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Livestock breeding management effects on milk production and reproduction performances of dairy cows in arid and semi-arid zones.

Presented by: **EULMI Hadjer**.

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In front of the jury:

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Mm. **DEGHNOUCHE Kahramen**	Professor	University of Biskra	**Supervisor**
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Thanks

Our gracious thanks go to ALLAH, our Almighty Creator, who gave me the will, patience, energy and strength to complete this work.

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Dedication

This work and all my success are dedicated to my father “EULMI Youcef”

with love and pride.

Abbreviation list

AFI	Apparent Fertility Index.
ASD	Agricultural Services Direction.
BCS	Body Condition Score.
DMP	Daily Milk Production.
DO	Days Open.
Ha	Hectare.
HRS	Herd Reproductive Status.
ICI	Inter-Calving Interval.
IEI	Inter-Estrus Intervals.
Kg/C/D	Kilogram/Cow/Day.
L/C/D	Litre/Cow/ Day.
LL	Lactation Length.
M	Months.
MCA	Multiple correspondence analysis.
MVS	Mineral Vitamin Supplement.
PC	Persistence Coefficient.
PMY	Peak Milk Yield.
PR	Pregnancy Rate.
RP	Reproductive Period.
SVMSDS	Single-Visit Multiple-Subject Diagnostic Survey.
TFI	Total Fertility Index.
UAA	Used Agricultural Area.
WP	Waiting Period.
°C	Degrees Celsius.

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Abstract

To comprehensively understand dairy cattle breeding performances across two distinct biotopes, we conducted a study that investigates farm types, performance variability, and limitations in arid region (AR) of Biskra and Ouled-Djellal and semi arid region (SAR) of southern Souk Ahras. Using data from surveys and on site visits that covered 92 and 121 dairy cattle farms in AR and SAR respectively, our research explores the link between breeding management, climate, and productivity strategies in order to improve breeding practices, animal welfare, and ultimately boost milk production in both regions. Results revealed that over 40% of farms are characterized by small herds, with ≤15 dairy cows. SAR farms benefit from both agricultural land types of 1–300 ha (Used Agricultural Area (UAA) and pastoral area), while those Saharan rely on small UAA. Fertility levels were higher in SAR farms where a fertility index ≤2 is recorded in 92.6% and days open period ≤90 days in 68.6% of farms. While both regions' average daily milk yield is around 15 litres/cow. Moreover, typology analysis identified several groups; those in AR are dominated by small herds with high fertility rates, reared under moderate breeding conditions leading to several problems, most notably mastitis. However, in SAR, classic groups of traditional character predominate with moderate milk production that seems the main breeding objective. Indeed, the zootechnical monitoring results (reproductive and milk production parameters) confirm the overall findings; significantly higher dairy and reproductive performance observed in the SAR farms. Therefore, to improve productivity across both regions, especially the AR, we recommend implementing strategic and reliable farm management practices that help facing constraints.

Key words: Dairy cattle, management practices, breeding performances, arid and semi arid regions.

