

# Agro-Pastoral Systems And Socioeconomic Dynamics Of Camel Husbandry In The Djelfa Steppe Region Of Algeria

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## Abstract

Camel breeding holds significant importance in the steppe regions of Algeria, with Djelfa being a key area for the integration of agro-pastoral practices and socio-economic dynamics. This study explores how camel farming contributes to livelihoods and adapts to environmental and economic changes. To evaluate camel farming practices by focusing on herd composition, management systems, and socio-economic impacts, as well as to identify breeder typologies while addressing environmental adaptation strategies. A structured socio-professional questionnaire was administered to 38 farms located in the Djelfa region and its surroundings. Data analysis utilized Multiple Correspondence Analysis (MCA) and Hierarchical Ascendant Classification (HAC) to establish farming typologies influenced by demographic and educational factors. The survey highlights the predominance of the Ouled-Nail breed, well-adapted to local conditions, accompanied by secondary breeds such as Aftouh and Chaambi. Herds, composed of 73% females, are primarily oriented towards milk production, which is essential for the local economy. Young camels, accounting for 41% of the herd, illustrate the sustainability and renewal of the stock. This study identifies three breeder typologies, influenced by age, habitat, and education level. Older breeders favor semi-intensive systems with fixed habitats, while younger ones adopt mobile extensive practices. Intermediate breeders, with more advanced education, implement intensive systems integrating modern techniques. Camel farming supports the economy and the well-being of local populations while ensuring the sustainability of steppe ecosystems.

**Keywords:** Camel farming, steppe production systems, agro-pastoral sustainability, socio-economic impact, Djelfa.

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## INTRODUCTION

Camel breeding (*Camelus dromedarius*) plays a central role in Algeria's agricultural economy, particularly in the Saharan regions where these animals, renowned for their resilience, thrive despite the harsh desert conditions. Camels represent an invaluable resource, providing not only meat and milk but also means of transportation. They also hold a significant place in the tourism industry, especially for cultural and Saharan tours [1]. Furthermore, this activity supports the livelihoods of nomadic and semi-nomadic populations while preserving their traditional ways of life in the face of challenges such as water scarcity and extreme climatic conditions [2].

In Algeria, although 93.5% of camels are found in the Saharan regions, mainly in the provinces of Tamanrasset, Adrar, Ghardaïa, Ouargla, and Biskra, the steppe regions, notably Djelfa and Laghouat, also host a portion of this population [3]. Traditionally, camel breeding systems have been classified based on herd mobility nomadic, transhumant and sedentary although this categorization is becoming less relevant in describing the current evolution of production systems [4]. A growing trend towards sedentarization is also observed, with increased utilization of pastures near farms [5].

The camel population in Algeria reached approximately 440,000 individuals in 2023, with an annual growth rate of 4% [5,6]. The Djelfa province accounted for 1,250 camels in 2021 [7]. Despite a marked increase in camels in Algeria and globally, research on camel breeding remains relatively limited compared to other livestock species. Existing studies on camel breeding systems in Algeria, many authors emphasise the opportunities and constraints of the sector, while others highlight the need for further research into

feeding regimes and management systems [1, 2, 5, 8, 9]. Moreover, Trabelsi et al (2012) et Chehma et al., (2023) explored the ecological impact of camels, particularly their role in seed dispersal and the regeneration of Saharan vegetation [10,11].

The present study examines the central role of camel breeding in steppe production systems and its socio-economic impact on local populations. It provides a detailed analysis of practices and dynamics within camel breeding systems in the central Algerian steppe, with a particular focus on the Djelfa region, based on a structured socio-professional questionnaire with closed-ended questions.

## 1. METHODOLOGY

### 1.1. Study Region

The Djelfa region, located in north-central Algeria, is a transitional area between the Sahara in the south and the Tell Atlas Mountains in the north. This region, characterized by high plateaus and semi-arid plains, experiences a semi-arid climate with hot, dry summers and moderately cold winters. Annual rainfall ranges from 200 to 400 millimeters, influencing both agricultural and pastoral practices.

The flora is dominated by species adapted to semi-arid conditions, such as *Stipa tenacissima* (Esparto grass) and *Artemisia herba-alba* (White wormwood), which are essential for preventing soil erosion and providing fodder for livestock. The fauna includes various rodents, reptiles, and birds, all well adapted to the environment.

Djelfa is renowned for its distinct pastoral practices, playing a crucial role in the local economy and in sustainable land management amid challenges like desertification and climate change.

Camel and sheep farming are the primary economic activities, integrated into an agro-pastoral lifestyle. In addition, drought-resistant crops such as barley and wheat are cultivated, while the production of camel milk and wool enriches the regional economy.

The mixed population includes Bedouin communities and more settled groups, rich in pastoral traditions, with flourishing festivals and handicrafts. The hospitality and solidarity of these communities are notable traits, celebrated during traditional festivals.

For this study, nine stations were selected, including seven within Djelfa and two in the surrounding region, representing various breeding systems (nomadic, semi-nomadic, and sedentary). Active participation from breeders and accessibility were crucial to obtaining reliable and representative data (Fig. 1).

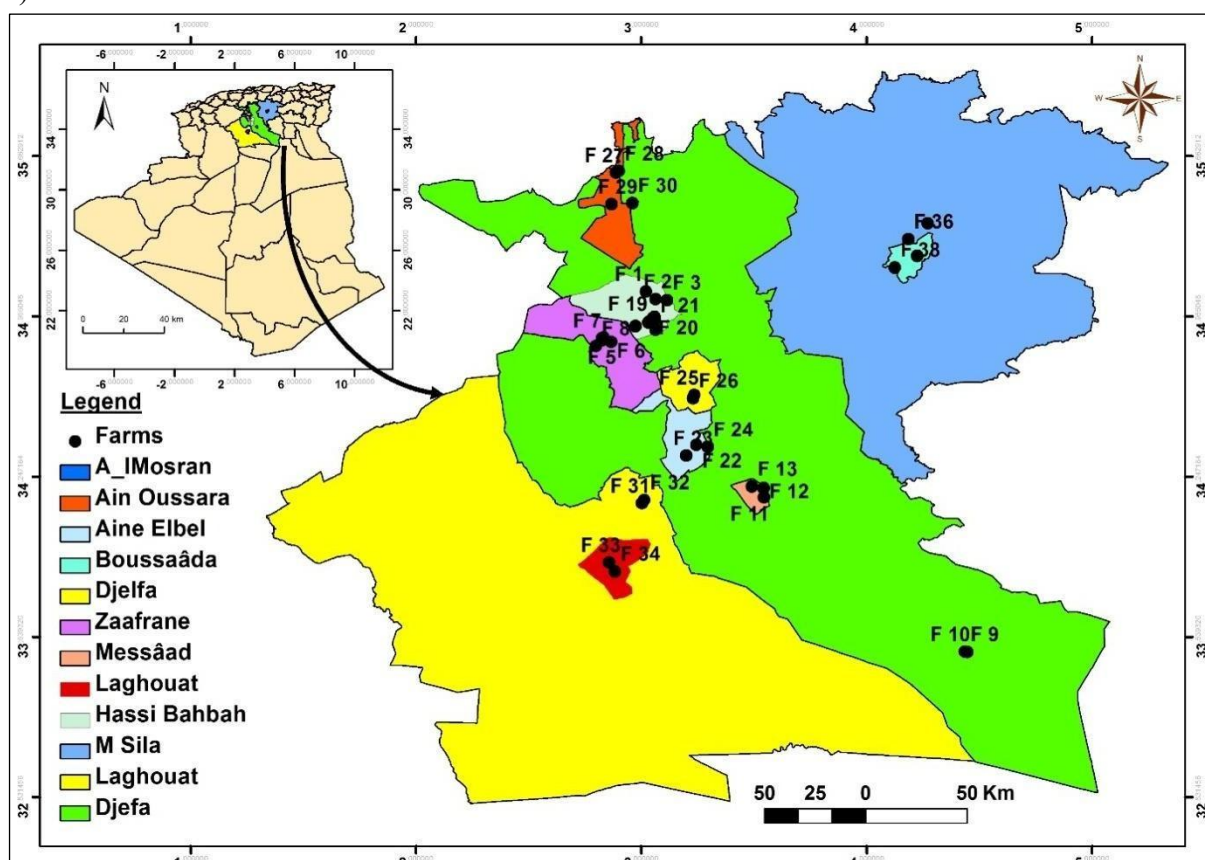


Figure 1. Geographic map of the study stations

### 1.2. Data collection

This descriptive study aims to evaluate the camel population and its role in agro-pastoral practices. Thirty-eight farms in Djelfa were studied over a three-year period using a structured socio-professional questionnaire with closed-ended questions. The questionnaire covered parameters such as breeding methods, breeder profiles, herd structure, and challenges associated with camel farming (Table 1).

