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Original Research Article

Characteristics and Typology of Goat Herding Systems in Arid Oases of Tunisia and Their Adaptive Potentialities of Reproduction

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Abstract: To characterize goats in the Tunisian oases areas where agricultural purposes and practices and breeders' distributions allow a better understanding of the dynamics of goat herding, a survey was conducted among 226 farmers in Tunisian oases. In goat breeding systems in the Tunisian south, breeders are often multiactive, and interventions on herds and pastures are minimal. The reproduction type is traditional, a method of natural mating without any intervention from breeders. The average age of breeders was 52.4years. Illiterates represent more than 50%. The recorded rates of adult death and abortion in Tunisian oasis regions are equal to 1.5% and 1.44%, respectively, showing the technical skills of breeders. Three different systems were identified. The first type was the "preoasis and suburban" system, which includes farms located around oases and irrigated areas. This herding type is sedentary; the peak reproduction occurs in spring. Sixty percent of farmers exchange their bulks during the mating season. Farmers (92.5%) do not practice flushing or steaming. Another type of breeding is the "mountain" system, which includes farms at the mountains of the Tamerza chain in the Jerid region and some farms in periurban areas around the villages of Fatnassa and Bechni from Nefzawa. The last system is characterized by its "transhumance and desert", which mainly includes farms in the desert of Rjim Maatoug. It is a specialized transhumant system where animal husbandry is the main activity of income in this region.
Keywords: Goat/Breeding system/Typology/Zootechnical parameters/Adaptive potentialities/Oasis.

1. INTRODUCTION

Livestock farming in tropical and Mediterranean regions has several specificities. The most obvious is the nature of the ecological constraints on these systems. Thus, the raised species and the rearing lines are well adapted to climatic and pastoral conditions characterized as "difficult", marked by severe seasonal climate irregularities (Dedieu *et al*., 2011).

In Tunisia, goat farming remains an important activity. Its importance results from its adaptation to the majority of the country's agroecosystems, which is due to the hardiness of local goats on the one hand and the flexibility of production systems in relation to socioeconomic and land contexts on the other hand. This study investigates the characteristics of predominated goat breeding systems and productivity performance in southwestern Tunisia (Jerid and Nefzawa).

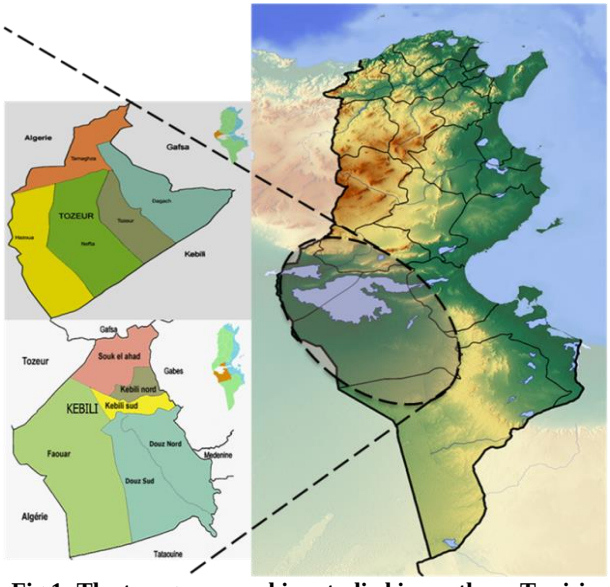

Fig 1: The two governorships studied in southern Tunisia

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2. MATERIALS AND METHODS

2.1 Study area

The study was carried out in two governorates of Tozeur (Jerid) (33°55′ North; 8°08′ East) and Kebili (Nefzawa) (33° 42′ 18″ North, 8° 57′ 54″ East). They are located in southern Tunisia and extend 2,767 million ha^2. This region borders the Gafsa governorate to the north, Algerian borders to the west, Tataouine governorate to the south and Gabes and Medenine governorates to the east (Figure 1).

2.2 Data collection

A structured interview type was used; the questions were formulated with the purpose of obtaining appropriate answers to fulfill the research objectives.

