

Review Paper

Characterization of Goat Breeding Systems in Tunisia and In the Mediterranean Region

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Abstract

Despite its socio-economic role in Tunisia, the goat has been considered an agent of natural resource degradation due to the excessive exploitation of forests and rangelands. Currently, goat farms are beginning to regain interest in different Tunisian climatic conditions. Goat breeding is distributed throughout the territory, particularly in the mountain areas, natural rangelands, and southern oases. The main systems encountered are (i) systems integrated into farms, (ii) livestock systems in mountainous and forest regions, (iii) oasis ecosystems, and (iv) Transhumant livestock systems. These farming modes are influenced by developments in agricultural systems in general, which change due to socio-economic development and are dependent on the availability of funding through national projects. In North African countries in general, transhumant pastoral systems dominate arid and semi-arid zones and are characterized by the seasonality of food resources, which are tightly influenced by rainfall. Extensive pastoral farming, mixed with sheep in regions with a dry climate and limited water resources, is the most widespread. Goat farming is a form of savings rather than an economic activity. Concerning the majority of Mediterranean countries; the existing farming systems reveal the importance of socio-territorial unity and available natural resources. The classification of goat farming systems is based on the resources used (natural rangelands or crop residues), the intensity of resource use (extensive or intensive), the types of livestock breeders (nomadic or sedentary), or the product generated and its quality. The dominant systems in the European countries of the northern Mediterranean shore are farms oriented to the production of goat's milk intended for the manufacture of cheeses.

Keywords: Goat, production system, Tunisia, Mediterranean region.

المخلص:

بالرغم من دورها الاجتماعي والاقتصادي في تونس، فقد تم اعتبار الماعز في بداية فترة الاستقلال، عاملاً من عوامل تدهور الموارد الطبيعية بسبب الاستغلال المفرط للغابات والمراعي بشمال البلاد. ولقد بدأ نشاط تربية الماعز يستعيد مكانته بصفة تدريجية منذ السبعينات من القرن الماضي، على المستوى الاقتصادي والاجتماعي في مختلف أنحاء البلاد التونسية بالمناطق الجبلية والمراعي الطبيعية والواحات الجنوبية. توصلنا من خلال هذا البحث إلى تصنيف أنظمة تربية الماعز إلى عدة أنماط (1) النمط المدمج في المستغلات الفلاحية، (2) النمط المتواجد بالمناطق الجبلية والغابية، (3) النمط الإيكولوجي بالواحات (4) والنمط الرعوي. مع الإشارة إلى أن أساليب تربية الماعز لا تزال مرتبطة بتطورات النظم الزراعية بصفة عامة و توفر التمويل من خلال المشاريع الوطنية. في بلدان شمال إفريقيا بشكل عام؛ تهيم النظم الرعوية على المناطق القاحلة وشبه القاحلة وتتميز بموسمية الموارد الغذائية، وتعتمد على هطول الأمطار. كما تعتبر النظم الرعوية للماعز المختلطة مع الأغنام في المناطق ذات المناخ الجاف والموارد المائية المحدودة، هي الأكثر انتشاراً. و يعتبر قطاع الماعز شكلاً من أشكال المدخرات العائلية ولا يرتقي إلى نشاط اقتصادي. أما بدول البحر الأبيض المتوسط؛ فإن أغلبية أنظمة تربية الماعز تبرز أهمية الوحدات الاجتماعية الإقليمية والموارد الطبيعية المتاحة. حيث تركز أصناف أنظمة تربية الماعز على الموارد المستخدمة (المراعي الطبيعية أو مخلفات المحاصيل)، أو كثافة استغلال الموارد (الموسعة أو المكثفة)، أو أنواع المربين من البدو أو الحضر أو جودة المنتج. وتجدر الإشارة إلى أن نظم تربية الماعز بالبلدان الأوروبية المتواجدة بصفاف البحر الأبيض المتوسط الشمالي، تتجه غالباً لإنتاج حليب الماعز المخصص لتصنيع الأجبان.

الكلمات المفتاحية: الماعز، نظام الإنتاج، تونس، منطقة البحر الأبيض المتوسط.