The data were analyzed thematically to highlight specific trends and challenges, with the aim of informing future strategies for camel conservation and the improvement of local pastoral practices.

### 1.3. Statistical analysis

Qualitative data from the surveys were subjected to multivariate analysis, including Multiple Correspondence Analysis (MCA) and Hierarchical Ascendant Classification (HAC) of the top five factors. Contributive variables to the classes derived from HAC were identified through Chi2 tests. The sex ratio, being the only quantitative data, was transformed into a qualitative variable. Only variables significant at the 0.05 threshold were retained for interpretation. The analyses were conducted using XLstat software (©Addinsoft 2024).

**Table 1.** Variables and modalities studied in the survey

Variables	Categories	Description
<b>Habitat</b>	Mobile (tent)	Nomadic lifestyle with temporary shelter.
	Sedentary (fixed)	Permanent residence in urban or rural areas.
<b>Farming system</b>	Extensive	Based on natural pastures with minimal human intervention
	Semi-intensive	Combination of natural pastures and supplemental feeding.
	Intensive	Use of modern techniques to maximize production.
<b>Type of dromedary</b>	Ouled Nail	Adapted to arid steppe conditions
	Aftouh	Native to Tindouf, robust and suited for transporting heavy goods.
	Sidi Cheikh	Originating from M'sila, excellent for milk production.
	Chaambi	From Biskra, resilient and used for milk, meat, and wool production.
<b>Herd composition</b>	Females	Dominance of females for reproduction and milk production.
	Males	Mostly slaughtered or used for other purposes
	Young	Camels < 4 years old.
	Adults	Camels aged 4 to 9 years, the optimal production period.
	Elders	Camels > 9 years, often reserved for reproduction or slaughter
<b>Type of feeding</b>	Forage	Feed provided to animals, such as dried grasses
	Grazing	Food obtained directly from natural pastures
	Local plants	Examples: <i>Acacia raddiana</i> , <i>Zilla spinosa</i> , <i>Tamarix aphylla</i>
<b>Farming objectives</b>	Milk	Production for consumption and sale of milk
	Meat	Production for consumption and sale of meat.
	Wool	Production for textiles and sale.
	Reproduction	Maintenance and improvement of the breed
	Work	Use for transport and other activities
	Socio-cultural	Ancestral heritage and socio-religious beliefs
	Environmental	Enhancement of specific pastures and preservation of the ecosystem

<b>Main activities</b>	Small ruminant farming	Production of goats or sheep, often complementing camel farming to diversify income.
	Other agricultural activities	Subsistence or commercial crops, such as cereals, vegetables, or fruit trees.
	Urban commerce	Sale of livestock products (meat, milk, wool) or other goods in urban markets.
	Exclusive camel farming	Specialization in camel farming to meet specific goals, such as milk or reproduction
<b>Constraints</b>	Overgrazing	Excessive pasture use, where the number of animals exceeds the land's regenerative capacity, leading to soil and plant degradation.
	Drought	Frequent, complicating access to water and agricultural production.
	Water access	Significant distances to find available water sources.
	Diseases	Multiparasitism, tick infestation, etc.

## 2. RESULTS

### 2.1. Descriptive analysis: breeders' profile

#### 2.1.1. Age and education level

In the Djelfa region, camel farming relies on a well-defined social and family structure. This activity is primarily carried out by older men, highlighting the younger generations' lack of interest in this profession. However, breeders over the age of 60 continue their activities with passion, demonstrating their attachment to agro-pastoral practices. All breeders are married and have between five and seven children, who often participate in farming tasks and agricultural activities, thereby perpetuating family traditions (Table 2).

Camel breeders in Djelfa generally have two permanent residences: one in the city and another in the countryside on tribal lands. They divide their time between these two lifestyles. Four breeders from outside the region (representing 10.5% of the 38 breeders studied) live in a bungalow or tent without their families but with two or three assistants from the same tribe. These assistants take charge of breeding tasks for a set period before returning to their home cities, where they are replaced by another group.

A shift from rural to urban lifestyles has been observed, with breeders favoring modern homes in the city. In response, the State has implemented a rural housing support program over the last two decades to curb this migration. Breeders involve their families in agro-pastoral activities, saving labor costs and ensuring reliable herd management.

Breeders adopt various pastoral mobility practices to adapt to changing conditions in the steppe, including seasonal movements to find pastures and water resources (transhumance). Approximately 70% of breeders in Djelfa practice this method to optimize resource use.

**Table 2.** Distribution of factors related to breeders

Stations	N.	Age (years)			Habitat		Activities	
		< 30	30-60	> 60	Fixed	Tent	AS	AM
Hassi Bahbah	3	0	2	1	2	1	1	2
Zaafrane	5	0	2	3	5	0	0	5
Messaad	5	0	1	4	3	2	0	5
Mousrane	8	1	2	5	7	1	2	6
Ain-Elbil	3	0	1	2	3	0	2	1
Djelfa	2	1	1	0	2	0	0	2
Ain-Oussara	4	1	1	2	0	4	4	0
Laghout	4	1	1	2	3	1	1	3

<b>Boussaâda</b>	4	0	2	2	2	2	2	2
<b>Total</b>	38	4	13	21	27	11	12	26
AS: Livestock farming only, AM: mixed activity (Livestock farming + agriculture or Livestock farming + trade).								

### 2.1.2. Education levels

In the field, camel breeders in the Djelfa region exhibit a moderate level of education, ranging from religious knowledge of the Quran and Hadith learned in "Zawiya" to primary and sometimes secondary education. Some breeders have no formal education. Despite the lack of technical training in farming, these breeders acquire the necessary skills directly on-site. They excel in breeding operations, meeting the needs of their herds and improving farm profitability, particularly in milk and wool production.

Given the rural socio-economic context of the time and the breeders' advanced age, it is understandable that they lack a high level of education. Formal training is often perceived as a waste of time and money, with breeders preferring to pass down and acquire farming know-how through family traditions at no cost. None of the respondents possess a university degree or specialized training.

This educational profile directly influences breeding practices and methods, underscoring the importance of tradition and practical experience in managing camel herds.

### 2.1.3. Diversification of activities among Djelfa breeders

In the Djelfa region, camel farming is often a complementary activity. About 69% of breeders (26 out of 38) diversify their income sources by raising other animals (notably sheep), engaging in agricultural activities including cereal cultivation, or practicing urban trades. This diversification reflects a pragmatic adaptation to local economic challenges. The remaining 31% focus exclusively on camel farming for camel milk and wool (louaber) production as their primary source of income. On pastures, farming activities are mainly carried out by the owner or a family member (95% of cases).