We focused on:

i. Structure of the farm (total area, utilized agricultural area (UAA), cropping system, buildings present, etc.).
ii. Livestock exploitation and feeding (type of feeding, access to pasture type of grazing, integration).
iii. Herd size and association with other species.
iv. Criteria of reproduction (fertility, prolificacy, etc.).
v. Productive aspects (productive season, kidding rate, productive level, etc.).
vi. Main productions and their destination.
vii. History of breeding genetics (provenance and breeder selection criteria).
viii. Economic importance of the various productions and the objectives of consequent selections.

2.3 Data analysis

2.3.1 Animal performances

Using the SAS software GLM procedure, we performed a multivariate variance analysis for the sex ratio, reproductive age, goat longevity, proliferation, fertility, adult mortality, and youth mortality, depending on the following factors: region, locality, type of exploitation, feeding system and age classes.

The ANOVA model is as follows:

$Y_{ijklmn} = \mu + Region_i + Locality_j + Rearing\ mode_k + Exploitation\ type_l + Feeding\ system_m + Age_n + \varepsilon_{ijklmn}$

Where:

Y_{ijklmn} = the quantitative variable studied (sex ratio, reproductive age, fertility rate, prolificacy rate, fecundity rate, abortion rate, adult mortality rate and youth mortality);
μ = general average of the population,
$Region_i$ = effect of the i^{th} region,
$Locality_j$ = effect of the j^{th} locality,
$Rearing\ mode_k$ = effect of the k^{th} rearing mode,
$Exploitation\ type_l$ = effect of l^{th} type of exploitation,
$Feeding\ system_m$ = effect of the m^{th} feeding system,
Age_n = effect of the n^{th} age group,
ε_{ijklmn} = residual error of mean = 0 and constant variance.

2.3.2 Typology of goat production systems

To establish a typology of the herds, a multivariate statistical analysis (multiple correspondence analyses) was performed using the same SAS software. Principal component analysis was used to produce uncorrelated variables (principal components), which were used for the consecutive cluster analysis.

3. RESULTS

3.1 Overview of goat breeding in Southwest of Tunisia

In goat farming systems in the Tunisian Southwest, the mean age of the respondents was 52.4 years. Farmers' level of education is generally low. The mean herd size of goats is 11.15 ± 8.9 heads per herd. Interventions of farmers on herds and pastures are minimal. Reproduction is traditionally performed by natural mating without any intervention of breeders.

3.2 Herd size

The total number of identified goats was 2518 heads held by 226 breeders. The average herd size in the oasis is 11.15 ± 8.9 heads per flock. It is 11.8 ± 9.5 heads per flock in the region of Tozeur (Jerid) and 10.5 ± 8.4 in the second region.

3.3 Sex ratio

Generally, the sex ratio varies by breed and farming system. In the case of a free mating system, it is necessary to predict 20 to 30 females per male. The sex ratio also depends on the age of the goat (ANOC 2002). Indeed, this ratio fluctuated on average from one buck for every ten to fourteen does.

3.4 Reasons for keeping goats

The breeding of sheep and goats in the Mediterranean Basin was closely related to crop production, stubble grazing and fallow. These husbandry practices were allowed, and even favored, by the positive effect they had on the fertility of the soil. In this study, we concluded that the major reasons for goat breeding are the production of manure required for oasis fertilization, the valuation of palm byproducts and the self-consumption of milk and meat.

3.5 Distribution of breeders

3.5.1 Distribution of the breeders according to education level and by sex

The majority of breeders were illiterate, with more than 50%, followed by those having a primary level of 31%. Graduate breeders represent 1.75%.

Goat breeders are mainly men, since they are the principal breeders responsible for agricultural tasks.

The male breeders represented92.7%. This rate is higher in the Nefzawa area with 94.7%.