Résumé

Afin d'analyser en profondeur les performances de reproduction et de production laitière des élevages bovins laitiers dans les biotopes arides et semi arides, notre recherche avait pour but d’étudier la variabilité des performances, les limitations et les types des exploitations dans la région aride (RA) de Biskra et Ouled-Djellal et la région semi-aride (RSA) du sud de Souk Ahras. En appuyant aux données issus d'enquêtes et visites d’élevages sur 92 exploitations de vaches laitières en RA et 121 en RSA, nous visons à déterminer le lien entre la gestion d'élevage, le climat et les stratégies de production afin d'améliorer les pratiques d'élevage, le bien-être animal et de stimuler la production laitière dans les deux régions. Les résultats ont révélé que plus de 40 % des exploitations sont constituées de petits troupeaux; avec ≤ 15 vaches laitières. Les exploitations de la RSA tirent profit de deux types de terres agricoles allant de 1 à 300 ha (Superficie Agricole Utile (SAU) et zone pastorale), contrairement à celles de RA se limitent à de petites SAU. Les niveaux de fertilité étaient plus élevés dans les exploitations de la RSA, où un indice de fertilité ≤ 2 est enregistré dans 92,6 % des exploitations et une période de jours ouverts ≤ 90 jours dans 68,6 % des exploitations. Sachant que le rendement laitier quotidien moyen des deux régions est de 15 litres/vache. De plus, l'analyse typologique a permis d'identifier plusieurs groupes ; ceux de la RA sont dominés par de petits troupeaux à fort taux de fertilité, élevés dans des conditions médiocres, ce qui entraîne plusieurs problèmes, notamment les mammites. En revanche, dans la RSA, les groupes classiques à caractère traditionnel prédominent, avec une production laitière moyenne. En effet, les résultats du suivi zootechnique (paramètres de reproduction et de production laitière) confirment les résultats généraux : des performances laitières et reproductives dans les exploitations de la RSA sont nettement supérieures. Par conséquent, pour améliorer la productivité dans les deux régions, en particulier la RA, nous recommandons la mise en œuvre de pratiques de gestion d'exploitation stratégiques fiables.

Mots-clés : Vaches laitières, pratiques d'élevage, performances de reproduction et de production laitière, région aride et semi-aride.

الملخّص

من منطلق أنّ أغلبية مساحة الجزائر عبارة عن مناطق جافة وشبه جافة ومع استمرار الجفاف النّاتج عن الاحتباس الحراري الذي تشهده الكرة الأرضية، تمّ إجراء دراسة معمّقة ومفصّلة حول أداء إنتاج وتكاثر الأبقار الحلوب في المناطق الجافة وشبه الجافة بشرق الجزائر لمعرفة خصائص المزارع بالمنطقة واستبيان طرق التّسيير فيها وتأثيرها على الأداء والإنتاج وكذا الصّعوبات التي تواجهها، بغرض استنتاج أسس واستراتجيات محكمة تهدف إلى تعزيز الإنتاجية وتسريع نمو القطاع الذي يشهد تأخرا وبعدا عن تحقيق الاكتفاء الذّاتي خاصة إنتاج الحليب رغم المجهودات المبذولة السّاعية لتطوير تربية الأنعام وزيادة الإنتاجية. استنادا إلى بيانات تمّ جمعها من خلال استطلاعات آراء الفلاحين والزّيارات الميدانية للمزارع (92 مزرعة في منطقة بسكرة أولاد جلال (جافة) و121 مزرعة في جنوب سوق أهراس (شبه جافة)، تمّت دراسة خصائص المزارع، حيث تميزت بقطعان صغيرة بمعدل لا يتجاوز 15 بقرة حلوب و معدل إنتاج 15 لترا من حليب للبقرة يوميا. كما تميزت قطعان المنطقة الجافة بخصوبة أقل مقارنة بالمنطقة شبه الجافة التي سجلت معدل خصوبة لا يتجاوز 2 في فترة لا تتجاوز 90 يوما بعد الولادة في أغلب مزارعها التي تميزت أيضا باستفادتها من الأراضي الفلاحية الخاصة و المساحات الرعوية الواسعة الراجعة لنسبة تساقط أعلى. كما أسفرت الدراسة التصنيفية لهذه المزارع عن عدة مجموعات في المنطقة الجافة، تميزت أبرزها بقطعان صغيرة ذات معدلات خصوبة عالية في ظل ظروف تربية متوسطة، مما تسبب في عدة مشاكل صحية أهمها التهاب الضرع. بينما هيمنت المجموعات الكلاسيكية ذات الطابع التقليدي والإنتاج المتوسط في المنطقة شبه القاحلة وقد أكدت مخرجات متابعة الأداء الفعلي للمزارع التي حددت كنموذج في كل منطقة النتائج السابقة؛ أداء تكاثري وإنتاجي أفضل في المنطقة شبه الجافة. تؤكد هذه النتائج على الحاجة الماسة لتطبيق استراتيجيات تسيير جديدة تعطي الأولوية للرعاية وتطوير الكفاءات والوسائل لتحسين تربية الأبقار و أوضاع المزارع في كلتا المنطقتين، خاصة في الجافة، وزيادة الإنتاجية بشكل مستدام.