The primary activities of breeders who participated in the survey are distributed as follows:

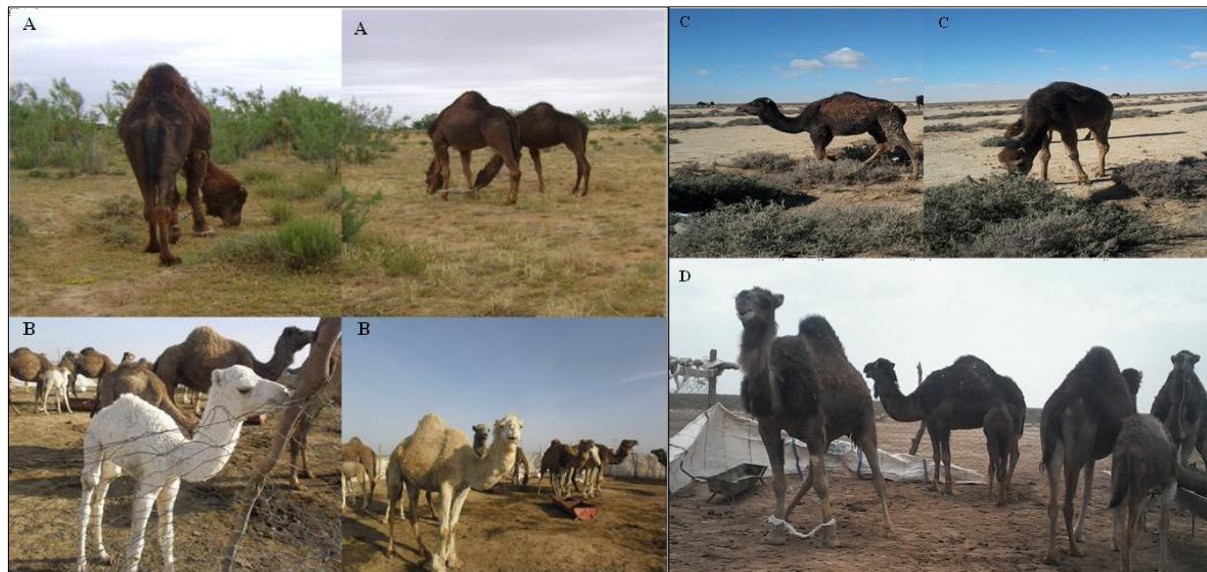
- Small ruminant farming (34%): Mainly focused on sheep, which helps mitigate risks (health or climatic) across different species.
- Other agricultural activities (21%): Especially cereal cultivation, which diversifies income sources and ensures efficient use of agricultural lands.
- Urban commerce (13%): Though practiced by a minority, it integrates breeders into the local economy.
- Exclusive camel farming (32%): Highlighting the importance of this activity as a primary source of income for many rural inhabitants of the Wilaya.
- This distribution of activities reflects the local population's ability to adapt to the various economic opportunities in the region.

## 2.2. Status of camel farming

### 2.2.1. Types of Camels

In addition to the predominance of a local camel type raised by Djelfa inhabitants (the Ouled-Nail type), there are three main camel types identified by surveyed breeders (Aftouh, Sidi-Cheikh, and Chaambi), showcasing the richness and diversity of camel breeding in the region, with each type offering specific characteristics and uses:

- **Ouled-Nail (Steppe Camel)**: Adapted to the arid conditions of the steppe, this resilient camel can travel long distances without water. Its well-developed hump stores ample fat, ensuring survival during periods of food scarcity (Fig. 2a). It is mainly used for transport but also valued for its milk and meat, with the milk noted for its high nutritional value.
- **Aftouh (Native to Tindouf)**: Robust and well-suited to Saharan conditions, this camel tolerates extreme temperatures and very dry environments. Its size and strength make it an excellent pack animal (Fig. 2b), often transporting heavy goods over long desert distances. It is also appreciated for its meat and milk.
- **Sidi-Cheikh (From M'sila)**: Known for good milk production, this lighter camel is adapted to semi-arid climates. Often smaller than other types, it remains very resilient (Fig. 2c). Breeders also value its meat.
- **Chaambi (Originating from Biskra)**: Renowned for its high resilience and adaptability to semi-arid environments, this camel has a robust physical constitution, enabling it to withstand drought periods (Fig. 2d). It is used both for milk production and as a pack animal. Its wool is highly sought after for local textile manufacturing.



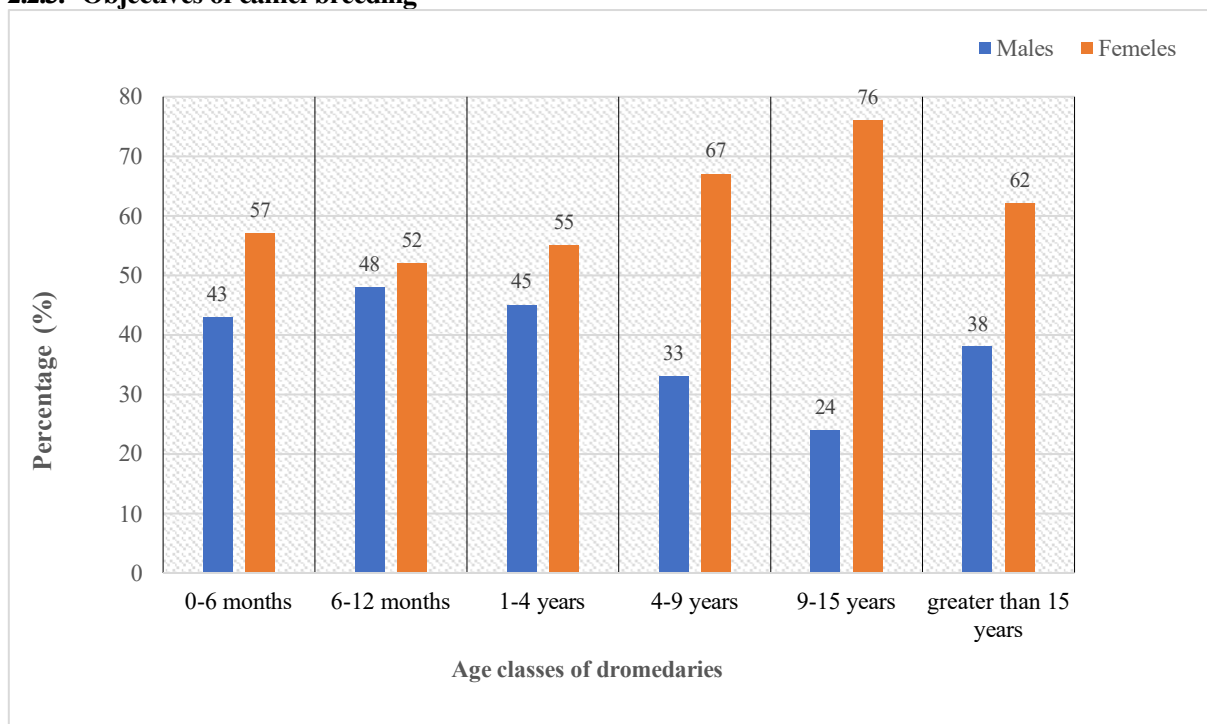
**Figure 2.** Photographs of camel breeds in the Djelfa region: (a) Ouled-Nail, (b) Aftouh, (c) Sidi-Cheikh, (d) Chaambi

### 2.2.2. Herd composition

In all the farms studied, the herd size does not exceed 50 animals. This structural limitation has a direct influence on management practices, in particular the selection of males for slaughter and the conservation of females for breeding. The proportion of females in herds is higher than males across all age groups (Fig. 3). Due to the sale of surplus males for slaughter, the proportion of females is significantly higher in the 4-9- and 9-15-year age categories. Sex ratios vary considerably between farms, ranging from 1.2 to 1.86. This indicates diversity in herd composition, particularly in reproduction and exploitation management.

**Figure 3.** Distribution of age classes of the dromedaries studied according to sex

### 2.2.3. Objectives of camel breeding



Camel farming in the area is primarily considered a source of income for the majority of breeders (69%), through the sale of camel milk and wool, as camel meat is less appreciated by local consumers.

Twenty-one percent of breeders claim to raise these animals purely due to socio-religious beliefs, viewing the camel, like the horse, as a noble animal and a precious ancestral legacy. For the remaining 10%, camel farming is valued for its environmental role. Certain pastures are not utilized by other livestock due to specific vegetation (halophytic/thorny plants) found in areas such as Sebkhia, Zaafrane and the Salt Rock of Djelfa.