3.5.2 Breeders' distribution according to the breeding mode

To respond to climatic, geographical, social and economic constraints or opportunities, breeders adopt modes of breeding, space and resource management, which adapt to different types of environments and associations with other activities (Dedieu *et al*., 2011). Three surveyed breeding modes, namely, the sedentary, semitranshumant and transhumant modes, were identified. The sedentary mode was the most common system, with a percentage of 80%, whereas the transhumant mode represented less than 20% of all goat herds in the study area.

3.6 Variation of zootechnical parameters

In the small ruminants sector, farm profitability depends primarily on the production efficiency of newborns. The most important factor affecting this efficiency is reproduction (Alexandre *et al*., 2010). In a small ruminant breeding system and the assessment of reproductive performance, fertility refers to the annual number of parturitions. However, the prolificacy is the number of young per litter.

3.7 Effect of breeding region, breeding mode, feeding system and age class on zootechnical parameters

Environmental effects are important and need to be taken into account for Tunisian local goat management and breeding improvement under harsh conditions (Ouni *et al*., 2010). Although the recorded rates of fertility, prolificacy and fecundity enumerated in the Jerid area were very acceptable (90.37%, 138.67% and 125.31%, respectively), they were slightly lower than those calculated in the Nefzawa region (94.03%, 140.27% and 131.89%, respectively). There were no significant differences between the studied areas (Table 1).

We enumerated four feeding systems: breeding systems based on the admission of green feeding with or without complementation and systems based on pasture with or without complementation. It is noted that the effect of the feeding system presents highly significant differences for the fertility, prolificacy and fecundity rates (Table 1).

The reproductive performances by goat age showed highly significant differences for both fertility and fecundity rates, but they showed nonsignificant differences at the prolificacy rate level (Table 1). Goats between 5 and 7 years of age show the most relevant performances in terms of fertility, prolificacy and fertility, at 93.07%, 145.63% and 137.58%, respectively. These parameters of very old goats (over 7 years old) decrease but remain more fertile than those of goats from 2 to 5 years old.

Table 1: Effect of variation of breeding region, breeding mode, feeding system, goat age and exploitation type on zootechnical parameters (fertility, prolificacy and fecundity rates)

Parameter	Fertility rate	Prolificacy rate	Fecundity rate
Breeding region	NS	NS	NS
Breeding mode	**	NS	**
Feeding system	**	**	***
Goat age	**	NS	*
Exploitation type	*	NS	**
NS: Non significative *: P<0.05 **: P<0.01 ***: P<*0.001*			

3.8 Typology

The typology covered the territory forming the major part of the Tunisian oasis region. In such areas, wide ranges of natural resource variants and livestock management have been identified.

3.8.1 Multiple correspondence analyses

Table 2: Variables and modalities used in multiple correspondence analysis

Variable	Modalities
Husbandry region	Nefzawa
	Jerid
Association Ovine/caprine	Yes
	No
Origin of the herd	Inheritance
	Purchase (market)
Feeding system	Green feeding (exclusively)
	Green feeding + complementation

	Pasture + complementation
	Pasture (exclusively)
Origin of bucks	Purchase
	Exchange
	Renewal
Steaming and/or flushing	Yes
	No
Season of kidding pics	Winter
	Spring
	Variable (all the year)
Longevity of bucks	< 4 years
	≥ 4 years
Longevity of does	2 < age < 7 years
	= 7 years
	>7 years
Type of exploitation	Extensive
	Semiextensive
	Family
Breeding mode	Transhumant
	Semitranshumant
	Sedentary
Fertility rate	FERT1< 90%
	FERT2> 90%
Fecundity rate	FECO1< 90%
	FECO2 90%< Fec2<120%
	FECO3> 120%
Prolificacy rate	PROL1< 120%
	PROL2 120%< prol2 < 200%
	PROL3>200%
Geographic location	El hamma
	Tozeur city
	Ibnchabbat
	Degueche
	Legwifla
	Nefta
	Tamerza
	Bechri
	Souk lahad
	Fatnassa
	Kebili city
	Douz
	Rjimmaatoug
	Jemna
	El Fawar
	Bechni
	Tombar

Multiple correspondence analyses, applied to 15 variables (Table 2) with 54 modalities, allowed discrimination of these modalities following three selected factors.

