility, predominates in the population with an average frequency of 0.86. In contrast, the ARR allele, linked to enhanced resistance, was observed at a much lower frequency of 19.9%, while the highly resistant ARR/ARR genotype was rare, occurring in only 3.9% of the sampled population. Targeted strategies to increase the prevalence of the ARR allele, such as distributing ARR/ARR homozygous rams, are strongly recommended (Gootwine, 2008).

Research conducted on 206 Palestinian Assaf sheep further highlighted the predominance of the ARQ allele, which represented 57.8% of the population. In comparison, the ARR allele accounted for only 19.9%. The insights from these studies underline the urgent need for targeted breeding programs aimed at increasing the frequency of resistance-conferring alleles, particularly the ARR allele, within the Palestinian Assaf sheep population. Such efforts could play a transformative role in reducing the incidence of scrapie through both genetic and management interventions.

1. **Conclusions**

The genetic improvement of Awassi and Assaf sheep in Palestine is vital for enhancing agricultural productivity and economic sustainability. These breeds are well-suited to the region's semi-arid climate, offering high fertility and milk production. However, challenges such as financial constraints, limited veterinary access, and environmental stresses threaten their potential. Furthermore, careful consideration of the socio-economic barriers faced by farmers is crucial for the success of genetic strategies. Implementing advanced genetic techniques and effective breeding programs, alongside improved management practices, can significantly boost productivity and support the livelihoods of local farmers, ultimately contributing to food security in the region.

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