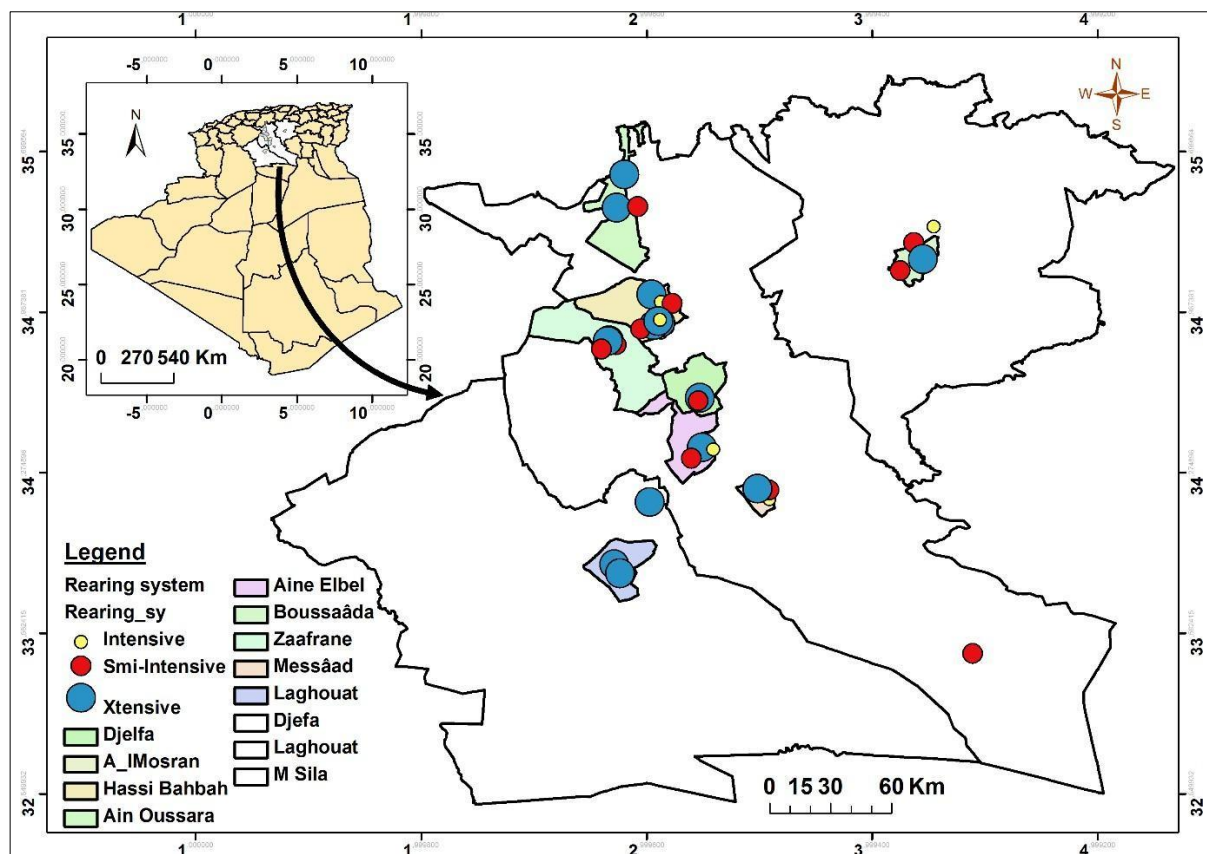
#### 2.2.4. Major types of camel breeding

Three breeding systems extensive, semi-intensive, and intensive are represented in the study area (Fig. 4). Three systems are uniformly distributed across the region with no apparent geographic gradient.

- **Extensive system:** Represented in blue, this is the dominant system in the Djelfa region. Extensive camel farms are typically located in rural and semi-arid areas with limited resources. In farms like Hassi Bahbah and Zaafrane, camels are raised freely (H'mil system) on vast stretches of land, relying mainly on natural pastures. This system is well-suited to the region's climatic and environmental conditions, enabling sustainable resource management.

- **Semi-Intensive system:** Indicated in red on the map, this system is found in specific areas where conditions allow for a combination of natural pastures and supplemental feeding. Semi-intensive farms around Ain-Oussara often benefit from better access to water and agricultural infrastructure, allowing more controlled camel farming.

- **Intensive system:** Represented in yellow, this is the least common system in the region. This type of farming is concentrated in specific localities where resources and infrastructure support intensive production. For instance, intensive farms near Boussaâda use modern feeding and management techniques to maximize camel milk and meat production. Only two farms use an animal identification system, enabling better traceability and streamlined herd monitoring.



**Figure 4.** Location of farms in Djelfa and neighboring areas according to the livestock system

#### 2.2.4. Criteria and constraints of camel farms

The constraints are primarily related to feeding (i) and health issues (ii).

(i) **Feeding Constraints:** Camels in Djelfa primarily feed on various plant species adapted to arid conditions. These include:

*Acacia raddiana*: A common acacia in arid steppe regions, its leaves and pods are nutritious.

*Zilla spinosa*: A thorny plant found in deserts and steppes, consumed for its leaves.

*Salsola foetida*: A halophytic shrub that grows in saline and arid soils of the steppe.

*Tamarixaphylla*: A tamarisk found in oases and desert environments, valued for its leaves and bark.

*Stipagrostis pungens*: A grass commonly found in arid and semi-arid regions, also known as "desert grass."

These plants, well-suited to steppe conditions, provide adequate nutrition for camels, contributing to their resilience in this challenging environment.

In addition to their natural diet, camels in farms may receive hay and concentrated feed to supplement their nutrition. Hay, typically made from dried grasses, serves as a vital source of fiber and nutrients. Concentrated feed, on the other hand, is specially formulated to provide essential vitamins and minerals for camel health.

However, in Djelfa, hay availability can be problematic due to difficult climatic conditions, recurrent droughts, and increased competition with cereal cultivation. The quality of hay can also be affected, leading to reduced nutritional value. Moreover, grazing degradation due to overgrazing (affecting 60% of grazing areas), frequent droughts, and land management policies exacerbate feeding constraints. Limited access to water is another major challenge, particularly during drought periods. Breeders often have to travel long distances to access water points.

Governmental and local initiatives offer training and subsidies to improve herd management practices. Research and innovation focus on enhancing camel management and health practices. Technological advancements, such as GPS tracking systems and mobile phone usage, allow breeders to manage their movements and resource utilization more efficiently, optimizing production and profitability.

Most surveyed breeders, 83%, are private landowners, while the remaining 17% are landless tenants who utilize grazing land through an annual rental system. Landowner breeders living in the steppe often combine cereal cultivation with camel farming. In recent years, there has been a trend towards vegetable and fruit cultivation, while preserving the tradition of domestic animal farming.

(ii) **Health Constraints:** Health issues in the area are similar to those observed in other camel farming regions and include:

- Multi-parasitism among adults, affecting approximately 72% of animals,
- Tick infestation, reported by 85% of breeders,
- Scabies, affecting around 68% of herds,
- Diarrhea in camel calves, observed in 78% of cases,
- Ringworm, a common fungal infection affecting about 62% of animals.

It is notable that over 90% of surveyed breeders have observed these conditions in their herds, considering health problems as a major constraint. However, the majority (87%) never report sick animals, which poses a challenge for herd health management.

### **2.2.5. Economic importance of camel production**

Camel farms play an essential role in the local economy through the production of milk, meat, and leather:

- **Camel milk:** Sold for between 500 and 700 DA per liter, it represents a significant source of income for breeders. With a female/male (F/M) sex ratio of 1.39 in Djelfa, the number of lactating females can be estimated at approximately 824. Each lactating female produces around 5 to 7 liters of milk per day, translating to a daily production of 4,120 to 5,768 liters and an annual production of 1.504 to 2.106 million liters, valued at 752 to 1,474 million DA (approximately €5.3 to €10.5 million).