The first vertical axis was explained essentially by the following variables: geographical location, type of farming (essentially transhumance) and kidding season. The second horizontal axis was substantially explained by the fertility rate, prolificacy and feeding system. The third axis was explained by fertility rate, abortions and mortality rates and the sheep/goat association.

3.8.2 Hierarchical classification and clusters' description

Hierarchical cluster analysis was performed on all variables. Three groups were retained, conserving a variance between groups of 62.4% of the total variability. Figure 2 shows the three groups of farmers.

The numerical interpretation of the outputs and the graphic representation established by the multiple correspondence analyses suggest that goat farming in oases could be characterized by the presence of three main farming systems according predominantly to the zone and mode of breeding:

1. Preoasis and urban system
2. Mountain and peri-urban system
3. Transhumant and desert system.

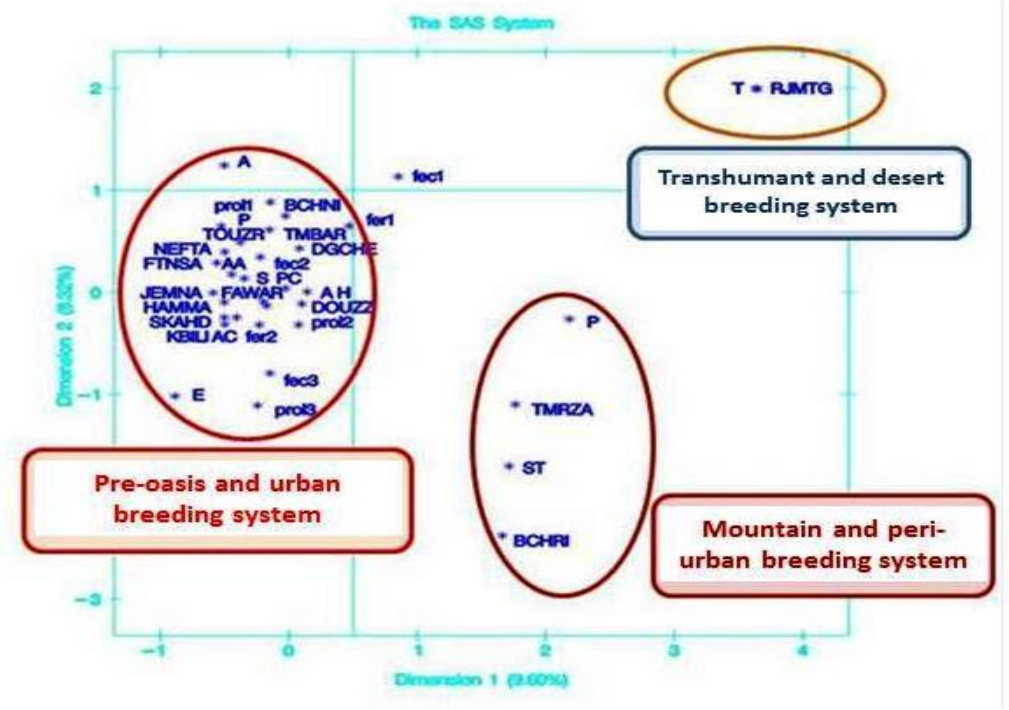

Fig 2: The three main farming systems' groups

3.8.2.1 Preoasis and urban system

This system includes goat herds located in the vicinity of oases and irrigated areas; it also includes herds grazing on the courses around the palm groves. Most of the farmers in the region belong to this system (76.5%). The breeding mode is sedentary. The peaks of reproductions occur in the spring. Sixty percent of breeders exchange their bucks during the mating season and target early kidding. More than 72% of goats are kept for more than seven years.

Flushing and steaming are generally practiced. In fact, we recorded fertility rates above 121% and prolificacy rates above 200%.