Introduction

The goat was among the first domesticated livestock, more than ten thousand years ago, contributing to the Neolithic revolution. Its domestication in the Zagros Mountains of western Iran was initiated between about 9900 and 9500 years ago (Zeder and Hesse, 2000). The goat was domesticated from the aegagre (*Capra aegagrus*) in the Fertile Crescent, the Euphrates and Tigris valleys, and southeastern Anatolia 10500 years ago (Peters et al. 1999; Zeder 2005). Among the main goat populations in the world are the European goat, which includes the Alpine, Saanen, Poitevin, Maltese, Murcian and Toggenberg breeds, the Asian goat, which includes the Angora and Kashmir breeds, and the African goat, which is mainly represented by the Nubian breed (Quittet, 1977). The distribution of goats in the world is presented in Figure 1. It is worth noting that Asia holds first place among the five continents, with 58.5% of the world's goat population (about 485 million heads). China and India, alone hold almost 55% of the world's goat population, 29 and 26% respectively (Utaaker et al., 2021). Africa is the second largest continent in terms of goat numbers, with nearly 34.5% of the world's goat population (286 million head in 2016). The largest goat numbers are mainly in Sudan, Nigeria, Kenya, Somalia, and Tanzania (Miller and Lu, 2019). North, Central, and South America together with Oceania account for only 4.7% of the world's livestock population, while Europe has only 2.2% of the world's livestock population (Figure 1). The development of the goat sector in the world is still poorly supported technically and institutionally and most goats are raised under traditional extensive or semi-extensive farming systems with low input levels. Goat milk production represents only 2% of the total world milk production, varying between 11.4 and 12.4 billion tons, during the last decades. Asia and Africa occupy the first and second positions in world production, respectively 58.1 and 35% (Miller and Lu, 2019). In Tunisia, goat farming has historically experienced a difficult period that has substantially slowed its development. The goat has been considered an agent of degradation of natural resources because of the excessive exploitation of forests and rangelands. In this respect, goat farming was prohibited in the northern and central regions (FAO, 2014). This prohibition caused a reduction in goat numbers of more than 90% in the North and 50% in the Center. As a result, the national goat population was concentrated in the southern regions, which accounted for over 60% of the national population (Gaddour, 2009). However, Gaddour and Najari (2010) consider that the goat remains among the most competitive livestock in marginal areas, characterized by very difficult natural conditions, and which require a minimum of the adaptive potential. Products from goat farming, mainly meat, contribute to the self-sufficiency of the arid regions of Tunisia. According to the same authors, the consumption of goat meat is one of the dietary habits of Tunisians because it is considered less fatty than that of the sheep species. Recently, a renewed interest is being shown in goat farming, given its economic and social role in rural areas. This is explained by the importance of differentiated value chains around goat products in milk and meat, playing a role in the diversification of animal protein sources and important economic opportunities for Agri-food processing on the national and international market (Gereffi et al. 2005). In this literature review, we propose to review the situation of the goat production sector and the main production systems in Tunisia and the Mediterranean basin.

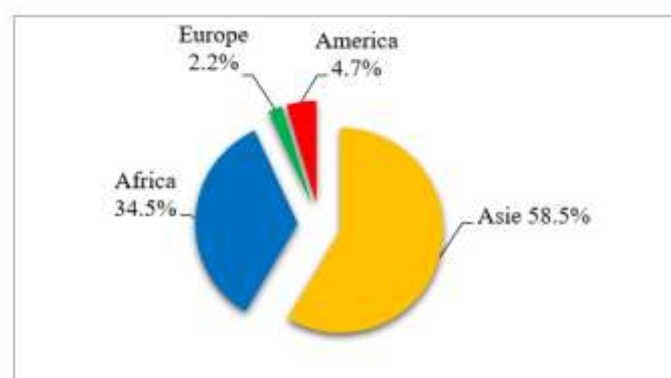


Figure 1. Distribution of the goat population in the world (FAOSTAT, 2014)

Development approaches of the goat production sector

The approaches to agricultural development for the benefit of farmers and particularly to the stockbreeders, in the world and Tunisia, have gone through a long process. In the beginning, it was the adoption of a technicist approach of classic extension to arrive more recently at the emergence and the evolution of several new approaches of proximity supervision better integrated, systemic, and participative (FAO, 2019). The current situation shows that the classic extension approach is being replaced by an animation-advisory approach, based on the organization of farmers into specialized, independent, and sustainable socio-professional structures (Islam et al., 2018; Poole et al., 2013). This approach was also at the origin of the revision of the ordinary extension mechanism by all operators in agricultural development in general and in livestock in particular. The objective is to give more importance to the involvement of livestock farmers themselves for the improvement of their local know-how and the appropriation of new techniques (ODESYANO, 2011). The systems approach has proven to be an effective tool for tracing both the importance and the complexity of the economic, social, and environmental issues that characterize this livestock farming. Generally speaking, livestock systems can be classified according to the resources available, the functions occupied, or the soil and climate conditions. Therefore, these factors could be behind the diversity of livestock systems (Miller and Lu, 2019; Islam et al., 2018). In terms of value chain development, a new paradigm is emerging that allows for the profitability of its entire links, whether in animal or crop production, and that is centered on the concept of the global value chain (GVC). This focuses on the sequence of complementary activities involved in the design, production, and marketing of a given product (Gereffi et al. 2005; Champion, 2014). Generally speaking, the CGV approach is based on four main concepts, namely, governance, coordination mode, upgrading, and key actors (Cheriet, 2016).

In Tunisia, the application of these new development approaches is little adopted in the field of goats. Indeed, the studies carried out remain sectoral and are currently limited to the country's oasis regions, which have benefited from the PICO project for the intensification of goat farming in the oases of Central West Tunisia (Nafti et al, 2016).

Socio-economic importance of goat production in Tunisia

Evolution of numbers and distribution of flocks

The prohibition of goat farming in the northern and central regions was at the origin of the regression of goats in Tunisia (Jort, 1958). The ban lifting by the Law (1970) has allowed the gradual evolution of the goat population illustrated from the year 1961 to the year 2015 (DGPA, 2019). The numbers have grown almost continuously as a result of progressive changes in breeding and feeding systems and various state support measures to the sector as part of the operations to alleviate the effects of drought and development of the milk and meat sectors (DGEDA, 2005). Recent statistics (Figure 2) for the last decade 2010-2020 show that the number of female units varies between 708 and 740 thousand (DGPA, 2020). The constraints of the sector are mainly the variation of the quality and availability of fodder, as well as the low level of technicality, both in terms of feeding and reproduction or health monitoring (DGPA, 2020).