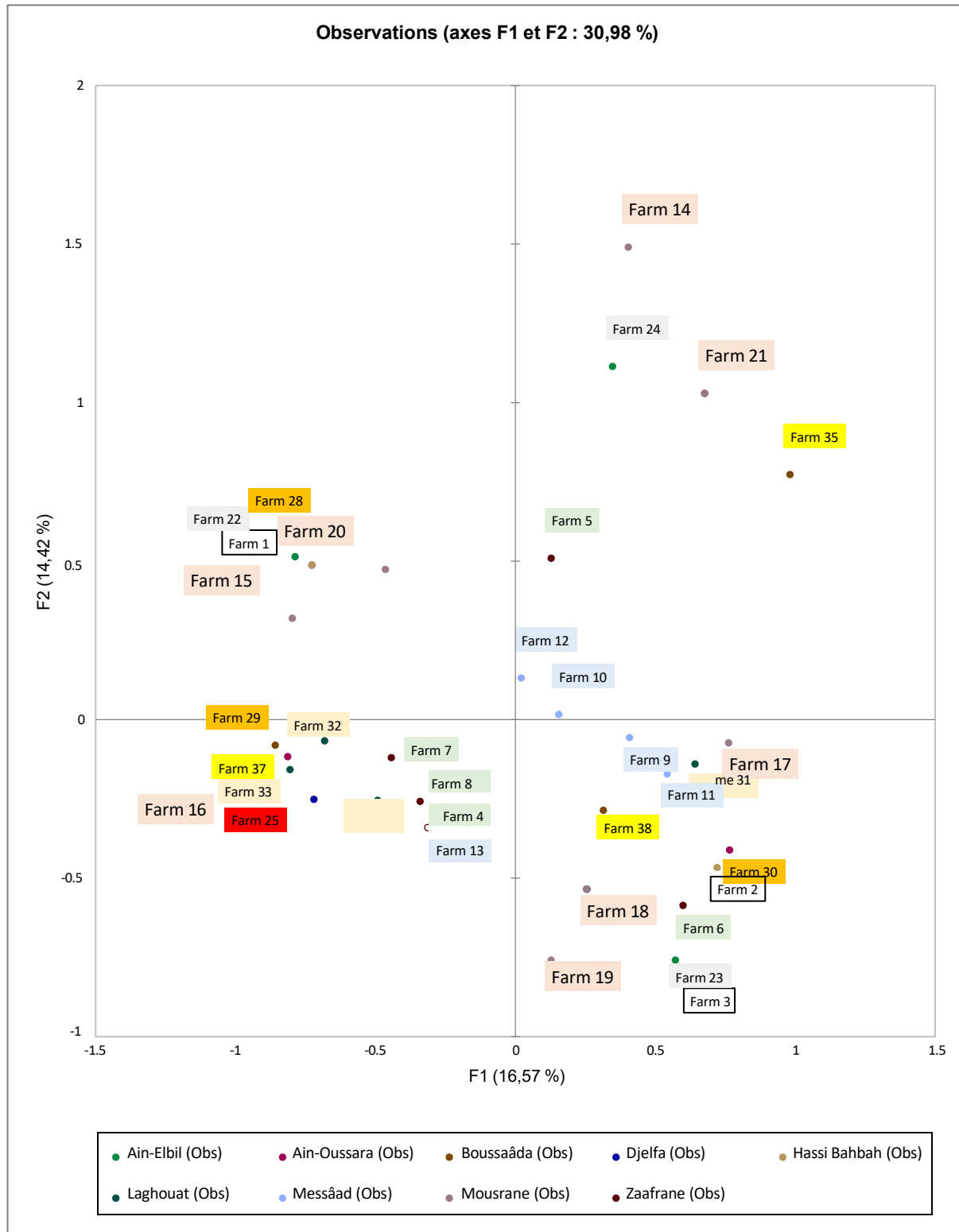
- **Meat and leather:** On average, a camel provides around 150 kg of meat and 40 kg of leather. For a herd of 1,250 camels with a slaughter rate of about 10% in Algeria [6], this equates to an annual production of 18.75 tons of meat and 5 tons of leather. In terms of value, meat production, estimated at an average price of 1,500 DA per kilogram (about €9/kg), represents approximately 28.13 million DA (around €168,750). Leather production, valued at 500 DA per piece (around €3/piece), contributes 2.5 million DA (about €15,000). Thus, the combined value of these two resources reaches approximately 30.63 million DA (€183,750) annually, underscoring the strategic importance of camel farming for the local economy.

This activity not only provides a source of income for breeders but also offers opportunities for the development of derivative industries, such as leather processing and meat commercialization.

### 2.3. Statistical typology

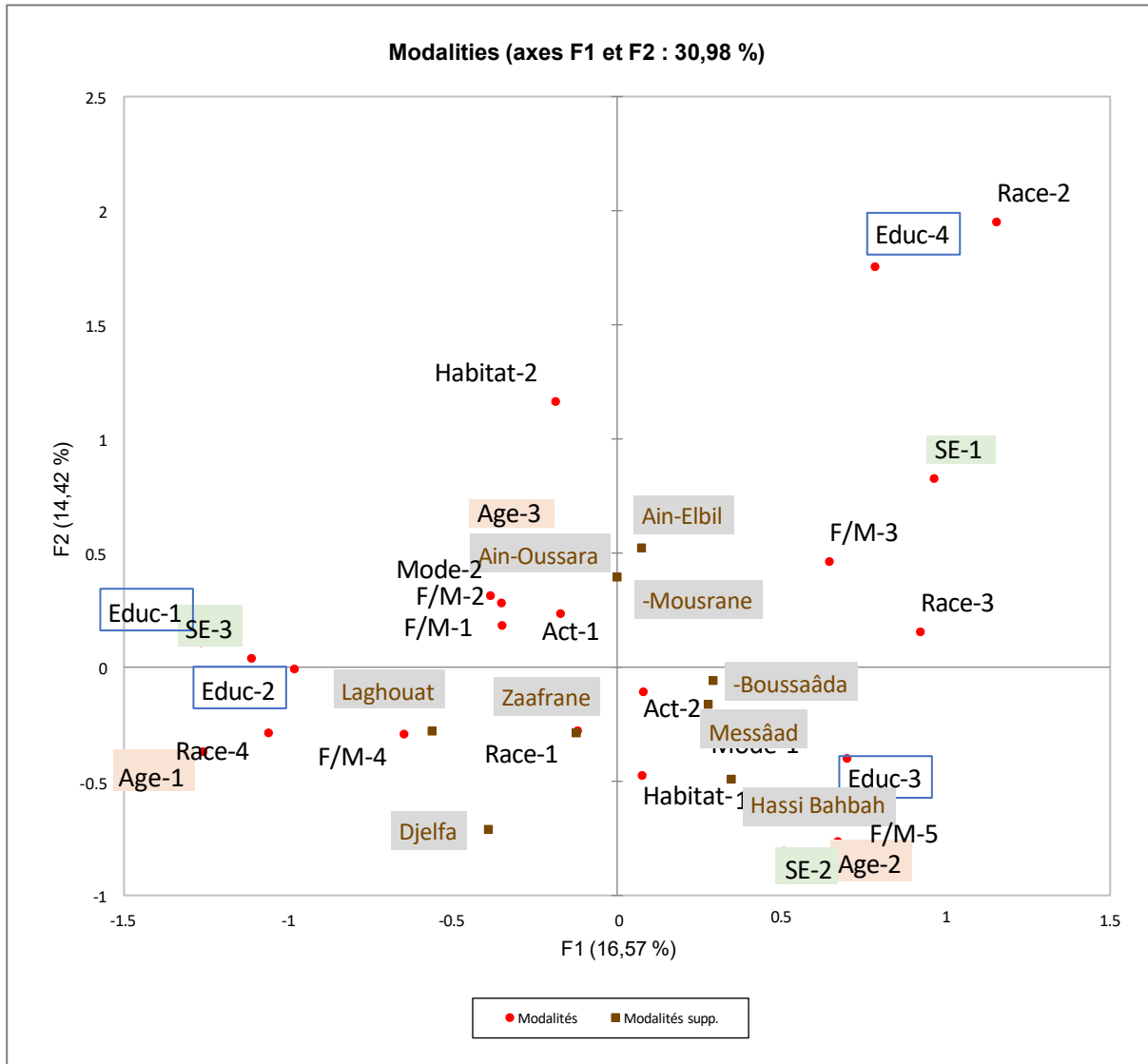
#### 2.3.1. Multiple correspondence analysis

The Multiple Correspondence Analysis (MCA) reveals that the studied variables exhibit weak correlations, indicating a relatively weak data structure. The projection of the various stations on the main factorial plane shows a limited effect of geographical positioning. However, a notable opposition is observed along



the main factor between the stations of Bou-saada, Messaad, and Hassi Bahbah on the right, and the stations of Laghouat, Djelfa, and Zaafrane on the left of the factorial plane (Fig. 5).

**Figure 5.** Projections of the active variables and the additional variable on the factorial plane (F1, F2) representing 31% of the total inertia.