3.8.2.2 Mountain and peri-urban system

This system mainly includes goat herds in the mountains of Tamerza and some farms in peri-urban areas around the Fatnassa and Bechri villages. The breeding mode is sedentary to mostly semitranshumant. Reproduction is guaranteed by males acquired from the market or exchanged between neighboring breeders. The births are autumnal. Dams are bred early enough, while males are only used late.

Flushing and steaming are rarely practiced. The fertility rates vary between 90 and 120%, and the prolificacy rate varies between 120% and 200%.

3.8.2.3 Transhumant and desert system

This system essentially includes herds of the desert zone of Rjim Maatoug. Herds of this system are generally old (because they are often inherited). The long period of breeding explains the specialization of certain families in pastoral breeding. The breeders practice transhumance in 90% of the cases according to the state of the routes (courses) of the region and the zones of destinations, fodder and water availability. The recorded fertility rates are the lowest, or even poor, less than 90% in most herds. The prolificacy rates found are approximately 100 to 120%.

4. DISCUSSION

4.1 Descriptive characteristics of herds and animals

Goat breeders are often multiactive. Dossa *et al*., (2015), Tesfaye *et al*., (2012) and Semakula *et al*., (2010) quoted this breeder's multiple activities among small ruminant breeders in West Africa, Uganda and Ethiopia. Additionally, Manirakiza *et al*., (2020) reported that in Burundi, the main source of income in most farms surveyed (84.4%) came from agricultural products, while 15.6% had other off-farm activities. Uncontrolled natural mating is the dominant system of reproduction, and bucks and does kept together throughout the year. Similar results were found by (Tesfaye *et al*., 2012 and Abraham *et al*., 2017) in Uganda and Ethiopia. Approximately 98.9% of breeders

allow mating of relatives (buck mate his mother and siblings) in Mandura, Metekel Zone, Ethiopia (Alebel *et al*., 2020). The average age of the breeders was 52.4 years, which was the same situation in the semiarid region of northeastern Brazil, with an average age of 52.2 years (Guilherme *et al*., 2017). For all the surveyed farmers, 73% were aged between 30 and 60 years, 13% were of advanced age (over 60 years) and 10% were aged between 15 and 30 years. This is slightly different from reported results by Srour *et al*., (2006) in Lebanon, where the majority age class is between 34 and 70 years. In Morocco, it is 30-75 years (Chentouf *et al*., 2005), while in Portugal, it is between 45 and 64 years (Pacheco 2002). Almost half of the sample farmers (51.6%) were between 30 and 50 years old, 24.8% were between 50 and 60 years old, 15.7% were over 60 years old and 7.9% were less than 30 years old (Manirakiza *et al*., 2020)

4.2 Herd size

It is important here to note that the size of goat herds is increasing, as mentioned by Rekik *et al*., (1996), when they stated that in Tunisia, sedentary goat keepers of the oases of Nefta and Tozeur usually keep five does in smallholding together with sheep or dairy cattle". Similar sizes of herds were found in Burkina Faso, Nigeria and Mali, with an average size of 11.5 goats (Dossa *et al*., 2015). A very close average herd size of goat smallholders was also found in Kano, Nigeria, with 15.5 goats (Akpa *et al*., 2010). Other researchers mentioned that an average household in northern Tanzania was 29.2 goats, with the majority keeping less than 20 goats (Nguluma *et al*., 2020).

4.3 Sex ratio

Alves *et al*., (2014) found that 1:20-1:40 male-to-female ratios in a 45-day mating season are sufficient for generating high rates of pregnancy without significant differences.

The sex ratio in our study was low (0.07-0.1) because herds were small holds. Additionally, the sex ratio in the visited herds varies according to the type of exploitation, the locality and the feeding system and the age at first mating. However, there were no significant differences by exploitation type, area, locality, or feeding system in the study area.