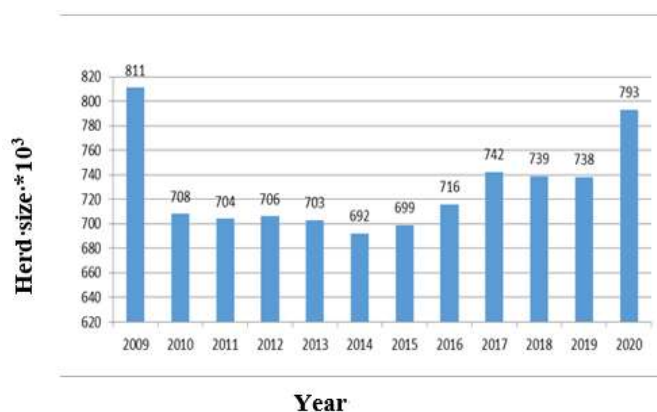


Figure 2. Evolution of the goat population in Tunisia (DGPA, 2020)

There are 209.120 female units in the North, 163.100 in the Center, and about 343.280 in the South of the country. In terms of the number of heads, the numbers are distributed as 27, 22, and more than 50% in the North, Center, and South respectively (DGPA, 2019). The updated geographical distribution for the year 2020 is shown in figure 3 (DGPA, 2021).



Figure 3. Distribution of the goat population in Tunisia (DGPA, 2021)

The situation of goat production in Tunisia

In Tunisia, goat farming is one of the main income-generating activities for rural populations (ODESYANO, 2016). However, the production of goat meat contributes only 7% to cover the needs of red meat; which presents 4% of the total meat production. Goat milk production is still low compared to southern Mediterranean countries (FAO, 2007). Similarly, the consumption of goat meat per capita is one of the lowest in the Mediterranean countries. Statistics published by the Ministry of Agriculture (DGPA, 2021) show a weak evolution of goat meat production, which varies from 9.2 to 10.7 tons during the period from 2011 to 2020 (Table 1). These irregular and unstable situations indicate a significant margin for progress in the sector, both in terms of production and in terms of promoting the processing and marketing of products.

Table 1. Evolution of goat meat production (1000 t) in Tunisia (DGPA, 2021)

year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Goat meat	9.2	9.3	9.5	9.5	9.2	9.5	9.5	9.6	10.2	10.7

Actions and development projects for the goat sector in Tunisia

Among the most important socio-economic development projects granted by the Tunisian State in favor of the goat sector we quote:

- The project of breeding and integrated development in the mountainous areas of the governorate of Bizerte (EDIMO, 1988-1991): This project is part of the technical cooperation with the GTZ. It had a character of extension activities for the stockbreeders of the region of Bizerte, to implement techniques of livestock management, selection, and hygiene (OEP, 1991).
- The project PICO / OEP-UCARDEC, (1993-1998): Consisted in the intensification of goat farms

in the oases to establish a goat milk sector and improve the income of farmers in the oases of the governorates of Gabes, Mednine, Kebili, and Tozeur (OEP, 2018).

- The project of agropastoral development and associated sectors (Prodefil): This project is supervised by the CRDA of Medenine and co-financed by IFAD and the EU. It is an integrated development project that aims to improve the living conditions of the vulnerable rural population and to create employment opportunities through the strengthening of the resilience of agro-pastoral production systems and the development of associated sectors. Among its components, the project foresees the development of the goat sector, through the improvement of the herd management, the health of the goats, and the management of the rangelands, as well as the technical supervision of the breeders (IRAM, 2020). On the other hand, the Office of Sylvo-pastoral Development of the Northwest (ODESYANO), since its creation in 1981, and through the components of support to agricultural and pastoral production of its development projects in mountainous and forested areas, has achieved actions to improve the performance of goat farms, through the distribution of goats improvers breeds, Alpine, Boer, and Damasquine. This action was carried out for the benefit of the associated breeders and reinforced by a technical supervision program in its intervention areas. The evaluations of these projects were based on the technical parameters of breeding, but the economic effects are generally insufficiently quantified (ODESYANO, 2005). The new strategic vision of socio-economic development of the goat breeding sector requires an orientation towards a program approach that should take into account certain dimensions, notably:

- (i) The adoption of a socio-professional organization of breeders focused on the promotion of value chains and goat agri-food products.
- (ii) Support for the coverage of the country's territory for the genetic characterization of the goat population to adequately express its diversified genetic potential.
- (iii) Taking into account the role of social categories, owners of small farms or landless, in the elaboration of goat breeding development strategies.
- (iv) The adoption of a regional multidisciplinary approach to research and development through collaborative mechanisms between the various support structures (technical services, the profession, and developers), with a view to an effective partnership for implementation, evaluation, and capitalization of the sector's achievements.
- (V) The development of goat enterprise production systems according to better governance of natural resources (ODESYANO, 2018).

Goat farming systems in Tunisia and the Mediterranean region

Goat farming systems in Tunisia

Farming systems are changing due to socio-economic development, and are dependent on the availability of funding through national projects. Also, genetic selection and biodiversity conservation programs for the local goat have been initiated in Tunisia but have never been completed, especially for milk (Gaddour et al., 2008). According to Nafti et al. (2009), goat farms are well adapted to the different Tunisian climatic conditions and are located in mountainous areas, natural rangelands, and southern oases.