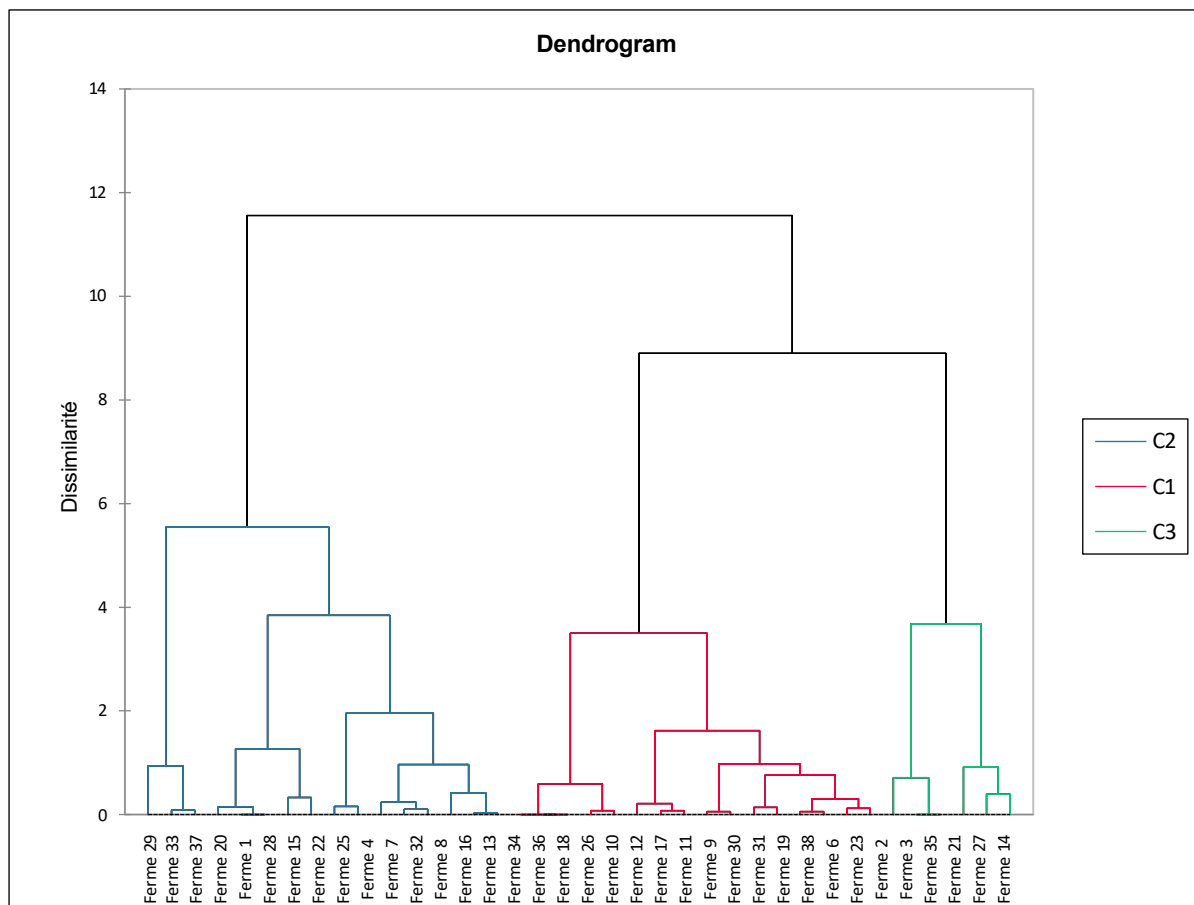
The distribution of the 35 farms on the same factorial plane shows that farms from the same station (represented by the same color) are relatively close to each other. However, this does not apply to all stations (Fig. 6).

**Figure 6.** Projection of individuals (farms) onto the main factorial plane (1,2). Farms of the same color belong to the same station.

### 2.3.2. Automatic classification

The dendrogram from the automatic classification identifies three main classes corresponding to 30% of the total variance (Fig. 7).

These classes reflect the diversity of farming practices in the Djelfa region and reveal groupings based on shared characteristics of the farms. The contingency table crossing the three classes with other active and supplementary variables highlights the following connections, based on significant Chi2 tests (Table 3). The variables retained to define these three classes are breeder age, housing, education level, farming system, and camel breeds used.



**Figure 7.** Dissimilarity dendrogram resulting from the automatic classification applied to the factor table (the first 5 representing nearly 63% of the initial inertia).

Non-significant variables, such as "Stations," "Activities," "Sex ratio," and "Lifestyle," did not show statistically significant links with the three identified classes, suggesting that they do not have a marked differential impact on camel farming types (Table 3).

**Table 3.** Distribution of factors related to breeders

Variables	Chi-square value	P
Stations	9,672	0,883 -NS
Age	13,908	0,008**
Habitat	6,296	0,043*
Activities	0,589	0,745 -NS
Sex ratio	12,817	0,118 -NS
Breeding system	47,896	<0,0001***
Lifestyle	2,102	0,350 -NS
Education	56,417	<0,0001***
Type of dromedaries	29,949	<0,0001***

### 2.3.3. Description of the three types of breeders

- Type 1: The oldest breeders, mostly living in fixed residences, adopting a semi-intensive system, with a primary education level, and primarily raising Ouled-Nail and Sidi-Cheikh camels.
- Type 2: Younger breeders, mostly living in tents, adopting an extensive system, with a low education level, and primarily raising Ouled-Nail and Chaambi camels.

- Type 3: Breeders of intermediate age (30–60 years), living in tents, adopting an intensive system, with a secondary education level, and raising Aftouh camels.

### 3. DISCUSSION

#### 3.1. Parameters of camel farming typology

Typological analyses of camel farming conducted in Morocco [12] Mauritania [13] and Algeria [14] highlight, similar to our findings, the diversity of camel farming practices. The three types of farming identified in Djelfa shed light on the different strategies adopted by breeders, shaped by various contextual factors, both extrinsic (climatic conditions, public policies) and intrinsic (personal choices, access to available resources) [2,15]. The main takeaway of the present study seems to be the prominent role of the generational status of breeders rather than their geographical location. There is indeed a close link between the breeder's age, lifestyle, and practices.

The three types of livestock farming identified in Djelfa (extensive, semi-intensive and intensive) reflect an organization based on land use patterns, whereas in Ouargla [16], the classification is based more on the socio-economic profiles of camel drivers. In the latter region, herders fall into distinct groups according to their trajectories and economic objectives (breeder-breeders, opportunists, conservers and meharists), illustrating a gradual transition between nomadism and sedentarization. In Djelfa, access to natural resources and pastoral management determine breeding strategies, while in Ouargla, proximity to urban centers has favored intensification and specialization. This diversity of practices, also observed in Morocco and Mauritania, highlights the impact of environmental, generational and socio-economic factors on the evolution of camel farming.

For instance, the older breeders (Type 1) mainly reside in fixed dwellings and practice a semi-intensive system to partially mitigate the aridity of their environment, as already observed by Gherissi (2019) in other regions of the Algerian Sahara such as El-Oued and Ouargla [17]. In contrast, younger breeders (Type 2), who live in tents, adopt a nomadic lifestyle and extensive practices, influenced by environmental conditions and resource availability. Through their mobility, they adapt to the constraints of arid climates. Lastly, intermediate-aged breeders (30 to 60 years), corresponding to Type 3, practice an intensive system, relying on their technical motivation supported by a higher level of education, with most having completed secondary studies. Consequently, they adopt more modern management techniques (e.g., access to supplemental feeding) to address the challenges of pasture scarcity [18].

This generational effect on camel farming practices has been observed in other regions, such as Saudi Arabia, Somalia, and Ethiopia, where camel farming is dominated by older generations, while the younger individuals often pursue alternative careers, influenced notably by urbanization [19,20]. However, the dominance of "elders" does not exclude younger family members (including children) from participating in farming tasks. This traditional practice, common in many rural communities worldwide, ensures the transmission of traditional knowledge [21].

Education levels also represent a distinguishing factor in camel farming types. Education is generally limited to religious teachings or primary education. This aligns with findings in other camel farming regions where formal education is scarce, and practical learning is prioritized [22]. The reliance on family traditions for farming knowledge is a common theme in pastoral societies, as also noted in studies conducted in Sudan and Kenya [23]. Meynard and Dourmad (2020) have similarly highlighted that breeders' education levels can significantly influence farming practices and productivity. For example, breeders with higher education levels may be more inclined to adopt modern management practices and select camel breeds better suited to local conditions. Additionally, those with access to educational and technical resources can optimize herd productivity by better understanding camels' nutritional and health needs [24].

The third distinguishing factor in farming types is the camel ecotypes raised, reflecting a certain phenotypic diversity that enables adaptation to local health and environmental contexts. Similar phenotypic distinctions have been documented in India, where different ecotypes appear adapted to specific environmental conditions [25]. However, in Algeria, this phenotypic diversity is not generally based on differentiated genotypes [26].