4.4 Reasons for keeping goats

Goats considered being a source of income throughout the year and contributing to the provision of family needs, mainly milk and meat. Rekik *et al*., (1996) mentioned that in Tunisia, sedentary goat keepers of the oases of Nefta and Tozeur usually keep five does in smallholding together with sheep or dairy cattle to provide income to households from the sale of meat, while milk is used for human consumption. Additionally, in Algeria in the Saharan regions, local goat populations are raised for their milk and meat (Djouza and Chehma 2018). In warm regions, farming systems incorporate important economic and social issues beyond even terms directly to livestock production. Animals, as family capital but also as a source of savings, income, and as a factor of production (animal, labor, manure), thus constitute precious goods, often more valuable than in the intensive contexts of temperate countries (Alary *et al*., 2011).

Manirakiza *et al*., (2020) indicated close results that the first goal in keeping goats was either selling them (24.3%), both selling them and producing manure (47.6%), or producing manure exclusively (28.1%). Most of the goat keepers (69.9%) used litter to increase the quantity of manure for crop fertilization. A similar remark was noticed with Ethiopian farmers, where the most important purpose of goat production in the study area was milk utilization (Tesfaye *et al*., 2012). Additionally, Abraham *et al*., (2017) cited that in northern Ethiopia, the most frequently reported reason for keeping goats was cash income generation followed by milk and meat production for home use. In Botswana (Monau *et al*., 2017), over 80% of the farmers kept goats for cash required for tuition, school uniforms and household commodities as well as restocking of animals.

More than 89% of the breeders of the region of Nefzawa practice goat breeding to produce manure. The same ascertainment was noticed for 59% of breeders in the Jerid area.

4.5 Distribution of breeders

4.5.1 Distribution of the breeders according to the education level

Similar results were shown in Kadi *et al*., (2013), who asserted that the academic level of goat owners in Algeria was very low; 39.36% of the breeders were illiterate without any academic level, 32% had an average education level and 25% had a primary education level. Only one breeder had a high level education. For agricultural training, only 3.19% did training courses. Farmers' level of education was generally low, with 57.4% not going beyond primary school, 21.6% followed informal schooling, 13.8% had no schooling at all and therefore were illiterate, and 7.2% had reached secondary school (Manirakiza *et al*., 2020).

In Turkey, the average mean educational level was 5.18 years, with 25.33 years of farming experience (Gül *et al*., 2016).

4.5.3 Distribution of breeders by sex

In the Jerid area, women's contribution was of prime importance, especially at home. However, their involvement in agricultural works is insubstantial (Rekik *et al*., 1996). This situation was observed in the state of Paraíba, a semiarid region of northeastern Brazil in a study; from 62 surveyed farms, 60 were men and two were women (Guilherme *et al*., 2017).

Abraham *et al*., (2017) noted that 98.67% of male breeders. In Burundi, most goat breeders (85.3%) were men, while others were widows (Manirakiza *et al*., 2020).

4.5.3 Breeders' distribution according to the breeding mode

Nomadic and Transhumance systems were very popular in the Mediterranean and East Anatolian regions of Turkey. However, modern sedentary production systems have been a recent trend in goat production, replacing these time-old traditions. The two traditional systems use all family members to take an active role in the management activities of the herd (Daskiran *et al*., 2017).

4.6 Variation of zootechnical parameters

This traditional mode of reproduction is also the most applied in Algeria, with a percentage of almost 96% (Kadi *et al*., 2013). The fertility rate of 92.2% is higher than most of the previous studies (Ben Said 1992; Ben Salem and Ben Hammouda, 1995; Rekik *et al*., 1996) in Tunisia and in neighboring Mediterranean countries (Chentouf *et al*., 2006; Arrebola Molina *et al*., 2009). Breed and lambing seasons interacted to produce effects on the birth weight of offspring, although lambing season alone did not have a significant effect on Boer and Kalahari Red goats (Kandiwa *et al*., 2020).

The fecundity rate is quite high, with a value of 128.6% in all visited farms, with a maximum of 156% confirmed by Ammar *et al*., (2011) in southern Tunisia goat breeding. In addition, these fecundity rates border up or exceed the rates found by Ben Salem and Ben Hammouda (1995), Arrebola Molina *et al*., (2009), Hassani (1997) and Belhassan *et al*., (1998).