الكلمات المفتاحية: مناطق جافة وشبه جافة، الأبقار الحلوب، أداء تكاثري، إنتاج الحليب.

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INTRODUCTION

Milk holds a significant position in the Algerian diet, serving as a cornerstone of the nation's nutritional landscape. Its per capita consumption in Algeria has witnessed substantial growth over the years, from 110 kg/year (Dilmi, 2008) to 115 then 130 litres/year (F O, 2018; African Manager, 2023) which is significantly higher than the world average (Vargas, 2020).

Indeed, its production has seen significant growth in recent years, with local production estimated at over 3 billion litres in 2015 (Meribai *et al.*, 2016), despite this increase in fresh milk production, Algeria's milk banc stills reconstituted from dairy powder, so its industry is highly dependent on the world milk market, and the collection level remains low and far below expanding population demand and needs on this essential/ integral component of Algerian cuisine, that have grown above 4.5 million metric tons (Hales, 2020). This places Algeria among the top milk consumers (Bentaleb *et al.*, 2023) and importer (Rebbah and Beloucif, 2021) in the Maghreb region and worldwide.

Consequently, the national government has, over years, implemented a series of comprehensive policies and initiatives aimed at bolstering milk production to achieve self-sufficiency in milk production by 2030, by promoting dairy cattle breeding which remain a major contributor to agricultural economic sustainability, a significant component of agricultural output value (Mamine *et al.*, 2021) and a priority for economic development.

Over the years, ovine livestock predominates in Algeria with a rate of 79% of the total livestock population, while cattle breeding represent only about 6% of the total population.

The cattle breeding industry has experienced consecutive declines since 2015, when it was estimated to be close to 2.2 million head, then about 2.13 million head in 2016, 1.94 million in 2017, and more than 1.86 million in 2019 (Abdelli *et al.*, 2021).

Currently, Algeria's cattle population is estimated to be around 2 millions, with over 932875 dairy cows, primarily concentrated in the northern regions, particularly Skikda and Setif (MADR, 2022), due to the availability of grasslands, which benefit from high rainfall. In fact, several factors influence cattle breeding distribution, productivity, welfare, and sustainability, including intrinsic factors such as breed, genetics, health and age, and extrinsic factors such as breeding management, and environmental conditions which, mainly climate and season, can impact fertility and reproductive efficiency besides milk production because heat stress has significant negative effects on both physiological and behavioural aspects in dairy cattle, leading to substantial losses in milk production and reproductive issues (De-Rensis *et al.*, 2017; Liu *et al.*, 2019). Management is also an important factor that includes aspects such as reproduction practices, milking, health and disease prevention, feeding and housing, given that dairy cattle need enough space to move around and express comportment and receive a balanced diet that is rich in nutrients to produce milk in quantity and quality.

Dairy sector faces significant challenges, stemming from the dominant arid and semi-arid climate (Algeria is almost entirely arid and semi-arid (Zeroual *et al.*, 2013). This harsh environment affects production and animal welfare, given that heat stress can decrease milk yield and quality, as cattle prioritize thermoregulation (Habimana *et al.*, 2023), can negatively impact conception rates, calving intervals, and sperm quality (Wolfenson and Roth, 2019; Sumi *et al.*, 2022) besides health problems such as mastitis and respiratory issues. Also, this climate limits natural pastures and water resources, which makes it difficult to produce enough feed so price increases, this high costs is also a significant challenge for farmers. As a result, farmers often can't adopt improved technologies and practices but rely on traditional practices that moreover negatively impact herd health and productivity.

However, investing in research and development of drought-resistant fodder crops, water harvesting initiatives and water-efficient irrigation systems can significantly reduce dependence on imported feed, offering farmers greater autonomy and reducing production costs. Technology adoption programs can improve herd health and milk quality, while knowledge sharing and professional training opportunities can equip farmers with best practices for animal health and management, ensuring optimal productivity and herd welfare.