Conversely, the sex ratio did not distinguish the farming types identified through classification, although it can provide insights into the purposes of farming. A large predominance of females may indicate a focus on milk production, while a higher proportion of males may suggest a preference for fattening young males

for slaughter. According to the MADR report (2021), females accounted for approximately 68% of the total camel population in Djelfa, with an average ratio of 1.78, higher than that of our sample [7]. The milk-oriented vocation of herds in the Wilaya of Djelfa, including within our sample, appears widespread but not exclusive. Indeed, traditional camel farming tends to be multi-purpose [27], with milk specialization emerging alongside intensification and the commercialization of camel milk [28].

Some geographical variability is observed, with a notable opposition between certain farms on the main factorial plane. Specifically, significant differences are observed between the stations of Bou-saada, Messaad, and Hassi Bahbah on one side, and Laghouat, Djelfa, and Zaafrane on the other. This opposition could be explained by ecological differences, such as variations in available natural resources, and socio-economic factors, including local infrastructure and levels of economic development.

The Algerian steppe is marked by significant environmental contrasts among the study stations. For instance, Bou-saada, Messaad, and Hassi Bahbah experience lower rainfall and increased soil salinization, severely affecting water resource availability and pasture productivity. Vegetation in these areas mainly comprises drought-resistant plants, such as Alfa grass. On the other hand, the stations of Laghouat, Djelfa, and Zaafrane receive slightly higher rainfall and are less affected by desertification, fostering a richer vegetation diversity and more productive agriculture. These environmental differences may result in varying farming practices between stations, compounded by other factors such as breeders' individual characteristics (generation, objectives). However, it seems that camel farming practices are more influenced by socio-economic and educational factors than geographical location.

Studies by Kamili et al., (2020) and Julien et al., (2021) in Morocco emphasize that farming practices and agro-pastoral systems are often shaped by the specific environmental and socio-economic contexts of each region, particularly access to water and pastures [29,30].

Herd size varies from region to region, influenced by ecological, economic and cultural factors. In this study, herds in the Algerian steppe were limited to less than 50 head, suggesting more restricted management with moderate resources and more controlled access to pasture. In contrast, in the desert region of Ain Beida, the Châambas manage herds of up to 500 head, an extensive breeding strategy favored by a more arid environment requiring extensive movement to ensure the animals' subsistence. This disparity reflects distinct management styles: while the small herds of the steppe are probably adapted to family or semi-commercial farming, the large herds of the desert respond to an economic rationale more focused on production and mobility. Climatic impact, resource availability and traditional practices thus shape differentiated strategies between these two zones, illustrating the adaptation of herders to the constraints of their territory [16].

### **3.2. Socio-Economic importance**

Although camel breeders in the region attribute cultural and religious significance to camel farming, economic objectives remain predominant [8]. Breeders in Djelfa derive their income from the sale of milk, animals for slaughter, and, to a lesser extent, wool. The growing importance of camel milk sales aligns with current global trends [31]. In many parts of the world, camel milk is highly sought after for its dietary properties and its real or perceived health benefits. Moreover, trends toward milk specialization are observed in many regions worldwide, including Algeria [32,33].

For instance, in their study of dairy camel farms in Ghardaia, Bensemaoune et al., (2018) demonstrate a degree of specialization aimed at maximizing animal productivity, such as housing, feeding and herd renewal management [2]. In Djelfa, a "mixed" system predominates, strongly marked by family participation, with a predominance of the local "Ouled-Nail" camel type and farming practices drawn to the high economic value of camel milk, though not exclusively so. Herds are small, not exceeding fifty individuals, and are primarily managed by private landowners. While Ghardaia focuses on milk specialization, Djelfa maintains agro-pastoral traditions with particular attention to resource management and a strong community approach.

### **3.3. Health challenges**

Camels in Djelfa face various health challenges, including gastrointestinal parasites. Studies by scientists such as Bekele (2002), Ibrahim et al. (2016) and Bouragba et al. (2020) show that these parasites have a significant impact on herd health and complicate management efforts. Parasitic infections are widespread and diverse. Analysis of parasitic infections in camels reveals high rates of multi-parasitism, which is consistent with the findings of numerous other researches [34,35,36].

The importance of parasitism can be attributed to several factors: (i) local environmental conditions, particularly grazing practices that may promote the spread of parasites due to insufficient turnover ; (ii) animal management and antiparasitic treatment techniques, often based on traditional knowledge, which are inadequate for effectively controlling parasitic infections ; (iii) the density and interactions within herds, facilitating parasite transmission. Furthermore, disease monitoring and reporting practices, which appear to be limited, also contribute to the high prevalence of infections, as breeders do not always report illnesses, thereby delaying necessary medical interventions.

## CONCLUSION

This study highlights observable trends across the Saharan region, extending beyond Algeria. The crucial role of camel farming in the agro-pastoral systems of the steppes emerges as an essential lever, not only for ecological sustainability but also for the socio-economic well-being of local populations. Indeed, this activity reflects a diversity of farming practices influenced by breeders' socio-economic and educational factors and demonstrates remarkable adaptability in the face of environmental and economic challenges. In this context, the commercialization of camel milk, as well as by-products such as wool, represents a major asset. This shift toward a more market-oriented pastoral economy strengthens breeders' motivation to maintain these traditional practices while meeting the growing needs of local communities. The farming types, primarily distinguished by breeders' age and education levels, reveal varied adaptation strategies, with a trend toward intensification, notably through the use of supplemental feeding to counteract the scarcity of pastoral resources.

To be sustainable, camel farming development plans crafted by agricultural development organizations must fully integrate the central role of this activity in the steppes and its positive impact on local populations. Promoting camel products, particularly camel milk, is essential to make it an economic engine for pastoral systems in the steppes while ensuring the longevity of this millennia-old tradition.

## Conflicts Of Interest

The study was conducted without any conflicts of interest.

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## REFERENCES

- [1] Adamou, A., and Faye, B. (2007). Camel breeding in Algeria: constraints and development prospects. *Cahiers Du CREAD*, 77-97.
- [2] Bensemaoune, Y., Beziou, S., Senoussi, A., and Chehma, A. (2018). The Camel Breeding System in the Ghardaïa Region: Situation and Perspectives. *BioResources Review*, (8)2, 21-33.
- [3] Sadoud, M., Nefnouf, F., and Hafaoui, F. Z. (2019). Camel meat in two regions of southern Algeria. *Meat and Meat Products Reference*, 1-11.
- [4] Faye B., (2018). What future for camel pastoralism in the world? Proc. The 5th Conference ISOCARD "Recent advances in camelids biology, health and Production", 12-15 Nov. 2018, Laâyoune, Morocco (A. Sghiri et F. Kichou Eds), IAV Hassan II, 32-38
- [5] Moula, N. (2023). Camel Breeding in Algeria. *Biol. Life Sci. Forum*, 22(1), 4. <https://doi.org/10.3390/blsf2023022004>
- [6] Food and Agriculture Organization- FAO. (2025). *World Food and Agriculture- Statistical Yearbook 2025*. 418p. Rome. ISBN: 978-92-5-140174-3. <https://doi.org/10.4060/cd4313en>
- [7] Ministry of Agriculture and Rural Development of Algeria- MARD. (2021). *Agricultural statistics, Area and production*. MADR, Directorate of Agricultural Statistics and Information Systems, series "B" (2019), 1-87. <https://madr.gov.dz/wp-content/uploads/2022/04/SERIE-B-2019.pdf>
- [8] Abazi, A., Senoussi, A., and Faye, B. (2023). The Mehari camels (*Camelus dromedarius*) in the Algerian northern Sahara: what are its characteristics and what types of farming vocations adopted in the Ouargla region? *Journal of Camelid Science*, 17(i), 1-12. <http://www.isocard.info/en/journal>
- [9] Boukhechem, S., Dib, A. L., Bougherara, H., Bouaziz, A., Kadja, L., Ghougal, K., Oubira, I., Chari, Z., Kerrou, N. S., Lamri, M., Lakhdara, N., and Bererhi, E. H. (2023). Breeding and Nutrition of Camels in Algeria, 5.
- [10] <https://doi.org/10.3390/blsf2023022005>
- [11] Trabelsi, H., Senoussi, A., and Chehma, A. (2012). Study of the dissemination of seeds of spontaneous plants in the feces of dromedaries in the northern Algerian Sahara. *Drought*, 23(2), 94-101. <https://doi.org/10.1684/sec.2012.0338>
- [12] Chehma, A., Mahma, H., Trabelsi, H., and Huguenin, J. (2023). Place of the Dromedary in the Ecological Balance of Its Saharan Ecosystem. *Biology and Life Sciences Forum*, 22(7), 7. <https://doi.org/10.3390/blsf2023022007>