4.7 Effect of breeding region, breeding mode, feeding system and age class on zootechnical parameters

The goat is experiencing a revival of undoubted zootechnical interest. Indeed, the goat is a short-cycle species that can live in the rather difficult conditions of the Sahelian zone, where the forage available rarely exceeds eight months in the year (Fernandez 2006). Goats are well adapted to the dry areas they have conquered thanks to their good resistance to rinderpest and heat stress (EMVT 1989).

In addition, it was found that a higher feeding level of Payoya goats allowed better sexual behavior in bucks when the male effect was used on the local livestock to breed females (Zarazaga *et al*., 2009).

At the breeding mode level, a significant variation was found only with fertility and fecundity, which confirms that prolificacy is a breed characteristic. The decrease in fertility and fecundity rates in the transhumant mode can be explained by the fact that the goat is an active animal on pasture and cut significant distances and by the brawls that took place between them at the watering points, especially in the last months of pregnancy.

As clearly noticeable, there were no significant differences between the studied areas in countries with high environmental diversity, such as Brazil (Lopez *et al*., 2012). The parity groups 2–5 were 1.8 times more likely ($P < 0.05$) to become pregnant than primiparous goats and animals with more than five parturitions (Mellado *et al*., 2006).

Primiparous goats were half as likely to become pregnant as were multiparous goats. In contrast, does in parity groups 2–5 were 1.8 times more likely ($P < 0.05$) to become pregnant than all other goats (Mellado *et al*., 2006). This can be justified partially by the fact that the risk of stillbirth was lower ($P < 0.05$) in goats with fewer than six parturitions (Mellado *et al*., 2006). This trend of improvement in zootechnical performance with age was also noted with black Bengal goats, with average litter sizes in the 1st, 2nd, 3rd and 4th parities of 1.29, 1.71, 1.87 and 2.17, respectively (Chowdhury *et al*., 2002). Additionally, for dairy goats, age has a great influence on milk production. The age of the dam significantly affected the average milk production, with the onset of production being the age of 2.0 years, reaching a peak at the age of 6.5 years (Mburu *et al*., 2014).

4.8 Typology

A typological study of the pastoral farming of small ruminants conducted by Najari *et al*., (2011) in Tunisian arid regions illustrated the impacts of socioeconomic changes on the structures and technical functioning of the sector. The data collected were analyzed by multiple correspondence analyses and discriminated 4 main sheep and goat farming systems: a system grouping the breeding of the desert zones, a system located on the courses of Ouara and Dhahars, a system consisting of peri-urban herds and the last system is located in oases and irrigated areas.

The same classification (according to agroecological zones and mode of exploitation) was cited by Manirakiza *et al*., (2020), who stated that cluster analysis of the goat production systems resulted in two opposed groups and one intermediate. On the one hand, there are dry lowland systems characterized by large herds composed mainly of indigenous animals grazing freely and having high market characteristics. On the other hand, there are humid highland systems characterized by small herds composed of indigenous and crossbred animals and by low market characteristics. Laouadi *et al*., (2018) affirmed in a multivariate analysis the categorization of goat farming in the Laghouat region into three groups corresponding to three different farming systems: cluster 1 (pastoral system), cluster 2 (mixed crop-livestock system) and cluster 3 (small herds in zero grazing system).

Chentouf *et al*., (2004) described a comparable typology of goat farms in the Chefchaouen region of northern Morocco according to the criteria of geographical location, herd size and type of production. Devendra (2007) and Dedieu *et al*., (2011) stated that livestock systems can be classified according to the available resources, occupations, or pedo climatic conditions. All these typologies reveal diversity between extensive pastoral and intensive confined livestock farms or between subsistence and strictly commercial farms. In Lebanon, small ruminant farming systems have been discriminated mainly by farm and herd structure, fodder system management and rangelands, irrigation characteristics and economic balance through factorial analysis undertaken by Srour *et al*., (2006).