Indeed, Algeria is conducting a livestock census to assess its animal resources, understand the beef sector, and identify farms requiring support. This new census aims to create a digital database for better management of the livestock sector, including beef, sheep, and goats, and to preserve and control the livestock population through traceability of animals (Bouzid, 2022).

Various initiatives have encompassed a range of measures focusing on large-scale and small-scale farmers, including the importation of high-yielding dairy cattle breeds, the artificial insemination to enhance the genetic pool of the nation's dairy herd, subsidies for feed, loans, and veterinary services, prohibition of subsidized milk powder use for the manufacture of pasteurized milk, land allocation specifically designated for dairy farming to promote dairy cattle breeding in Saharan regions and infrastructure development projects, including the creation of Milk Collection Centres to improve distribution efficiency and strengthen market access for smallholder farmers. One notable project, the H'lib Dzair project, has been instrumental in empowering Algerian smallholder dairy farmers. It focuses on technical training, mentorship, and financial assistance to enhance productivity, reduce ecological footprint, and explore alternative revenue streams beyond traditional milk production by equipping farmers with best practices and innovative, providing on-farm guidance and support from experienced professionals to facilitate the application of newly acquired knowledge, cost-reduction trials and credit facilitation (Mehadi and Kezzar, 2022).

By addressing these challenges and embracing the opportunities, Algeria can strengthen its dairy cattle breeding sector and ensure its continued contribution to the country's food security and economic development.

But, despite these efforts that aim to meet domestic demand, reduce import dependence, and boost exports (Hales, 2020), Algeria continues to face challenges in meeting the ever-increasing domestic demand for milk and the gap between local supply and demand persists and necessitates continued efforts to enhance milk production (Kardjadj and Dachung, 2016).

Consequently, we started this research to more understand the livestock global situation in arid and semi-arid regions and since, various indicators are used to evaluate dairy cattle farming:

Animal welfare indicators: These are related to the comfort of the animal, injuries and diseases, mortality, reproduction and feeding practices, the general atmosphere (Lebrun *et al.*, 2019).

Fertility indicators: Usually to evaluate fertility performance in herds, key indicators are used such as age: age at first calving, calving interval, number of services per conception, first insemination success rate, gestation rate/percentage, days open, and interval from calving to first heat (Mariscal-Aguayo *et al.*, 2016; Armengol *et al.*, 2023).

Milk production indicators: Including milk yield, milk composition, mastitis prevalence, lactation length, etc. (Oliveira *et al.*, 2020).

Economic indicators of the farm: By calculating the cost of milk production, taking into account all food, operational (health, reproduction, etc.) and structural costs, production level, and by-products value (calves, manure, etc.) (Darej *et al.*, 2017; Brocard *et al.*, 2020).

Our study aims, using these indicators, to evaluate the livestock conditions in the arid and semi-arid regions of eastern Algeria and characterize the management of dairy cattle farms. By gathering information from agricultural farms, we seek to provide final recommendations that will contribute to the enhancement of livestock conditions. This includes understanding the effects of high temperature and overcoming aridity constraints through appropriate breeding and management strategies, ensuring the long-term viability of dairy cattle breeding in hot climates. Through these efforts, Algeria's dairy sector can transform itself into a sustainable and thriving force, guaranteeing the nation's continued access to nutritious dairy products while serving as a model of arid-adapted resilience for other arid regions around the world.

I. Problematic and Research Objectives

The local agricultural sector of Algeria is intricately woven with the influence of climatic fluctuations, seasonal variations, and the dynamic nature of farm management shaped by government programs and initiatives aimed at sector enhancement. This dynamic interplay has resulted in a diverse spectrum of breeding systems, production strategies, and herd size disparities across farms, also level of milk production does not allow for self-sufficiency, leading to significant milk imports.