Farm integrated systems

At the farm level, the breeding system constitutes a logical and ordered sequence of technical

breeding operations applied to a set of animals kept homogeneously. In their study on the characterization of goat breeding systems carried out in the humid and sub-humid zone of the Bizerte region (northern Tunisia), Ben Salem and Ben Hammouda (1995) consider each goat breeder as the head of a farm that is integrated into its economic and social environment. The authors affirm the traditional character of these farms, generally associated with bovine and ovine species, and identify four classes of goat breeders based on a typology of farms.

- (i) The class of landless farmers, whose farm area varies between (0) and (5) ha, corresponds to the farming system where the goat species is dominant (66% of the herd) compared to the bovine and ovine species. This category of farmers has the best prolificacy rate (around 150%), a high culling rate, given that the herd constitutes for them a cash flow to which they have recourse in the event of family needs, and the highest gross margin per goat. This seems to be explained by negligible feed costs, using pasture and by-products that are not purchased.

- (ii) A livestock system represented by goat farmers with an average farmland size of less than five ha and a herd made of goats and cattle. These farms are characterized by intensive crops other than fodder, cereals, and legumes, which account for 21 to 61 % of the useful agricultural area (UAA).

- (iii) A category of livestock farmers with a predominance of goats cohabiting with sheep and cattle distinguishes farms smaller than 20 ha.

- (iv) A livestock system characterized by large-scale farmers with land areas of more than 20 ha. They have mixed livestock with a proportion of 30 to 38% of sheep in the workforce. These farms have the lowest gross margin per LU of goats and the highest abortion and mortality rates of adults and youngsters compared to other farming systems. This indicates a failure in their hygiene and breeding programs. Finally, there is a culling rate ranging from 15 to 19%, justified by the replacement of unproductive goats. Their farming system is intensive and is characterized by the dominance of fodder crops in the humid region and legumes in the sub-humid region.

Livestock systems in mountainous and forest regions

These regions constitute in large part the priority areas of intervention of the ODESYPANO, which in its reports, denote the importance of altitude on the structures of livestock in the mountainous areas of north-west Tunisia, the specific composition of the herd, and the degree of crossbreeding of the local cattle population in the classification of livestock systems. About these three criteria, it was found that in the high mountains the herds are composed of local goats only or in association with cows of the local population most often (Byaruhanga et al., 2015). However, in the mid-altitude and the foothills, the local cow and its crossbred products dominate the composition of the herds, often with the presence of sheep and goats (Muigai et al., 2017). On the other hand, in the valleys and on the plains, breeding conditions are more favorable to the dairy cow in areas served by milk collection networks. To reduce the cost of investment and the risk of capital loss, sheep are gaining ground in these areas. Nevertheless, it was deduced from the same source that the dominance of a species in a flock is a relative notion. The number of cows is constant, averaging 5 head, in the three systems, but it is rather the number of sheep and goats that is variable. On the other hand, the Agro-Sylvo-Pastoral goat farming system is predominant in the mountainous regions of northwest Tunisia where the goat is most often associated with the local cow (ODESYPANO, 2003). Ammar et al. (2011) reported that herds located mainly in the hills and mountainous and urban areas close to the villages are conducted in extensive agro-pastoral systems. This system is traditionally based on grazing and the use of fodder crops and spontaneous vegetation. It is adopted mainly for the local goat (figure 4) since it allows it to satisfy most of its needs in winter and spring. According to

Rouissi et al. (2005), this type of breeding is also found in the center and south of Tunisia and it concerns mainly the local goats. The needs of the animals are met by rangeland and supplementation of the ration composed mainly of farm concentrate and barley.



Figure 4. Local goat herd in the mountainous and forested areas of northwest Tunisia reared in an agro-pastoral system.

Livestock in oasis ecosystems

These livestock ecosystems characterize the Tunisian oases where the goat replaces the dairy cow in the supply of milk intended mainly for self-consumption. The goat is present as the most balanced animal material with the resources of the oasis system in southern Tunisia and is part of the oasis's socio-cultural heritage (Villemot, 1995). The oasis offers a complex production system where the goat plays an important role. Indeed, in the south, the herds are located around the oases, and the diets are based on greenery and concentrate (Jemali et Villemot, 1996; Rouissi et al., 2005). This system is dominated by goats crossed with pure breeds. In addition, the ecosystem of Tunisian oases is characterized by small farms used in intensive mode and polycultures are quite developed. In this system, the goat is in one of the mini herds and it confers different products. Following the socio-economic changes and the shift of farms, the oasis system is undergoing profound changes (FAO, 2007). For this reason, this oasis region had benefited in the 90s from a project of intensification of dairy goat breeding (PICO) to maintain this system of breeding. According to Jemali and Villemot (1996), in the case of this system, the goat herds management is generally in charge of the shepherd who takes care of them in the pastures of the surrounding steppes during the day, while at night each owner recovers his herd to provide it with alfalfa hay or concentrate at the trough in case of food shortage. The study conducted by Nafti et al. (2016) in the Djerid and Nefzawa regions representing about 80% of Tunisian oases, has identified three main goat farming sub-systems:

- A first pre-Oasis and urban sub-system which is the most preponderant (76.5% of the breeders) which includes those located around the oases and irrigated areas, and also includes flocks grazing the palm grove rangelands. This type of breeding is characterized by good reproductive performance with peaks in the spring. In this case, 60% of the farmers adopt early deworming, while 92.5% of the farmers do not practice flushing and steaming.
- A second subsystem in the mountains of the Tamerza range in the Djerid region and the peri-urban areas around the villages of Fatnassa and Bechni in Nefzawa.
- The third mode consists of a transhumant pastoral sub-system that is tightly dependent on the rangelands state in the region.