4.9 Adaptive potentialities of reproduction under arid conditions

Adaptation is presented as a very complex set of characters; it manifests itself in the behavior, morphology and productive abilities of the animal. When other characteristics condition productivity, hardiness contributes to the survival of the animal, which must first live, even if it does not produce. In addition, it is by living in the same environment that generations of an animal group could settle the hardiness genes. The natural selection process allowed the native goat population to develop variability in hardiness characteristics. Hence, this made it an authentic genetic heritage endowed with a continual evolution in favor of adaptation. The local goat populations are considered to be meat-based, without, moreover, having considerable growth and weight. Indeed, they are suckling breeds. The recorded performances represent a synthesis of animal potentialities and those of an arid, hot and restrictive environment (Alexandre *et al*., 1997 and Gromela *et al*., 1998).

In fact, studies carried out on several goat genotypes in the oases of arid regions (Najari *et al*., 1996 and Najari *et al*., 2000) have shown that the weight at birth has a tight relationship with the genetic group. Additionally, the results obtained by Mellado *et al*., (2006) in their study about factors affecting the reproductive performance of goats in a hot arid environment supported the idea that hot dry weather favors the reproductive performance of goats. Furthermore, Benjelloun (2015) identified several sets of candidate variants, genes and biological processes in small ruminants that are likely involved in local adaptation to various eco-climatic conditions. Nevertheless, Yang *et al*., (2016) reported that their study offers novel insights into rapid genomic adaptations to extreme environments and provides a valuable resource for future research on livestock breeding in response to climate change when they deduced that certain positively selected genes are functionally relevant to a specific environment and could also facilitate high-altitude and arid adaptive processes. These results are in accordance with the recorded performances at the level of our study of good zootechnical parameters of local goats well adapted to their ecotype (in the two studied oasis zones) without significant differences between them. However, significant differences were noted at the level of breeding modes, feeding systems, types of exploitation and, to a lesser degree, the age of goats. Such performances illustrate the genetic and physiological compromise between reproductive and adaptive potentialities. It also requires sufficient knowledge of the genetic parameters and the modalities of genotype*arid environment interactions (Steinbach 1987).

In hot and irregular climate regions, particular emphasis should be placed on the repeatability of genotype responses to the large margin of variation in environmental components that affect production (Najari *et al*., 2000). Consistent performances express the capacity of breeds to buffer the irregularity of the breeding environment and facilitate their management (Najari *et al*., 2003).

5. CONCLUSIONS

Goats play an important socioeconomic role in many marginal rural areas of the world. Indigenous goat breeds have played an important role in the livelihood strategies of impoverished farmers. They are also valued for their productive performance, adaptation and disease resistance (Daskiran *et al*., 2017).

On the whole, goat farming in southern Tunisia has often been considered traditional because of the lack of adequate infrastructure and the low use of concentrate feeding and veterinary inputs. Genetic resources encountered in the area show a dominance of local breeds. The present study also revealed that there are three types of farming systems in the area: preoasis and urban systems, mountain and peri-urban farming systems and transhumant and desert farming systems.

The characterization of the local goat farming systems and their reproductive abilities makes it possible to apply some recommendations to improve the productivity of local goat farming. Among the possible ways in this regard is the improvement of the genetic potentialities of the population. In particular, local goats are more profitable in each breeding system, either by increasing production or by reducing losses of herds. In addition, the lack of suitable methodologies of selection for arid areas and animal populations makes it difficult to detail these improvement plans (Owen 1987).

Therefore, our recommendations will be limited to certain proposals and ideas that allowed for a more rational exploitation of the genetic structure of our goat population. It is therefore an attempt to match the

genetic potential of the local goat to the conditions, objectives and resources of each rearing system by exploiting certain performances more than others for each case. Simultaneously, simple and feasible selection schemes were developed for each production scenario, taking into account scientific knowledge, technical specificities and practical arrangements. Additionally, to ensure the sustainability of indigenous goat genetic resources, some conservation methods could be implemented. The successful implementation of these strategies requires the active involvement of farmers, researchers, policy makers, and nongovernmental and international institutions by developing and supporting various policy issues.

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