Given the pivotal role of reproduction in milk production enhancement, our proposed approach focuses on a multifaceted analysis of breeding systems. This analysis seeks to identify distinct farm types, unravel the variability in performance outcomes, pinpoint limitations, and critically examine the impact of climate and breeding practices on both breeding and productivity improvement.

To comprehensively assess zootechnical performance in two distinct biotopes – arid and semi-arid regions – our study will employ a three-pronged research approach comprising surveys and site visits. These data collection methods will provide a holistic understanding of the intricacies of breeding systems and their implications for milk production.

The arid region, characterized by scarce water resources and harsh climatic conditions, presents unique challenges for dairy farming. Our study aims to delve into the breeding practices employed in this region and their impact on productivity.

In the semi-arid region, with its slightly more favourable climatic conditions, we will explore the diversity of breeding systems and their associated performance outcomes. This analysis will shed light on the factors influencing milk production in this region.

By conducting comprehensive research in both biotopes, we aim to provide valuable insights into the interplay of breeding systems, climate, and productivity enhancement. These insights will contribute, by knowing how to adapt to arid conditions, to the development of informed strategies for optimizing breeding practices and welfare and maximizing milk production in such environments and diverse agricultural landscape of Algeria.

To achieve a thorough comprehension of dairy farming practices, management variations, and their impact on performance, it is imperative to conduct a detailed farm identification and description process. This entails:

- Identifying and analyzing the constraints hindering the development of dairy cattle farming in each region which is crucial for formulating effective strategies to enhance productivity and foster sector growth. This involves assessing factors such as resource availability, infrastructure limitations, and market challenges.
- Developing a typology to categorize different types of farms in both regions to simplify the understanding of variability while preserving essential characteristics. This categorization allows for targeted interventions tailored to the specific needs and challenges of each farm type.
- Analyzing a representative farm model in each region to provide valuable insights into breeding practices throughout the year. This analysis encompasses the description, analysis, and precise evaluation of dairy and reproductive performance, enabling the identification of best practices and areas for improvement.

By undertaking this comprehensive approach, we can gain a deeper understanding of cattle breeding systems in both arid and semi-arid regions of Algeria. This knowledge will serve as the foundation for developing evidence-based strategies to enhance productivity and foster the growth of the dairy sector, contributing to the overall development of the agricultural sector.

EXPERIMENTAL SECTION

II. Research Methodology

II.1. Choice of Study Area (Justification)

The study area encompasses two distinct bioclimatic regions. The first is the Biskra and Ouled-Djellal region in south eastern Algeria (Figure 1), situated at 34°48' North and 05°44' East (Benmehaia *et al.*, 2018) acting as a virtual barrier between the northern and southern parts of the country (Bouchahm *et al.*, 2016). This region is characterized by arid conditions, featuring high daily temperatures that peak at 46°C from June to August (Azzouzi *et al.*, 2018), along with minimal annual rainfall of 120 to150 mm/year (Mechaala *et al.*, 2022).