Transhumant livestock systems

This breeding system characterizes a large part of southern Tunisia, mainly the livestock of the desert area of RjimMatoug, where 90% of the breeders are transhumant in search of pasture and the availability of water. This mode of breeding is marked by old herds, the self-production of broodstock, the manifestation of the phenomenon of inbreeding, and the morphological homogeneity of animals black colored (Ammar et al., 2011). Najari et al. (2011) identified in their study of arid regions four main systems of mixed sheep-goat breeding namely, a system of desert areas, a pastoral system on the Ouera and Dhahers rangelands, a third system in the oases and irrigated areas, and a fourth system outside the oases in central and southern Tunisia. In the same region of southern Tunisia, Abdouli and Nefzaoui (1993) identified the goat farming system with an agro-pastoral mode characterized by small herds of goats mixed with sheep and whose diet is based on degraded rangelands and agricultural by-products. This shows the complexity of goat farming in rural areas and the different ecosystems with pastoral and agroforestry vocations, compared to the "conventional" notion of the agricultural holding attributed strictly to the useful agricultural area (UAA).

The main goat breeding systems in the Mediterranean region

Regarding the majority of Mediterranean countries, the accumulated experiences would present great opportunities for technology transfer that could be transposed to the socio-economic context of Tunisia. In these countries, the definitions of the breeding system published in the literature reveal the importance of the socio-territorial unit and the available natural resources. It turns out that goat farming systems are classified into two main categories, namely the animal production system, and the mixed farming system. This classification is based on the resources used (natural rangelands or crop residues), the intensity of resource use (extensive or intensive), the types of producers (nomadic or sedentary), or the product generated and its quality (milk, meat, or dual-purpose). Goat production systems in the world are mostly classified as extensive (Escareno et al., 2012).

The case of North Africa

According to Peacock (1996), transhumant pastoral systems in North African countries dominate arid and semi-arid areas and are characterized by the seasonality of food resources, dependent on rainfall, and are a form of savings rather than an economic activity. In Algeria, the results of the study carried out by Kady et al., 2013; Fantazi et al 2017; Belantar et al., 2018 and Belkhadem et al., 2019 intend to characterize goat farming in the mountainous regions of Kabylia on 94 breeders, confirm the extensive nature of the goat farming system in these regions, where it is noted that breeding and reproduction techniques are poorly mastered, in addition to the lack or absence of extension and structuring of the goat sector. In their comparative study of goat production systems in Andalusia and northern Morocco, (Benjelloun et al., 2015; Chentouf et al. (2009) recorded semi-extensive production systems based on grazing for half of the herd's needs. These two regions have several similarities and are characterized by mountainous terrain, high annual rainfall (over 800 mm), and an ecosystem formed by a Mediterranean forest cover consisting mainly of holm oak, cork oak, and herbaceous shrub species. Goat breeding in northern Morocco exploits the local northern goat known as Romia, known for its dairy abilities (Chentouf, 2007). In contrast, the semi-extensive dairy farming system in Andalusia is dominated by the local Payoya breed. This study emphasizes the use of family labor with mechanization and a larger herd size in Andalusia. Feeding practices are characterized by the high use of concentrated feed in both regions, with a higher ratio of concentrate to milk produced in Northern Morocco. This result illustrates a low level of milk production and feed intake at the trough. The fertility and prolificacy rates are comparable; however,

the mortality rate of kids is high on the farms of the northern region of Morocco. This situation is explained by sanitary problems and the collection of milk by the breeders for marketing to the detriment of the feeding of kids deprived of replacement milk. In a similar typology of goat farms in Morocco, Chentouf et al. (2004) distinguished between two types of farming, namely, a meat production system based on forest resources and a second mixed meat and milk system based on forest resources and farming.

Case of the Euro-Mediterranean region

Dairy goat production systems are commonly found in the countries of the Mediterranean basin, due to their economic, environmental, and social importance, especially in Spain, France, Italy, and Greece (Pirisi et al., 2007). Although Europe holds only 2.5% of the dairy goat population, its production represents 18% of the world's production of goat milk (Ruiz Morales et al., 2019; Napoléone et al. 2015). In France, goat milk production exists mainly in the mountainous regions of the Massif Central and the Alps and the arid regions in the southern part of the Massif Central and the southeastern part of the Mediterranean region. In these areas, production alternatives are scarce due to the lack of arable and fertile land, which limits the extension of forage areas (De Rancourt et al., 2006). In Spain, in regions where rangelands have become increasingly scarce, among the two production systems identified, there is a first system based on improved rangelands with the use of concentrate for a longer period of the year and a second traditional production system, which uses only natural rangelands. Spain has the second-largest goat population in Europe, with 18.3 million females. The extensive system is predominant in hilly areas with low rainfall, with degraded and seasonal rangelands, fodder shrubs, and occasional stubble. Recently, this system has given way to a semi-intensive system in family enterprises with sheep enclosure at night, and concentrated supplementation according to the level of production (Castel et al., 2011). In Greece, sheep, as well as goats, are important Enterprises, especially in mountainous regions that are considered less favorable for sustainable agricultural activities. These small ruminants are mainly raised for milk production. The high price of concentrate, the low availability of fodder, and the preference for lean meat by the consumer are the reasons for the early slaughter for the production of light carcasses of kids and young lambs. In Turkey, the traditional transhumant livestock system has evolved into a sedentary system due to social and economic changes in the country. The reduction in the size of flocks and the use of arable land for agricultural intensification and the change in the lifestyle of livestock keepers in favor of the cities are the main precursors of the dominance of the sedentary system. The latter is commonly observed in Central Anatolia, Southeast Anatolia, and Marmara (Gelasakisa et al., 2017; Kukovics et al., 2016; Kukovics, 2014). The government is shifting towards cow's milk enterprises, poultry farming, and cattle fattening at the expense of the goat and sheep industry. Jordan and Cyprus have succeeded in promoting the quality of goat milk for fresh consumption and also processed into cheese and yogurt through the organization of producers in a cooperative system (Cheriet, 2016).