- [13] Kamili, A., Faye, B., Saïd Tligui, N., Bengoumi, M. (2020). Typology of camel breeding systems in southern Morocco. *Breeding systems and supply chains*, 73 (2) : 71-80. <https://doi.org/10.19182/remvt.31862>
- [14] Biya, M. B., Ahmed, M. S. C., Dieye, C. Y., Diop, A. K. M., Mohamed, R. B., Salem, M. M., Sidatt, M., Elemine, K. M. S., Mohamed, M. S., N'Diaye, F. B., Meiloud, G., Konuspaveva, G., and Faye, B. (2021). Descriptive typology of camel farming system in Mauritania. *Livestock Research for Rural Development*, 33(3), 1-18. <http://www.lrrd.org/lrrd33/3/bjfaye3344.html>
- [15] Bedda, H., Hamdi, I., Babelhadj, B., Benbessisse, Y., and Adamou, A. (2024). Newly adopted dromedary husbandry systems and breeding practices in the Algerian northern Sahara. *Review of Livestock and Veterinary Medicine in Tropical Countries*, 77.. <https://doi.org/10.19182/remvt.37448>
- [16] Bensmira, Z., Bouju, S., Benchaben, H., Bensmira, M., Penin, M.L., and Noûs, C. (2020). Adaptation strategies of agropastoralists in the Algerian steppe in the face of climate change (case of the Ras El Ma region). *Cahiers d'Outre-Mer*, LXXIII (282), 205-236. <https://doi.org/10.4000/com.12259>
- [17] Abazi, A., and Senoussi, A. (2025). Typology and trajectories of camel farms in the Ouargla region, south-east Algeria. *Review of Livestock and Veterinary Medicine in Tropical Countries*, 78, 36967. <https://doi.org/10.19182/remvt.36967>
- [18] Gherissi, D. E. (2019). Characterization and function of reproduction in the Algerian dromedary. PhD thesis, University of Mohamed Chérif Messaadia - Souk Ahras, 137p (in french).
- [19] Meyer, C. (2009). Reproduction of large and small domestic camelids: Bibliographic note, 1-18. Cirad.
- [20] <https://agritrop.cirad.fr/550491/>
- [21] Ismail, A. I. H., Elrasheed, M. M., Al-Ekna, M., & Seliaman, M. E. (2023). Assessment of camel owners' knowledge and practical behaviors and its implication on environmental sustainability. *Emirates Journal of Food and Agriculture*, 35(10), 918-928. <https://doi.org/10.9755/ejfa.2023.v35.i10.3142>
- [22] Tadesse, Y., Mengistu, U., Solomon, A., Mohammed Yusuf, K., Kefelegn, K., and Tadelle, D. (2014). Husbandry and breeding practices of dromedary camels among pastoral communities of Afar and Somali regional states, Ethiopia. *Journal of Agriculture and Environment for International Development*, 108(2), 167-189. <https://doi.org/10.12895/jaeid.20142.238>
- [23] Farah, K. O., Nyariki, D. M., Ngugi, R. K., Noor, I. M., and Guliye, A. Y. (2004). The Somali and the Camel: Ecology, Management and Economics. *The Anthropologist*, 6(1), 45-55. <https://doi.org/10.1080/09720073.2004.11890828>
- [24] Schwartz, H. J., Dolan, R., and Wilson, A. J. (1983). Camel production in kenya and its constraints - I. Productivity. *Tropical Animal Health and Production*, 15(3), 169-178. <https://doi.org/10.1007/BF02239929>
- [25] Oselu, S., Ebere, R., and Arimi, J. M. (2022). Camels, Camel Milk, and Camel Milk Product Situation in Kenya in Relation to the World. *International Journal of Food Science*, 2022, 15. <https://doi.org/10.1155/2022/1237423>
- [26] Meynard, J., and Dourmad, J. (2020). Innovation in livestock farming: new approaches for new challenges. *INRA Animal Productions*, 27(2), 77-88. <https://doi.org/hal-01198221> HAL
- [27] Mehta, S., Dahia, S., Sharma, R., Tania, M., and Sharma, A. (2017). Camel genetic resources of India Jalori Camel. *ICAR National Research Centre on Camel*, 1-56. <https://doi.org/978-81-927935-6-6>
- [28] Burger, P., Ciani, E., and Faye, B. (2019). Old world camels in a modern world - A balancing act between conservation and genetic improvement. *Anim. Genet. (Immunogenet., Mol. Genet. et Function. Genom.)*, 50, 598-612.
- [29] <https://doi.org/10.1111/age.12858>
- [30] Faraz, A., Waheed, A., Mustafa, A. B., Tauqir, N. A., Mirza, R. H., Ishaq, H. M., Bilal, R. M., and Nabeel, M. S. (2021). Milk production potential of marecha camel (camelus dromedarius) in extensive and semi-intensive management systems. *Pakistan Journal of Zoology*, 53(1), 273-280. <https://doi.org/10.17582/JOURNAL.PJZ/20200227090212>
- [31] Faye, B. (2011). Which species for which spaces? Which systems for which territories? The challenges of sustainability in dairy farming. *Coll. Culture of World Milks*, Paris 5-6 may 2010. In : *Les cahiers de l'OCHA n°15*, 160-173.
- [32] Kamili, A., Faye, B., Tligui, N. S., and Bengoumi, M. (2020). Typology of camel farming systems in the south of Morocco. *Review of Livestock and Veterinary Medicine in Tropical Countries*, 73(2), 71-80. <https://doi.org/10.19182/remvt.31862>
- [33] Julien, L., Moutik, F. E., Haloui, C., Huguenin, J., and Sraïri, M. T. (2021). Demographic parameters and economics of camel breeding: a study in Morocco. *Cahiers Agricultures*, 30, 1. <https://doi.org/10.1051/cagri/2020039>
- [34] Faye, B., and Corniaux, C. (2024). Camel milk at the risk of political economy: from the gift economy to the market economy. *Review of Livestock and Veterinary Medicine in Tropical Countries*, (77), 1-7.
- [35] <https://doi.org/10.19182/remvt.37263>
- [36] Swelum, A. A., El-Saadony, M. T., Abdo, M., Ombarak, R. A., Hussein, E. O. S., Suliman, G., Alhimaidi, A. R., Ammari, A. A., Ba-Awadh, H., Taha, A. E., El-Tarabily, K. A., and Abd El-Hack, M. E. (2021). Nutritional, antimicrobial and medicinal properties of Camel's milk: A review. *Saudi Journal of Biological Sciences*, 28(5), 3126-3136.
- [37] <https://doi.org/10.1016/j.sjbs.2021.02.057>
- [38] Faye, B., and Konuspaveva, G. (2024). Camel milk composition and future market potential. *CABI Reviews*, 19 (1). <https://doi.org/10.1079/cabireviews.2024.0021>
- [39] Bekele, T. (2002). Epidemiological studies on gastrointestinal helminths of dromedary (*Camelus dromedarius*) in semi-arid lands of eastern Ethiopia. *Veterinary Parasitology*, 105(2), 139-152. [https://doi.org/10.1016/S0304-4017\(01\)00583-0](https://doi.org/10.1016/S0304-4017(01)00583-0)
- [40] Bouragba, M., Laatamina, A.E., Cheddad, F.E., Baroudi, D., Houali, K., and Hakem, A. (2020). Gastrointestinal parasites of dromedary camel (*Camelus dromedarius*) in Algeria. *Veterinary World*, 13(8), 1635-1640.
- [41] <https://doi.org/10.14202/vetworld.2020.1635-1640>
- [42] Ibrahim, A. M., Kadle, A. A. H., and Yusuf, A. A. (2016). Gastro-Intestinal Parasites of Camels (*Camelus dromedarius*) from Mogadishu, Somalia. *Open Journal of Veterinary Medicine*, 06(07), 112-118. <https://doi.org/10.4236/ojvm.2016.67015>