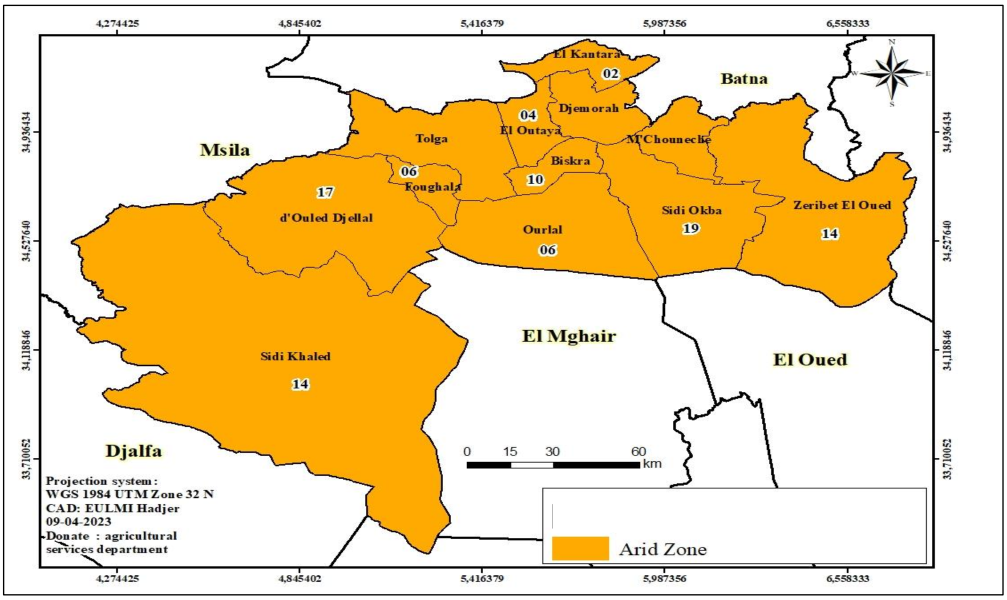


Figure 1: Biskra and Ouled Djellal' map plotted with samples distribution (arcgis, 2019)**.**

Its cattle's breeding has witnessed remarkable intensification processes in recent years; the cattle herd size has increased significantly, from 3996 head in 2013 reaching a peak of 5195 heads in 2021 and dairy workforce has also grown, rising from 2410 in 2013 to 2577 in 2021 (as shown in figures 2 and 3).

Currently, dairy cattle population exceeds 3000 head with more than 50% of pure breeds (ASDa, 2023). These two regions, where farmers have successfully raise dairy cattle by developing innovative techniques to overcome a number of challenges due to the arid climate, are excellent candidates for representing arid zones in our research. Indeed, studying their dairy cattle farming practices can provide valuable insights into how to adapt dairy production to arid environments.

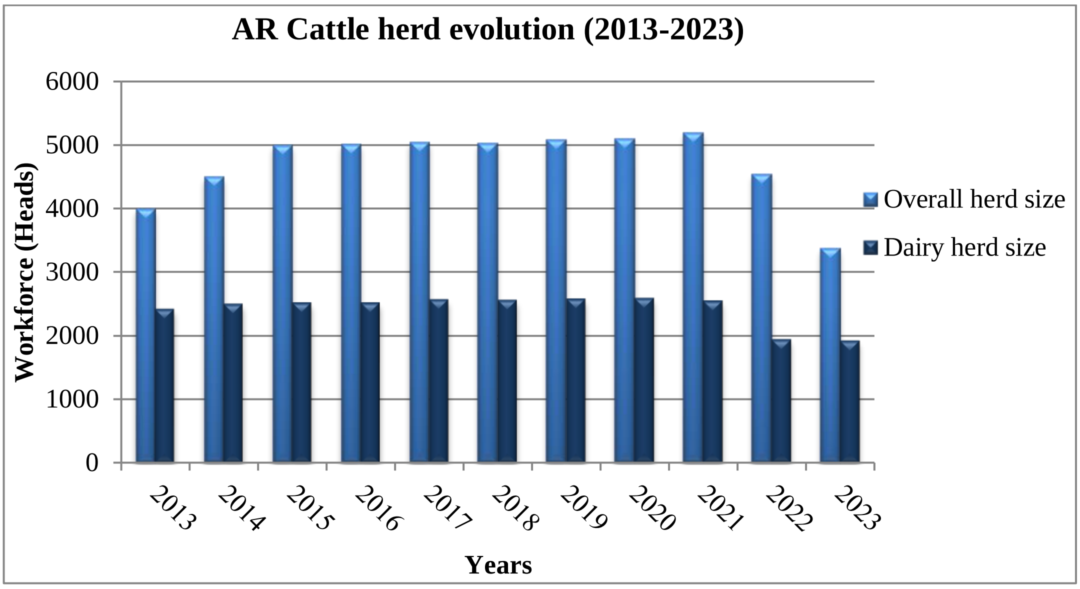


Figure 2: Biskra-Ouled-Djellal' Cattle herd (dairy and overall herd size) evolution between 2013 and 2023 (ASDa, 2023)**.**