Conclusions

The activity of goat breeding, in Tunisia as well as in the majority of the Mediterranean countries, is conducted in marginal lands in an extensive to semi-intensive mode. The variations of the modes of production and the products in all these regions take different orientations, essentially according to the food resources for the flock, imposed by the climate, the territorial conditions, and the socio-cultural aspect of the rural populations. The development projects of the goat sector carried out so far in Tunisia are mostly sectoral, giving priority to the actions of extension activities related to goat management and sanitary prophylaxis program. The introduction of exotic breeds for the improvement of milk and meat yields has followed an occasional route without strategic interest. More recently, in Tunisia, agricultural development approaches and farmer/breeder management methods are increasingly oriented towards the emergence and evolution of several new alternatives for local management, which are increasingly integrated, systemic, and participatory. The opening of innovative solutions, locally adapted, is required in the Tunisian context where the activity of

goat breeding is generally confronted with complex economic, social, and environmental issues. Regarding the concerns related to the notion of participatory and sustainable development, goat farming strategies should be based on a systemic approach. In this respect, the promotion of a territorial approach is essential for the development of value chains, associated with the organization of breeders into autonomous and sustainable socio-economic structures.

Author's Contributions

Khemiri H, Darej C, and Attia K. collect literature and prepared the first draft; Moujhaed N, Khemiri H, Darej C, and M'Hamdi N. revised the paper; Moujhaed N and M'Hamdi N validated the paper

References

- Abdhouli H. and Nefzaoui A. 1993.** Les systèmes d'élevage caprin en Tunisie, INRA.
- Ammar H. Bodas R. Ben Younes M. and López S. 2011.** Goat breeding systems in the South of Tunisia (Tataouine). In : Bernués A. (ed.), Boutonnet J.P. (ed.), Casasús I. (ed.), Chentouf M. (ed.), Gabiña D. (ed.), Joy M. (ed.), López-Francos A. (ed.), Morand-Fehr P. (ed.), Pacheco F. (ed.). Economic, social and environmental sustainability in sheep and goat production systems. Zaragoza : CIHEAM / FAO / CITADGA, 2011. (Options Méditerranéennes: Série A. Séminaires Méditerranéens ; n. 100), pp. 283-288.
- Ben Salem H. and Ben Hammouda M. 1995.** Caractérisation des systèmes d'élevage caprin dans la région humide et subhumide de Bizerte. MEDIT W 2/95, pp. 59-61.
- Belantar I. Tefiel H. and Gaouar S.B.S. 2018.** Phenotypic characterization of local goat population in western Algeria (Wilaya of Relizane) with morphometric measurements and milk analysis. Genetic Biodiv J. 2, 55-66.
- Belkhadem S. Tefiel H. Belantar I. Chahbar M. and Gaouar S.B.S. 2019.** Discriminant analysis on the morphometry of local goat breeds in the west of Algeria. Gen. Biodiv. J: 3(2): 49-56
- Benjelloun B., Alberto F.J., Streeter I., Boyer F., and Coissac E. 2015.** Characterizing neutral genomic diversity and selection signatures in indigenous populations of Moroccan goats (*Capra Hircus*) Using Wgs Data. Front. Genet., 6:107. Doi: 10.3389/Fgene.2015.00107
- Byaruhanga C, Oluca J, and Olinga S. 2015.** Socio-economic aspects of goat production in a rural agro-pastoral system of Uganda. Crops. 114:105. doi: 10.13189/ujar.2015.030604
- Fantazi K. Tolone, M. Amato B. Sahraoui H. Vincenzo di Marco L.P. La Giglia M. Gaouar S.B.S. Vitale M. 2017.** Characterization of morphological traits in Algerian indigenous goats by multivariate analysis. Genetic. Biodiv. J. 1, 20-30.
- Castel J.M. Mena Y. Ruiz F.A. Camunez-Ruiz J. and Sanchez-Rodriguez M. 2011.** Changes occurring in dairy goat production systems in less favored areas of Spain. Small Ruminant Research 96, pp.83-92.
- Champion C. 2014.** Liens entre organisation des filieres et transfert nutritionnels : cas du double concentré de tomate en Tunisie. Master Recherche, Montpellier SupAgro., 121p.
- Chentouf M. Ayadi M. and Boulanouar B. 2004.** Typologie des élevages caprins dans la province de Chef-chauoen : Fonctionnement actuel et perspectives. Options Méditerranéennes, Série A, n° 61, pp. 255-261.
- Cheriet F. 2016.** Filieres agroalimentaires et chaines globales de valeur: Concepts, méthodologies et perspectives de developpement. In: The value chains of Mediterranean sheep and goat products. Options méditerranéennes, A n°.115, 2016, pp.29-41.
- Chentouf M. Arrebola Molina F. Boulanouar B. Mesbahi H. Terradillos A. Caravaca F. Casas C. and Bister J.L. 2009.** Caracterisation des systemes de production caprine semi-extensifs en Andalousie et au Nord du Maroc: Analyse comparative. Options Méditerranéennes, An. n°.91, 2009-Changes in sheep and goat farming systems at the beginning of the 21st century, pp.37-41.

- Chentouf M., 2007.** Pysiologie de la reproduction et productivité de la chevre locale du Nord du Maroc. These de doctorat, Facultés Universitaires Notre-Dame de la Paix, Namur.
- De Rancourt M. Fois C. Lavin M.P. Tchakérian E. and Vallerand F. 2006.** Mediterranean sheep and goat's production: An uncertain future. *Small Ruminant Research* 62, pp.167-179.
- DGEDA. 2005.** Direction Générale des Etudes et de Developpement Agricole. Ministere de l'Agriculture.
- DGPA. 2021.** Statistiques de la Direction Générale de Production Agricole. Ministere de l'Agriculture, des Ressources Hydrauliques et de la Peche Maritime.
- DGPA. 2020.** Statistiques de la Direction Générale de Production Agricole. Ministere de l'Agriculture, des Ressources Hydrauliques et de la Peche Maritime.
- DGPA. 2019.** Statistiques de la Direction Générale de Production Agricole. Ministere de l'Agriculture, des Ressources Hydrauliques et de la Peche Maritime.
- Escareno L. Salinas-Gonzalez H. Wurzinger M. Iniguez L. Solkner J. and Meza-Herrera C. 2012.** Dairy goat production systems, Status quo, perspectives, and challenges. *Trop Anim. Health Prod.* 2013, 45, pp. 17-34
- FAO 2019.** Food and Agriculture Organization of the United Nations statistical databases. Available from: <http://faostat.fao.org/>
- FAO, 2014.** International Dairy Federation, International Farm Comparison Network. World mapping of animal feeding systems in the dairy sector [Internet]. 2014. Available from: <http://www.fao.org/publications/card/en/c/3fe753e29f1f4397acde2bd25afb95b7/> [Accessed: March 6, 2022]
- FAO.2013 "FAOSTAT."** Retrieved July 2019, from <http://faostat.fao.org/>.
- Gaddour A. 2009.** Diversité et amélioration génétique de la population caprine locale dans les régions arides du sud tunisien. Thèse de doctorat, FST, 170 p.
- Gaddour A. Najari S. and Ouni M. 2008.** Amélioration de la production laitière caprine par le croisement d'absorption dans une oasis du Sud tunisien. *Revue Elev.Med. Vet. Pays trop.* 61, pp.57-62.
- Gaddour A. and Najari S. 2010.** Indices d'efficacité zootechnique des génotypes caprins issus d'un croisement dans les oasis du sud Tunisie. *Revue de MédecineVétérinaire*, 161, 6, pp. 255-263.
- Gelasakisa AI, Rosea G, and Giannakoua R 2017.** Typology and characteristics of dairy goat production systems in Greece. *Livest Sci.* 197:22–9. doi: 10.1016/j.livsci.2017.01.003.
- Gursoy O., 2006.** Economics and profitability of sheep and goat production in Turkey under new support regimes and market conditions *Small Ruminant Research*, 62, pp.181-191.
- Gereffi G. Humfrey J. and Sturgeon T. 2005.** The governance global value chains. In: *Review of International Political Economy*, vol.12, n°1, pp.78-104.
- I.R.A.M., 2020.** Institut des Regions Arides de Mednine, Tunisie. Capitalisation de l'experience tunisienne et valorizations des acquis dans le domaine du developpement des territoires pastoraux. *Revue des Régions Arides*, v 47(2/2020). Octobre 2020, 188p.
- Islam MA, Hossain MN, Chokraborti SS, Rahman S, Tasnim A. and Al Zahir A. 2018.** Socio-economic profile of goat rearing farmers and their management practices in Sylhet, Bangladesh. *J Agric Ecol Res Int.* (2018) 15:1–10. doi: 10.9734/JAERI/2018/43818
- Jemali M. and Villemot J.M. 1996.** L'expérience tunisienne en matière de filière lait caprin: Le projet d'intensification de l'élevage caprin laitier dans les oasis tunisiennes (PICO. /OEP-UCARDEC). Les perspectives de développement de la filière lait de chèvre dans le bassin méditerranéen. Etude FAO production et santé animales.
- Kadi S.A. Hassini F. Lounas N. and Mouhous A. 2013.** Caractérisation de l'élevage caprin dans la