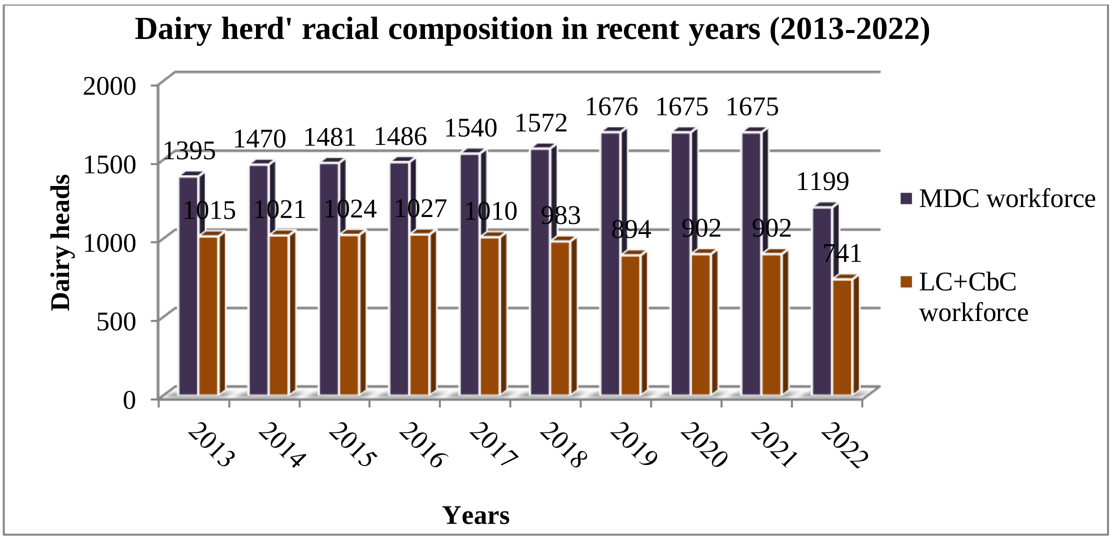


Figure 3: Biskra-Ouled Djellal' dairy herd racial composition in recent years (ASDa, 2023)**.**

MDC: Modern Dairy Cattle, LC: Local Cattle, CbC: Crossbred Cattle.

Despite this evolution, the milk collection rate, as depicted in Figure 4, has continued to decrease over the years (ASDa, 2023).

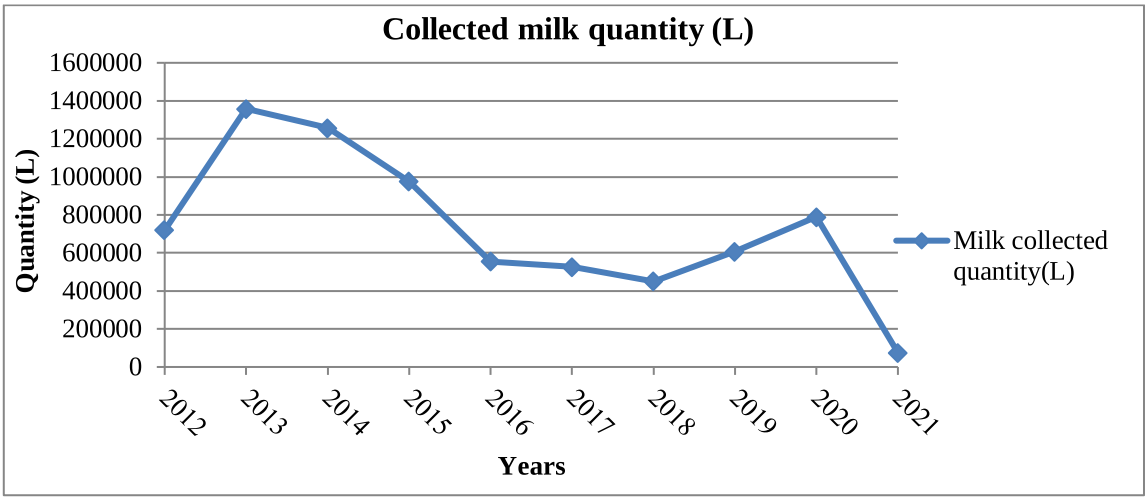


Figure 4: Biskra-Ouled-Djellal' quantity of collected milk in last years (ASDa, 2023)**.**