- région montagneuse de Kabylie en Algérie. In : Chentouf M. (Ed), Lopez-Francos A. (Ed), Bengoumi M. (Ed), Gabina D. (Ed) « Technology creation and transfer in small ruminants : roles of research, development services and farmer associations ». Tangier, Morocco, 11 to 13 June 2013. Options méditerranéennes: Series A. Mediterranean Seminars. N°108, pp.451-456.
- Kukovics S, Horn P, and Baranyai G, 2016.** Sustainable goat farming in central and eastern Europe and Hungary. Libro de Actas de Sustainable goat breeding and goat farming in Central and Eastern European countries. Rome, Italy: Food and Agriculture Organization of the United Nations FAO; 2016. pp. 7–30.
- Kukovics.2014.** Sustainable Goat breeding and goat farming in Central and Eastern European countries. Proceedings of European Regional Conference on Goats Rome, Italy: Food and Agriculture Organization of the United Nations (FAO); 2014; p. 297
- Miller BA and Lu CD. 2019.** Current status of global dairy goat production: an overview. Asian Austr J Anim Sci. 32:1219–32. doi: 10.5713/ajas.19.0253
- Muigai, A. W., Okeyo, A. M., and Ojango, J. M. 2017.** Goat production in eastern Africa: practices, breed characteristics, and opportunities for their sustainability. In *Sustainable Goat Production in Adverse Environments: Volume I* (pp. 31-57). Springer, Cham.
- Nafti M. Khaldi Z. and Haddad B. 2016.** Genetic relationships and structure among goat populations from southern Tunisia assessed using microsatellites. Journal of new sciences, Agriculture and Biotechnology, 27 (5), pp. 1488-1497.
- Najari S. Gaddour A. Abdennebi M. Ben Hammouda M. and Khaldi G. 2011.** Systemes d'élevage des petits ruminants sur les parcours des regions arides tunisiennes. In: Khlij E. (ed.), Ben Hammouda M. (ed.), Gabina D. (Ed.). Mutations des systemes d'élevage des ovins et perspectives de leur durabilité. Zaragoza : CIHEAM/IRESA/OEP.p.61-65 (Options Méditerranéennes : Série A. Séminaires Méditerranéens ; n.97)
- Napoléone M. Ben Salem H. Boutonnet J.P. López-Francos A. Gabiña D. 2015.** The value chains of Mediterranean sheep and goat products. Organisation of the industry, marketing strategies, feeding and production systems. Zaragoza : CIHEAM, 2016. 705 p. (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 115). Joint Seminar of the Subnetworks on Nutrition and on Production Systems of the FAO-CIHEAM Network for Research and Development in Sheep and Goats, 2015/06/16-18, Montpellier (France). <http://om.ciheam.org/om/pdf/a115/a115.pdf>
- ODESYANO. 2018.** Office de Développement Sylvopastoral du Nord-Ouest. Orientations stratégiques de l'ODESYANO.
- ODESYANO. 2016.** Office de Développement Sylvopastoral du Nord-Ouest. Rapport d'Activité.
- ODESYANO. 2011.** Office de Développement Sylvopastoral du Nord-Ouest. Rapport d'Activité.
- ODESYANO. 2005.** Office de Développement Sylvopastoral du Nord-Ouest. Rapport d'Activité.
- ODESYANO. 2003.** Office de Développement Sylvopastoral du Nord-Ouest. Rapport d'Activité.
- OEP. 1991.** Office d'élevage et des pâturages. Rapport d'Activité, Projet EDIMO. 1988-1991.
- OEP. 1998.** Office d'élevage et des pâturages. Rapport d'Activité, Projet PICO.1993-1998.
- OEP. 2018.** Office d'élevage et des pâturages. Strategie de production de viande.
- Peacock C. 1996.** Improving goat production in the tropics: A Manual for Development workers. Published jointly by FARM- Africa and Oxfam (UK and Ireland), Oxfam, UK. 87 pp.
- Peters J. Helmer D. Von den Driesch A. and Sana-Segui.M., 1999.** Early Animal husbandry in the northern Levant. Paléorient. , 25, pp.27-48.
- Pirisi A.Lauret A. Dubeuf JP. 2007.** Basic and incentive payments for goat and sheep milk in relation to quality Small Ruminant Research, 68, pp.167-178.
- Poole N., Chitundu M. and Msoni R. 2013.** Commercialization: a meta-approach for agricultural

- development among smallholder farmers in Africa Food Policy, 41, 155-165
- Quittet E. 1977.** La chèvre, Guide de l'éleveur. La maison rustique(Eds). Paris,ISBN -27066-0017-9, pp. 18-20.
- Rouissi H. Chermiti H. and Mahouachi M. 2005.** Système d'élevage des petits ruminants. Kairouan, Tunisie, 4p.
- Ruiz Morales, F. A., Castel Genís, J. M., and Guerrero, Y. M. 2019.** Current status, challenges, and the way forward for dairy goat production in Europe. Asian-Australasian journal of animal sciences, 32(8), 1256–1265. <https://doi.org/10.5713/ajas.19.0327>
- Utaaker KS, Chaudhary S, Kifleyohannes T and Robertson LJ.2021.** Global Goat! Is the Expanding Goat Population an Important Reservoir of Cryptosporidium? Front. Vet. Sci. 8:648500. doi: 10.3389/fvets.2021.648500
- Villemot JM. 1995.** La chevre dans les oasis du sud tunisien. Réussir- chevre, N°209, pp. 39-42.
- Zeder MA and Hesse B. 2000.** The initial domestication of goats (*Capra hircus*) in the Zagros mountains 10.000 years ago. Science, 287(5461), pp. 2254-2257. In the state of the world's animal genetic resources for food and agriculture FAO Rome, 2007.
- Zeder MA. 2005.** A view from the Zagros: New perspectives in livestock domestication in the Fertile Crescent. In: The first steps of animal domestication. New archaeological approaches. (Eds. Vigne JD, Peter J, Helmer D). Oxbow Books, Oxford, UK. pp. 125-146.