The second region is Souk Ahras, a prominent dairy basin in Algeria with abundant cattle population with the majority located in the northern areas, particularly Mechroha and Hennancha. Over 37% of these are pure breeds, predominantly Holstein and Montbeliarde. The progression of its cattle herd and dairy performance over the last decade is depicted in Figures below (data sourced from the Agricultural Services Direction (ASDb, 2024) and analyzed using Excel software).

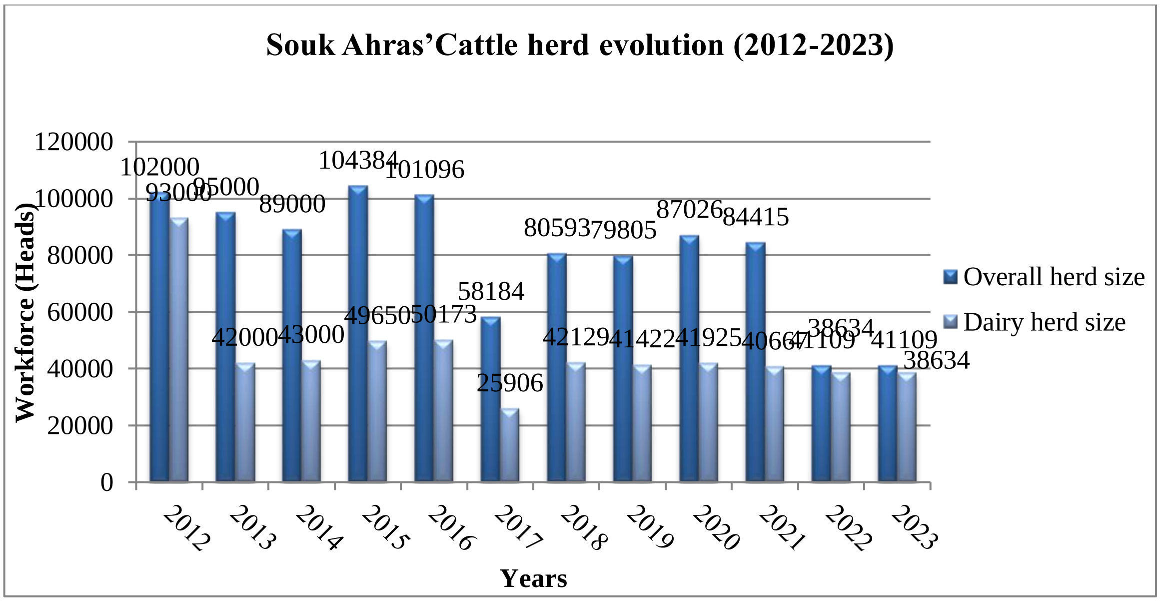


Figure 5: Souk Ahras' Cattle herd (dairy and overall herd size) evolution between 2012 and 2023 (ASDb, 2024)**.**

The global cattle population has experienced a downward trajectory, with a notable decrease from 102000 head in 2012 to a current standing of 41109 head in 2023. This trend has been accompanied by significant dips in 2017 and 2022, with the herd size falling to 58184 and 41109 head, respectively.

A similar trend is observed in the dairy herd, which decreased from 93000 head in 2012 to over 38000 head in 2022. This decline is primarily attributed to the gradual replacement of local and crossbred cattle by modern dairy breeds which increased from 10707 head in 2015 to 22807 head in 2022, as shown in Figure 6. As a result, and despite this increase in imported breeds, Souk Ahras' dairy production has declined from over one million litres in 2013 to 75438 litres in 2021 and 94541 litres in 2022, as shown in Figure 7.

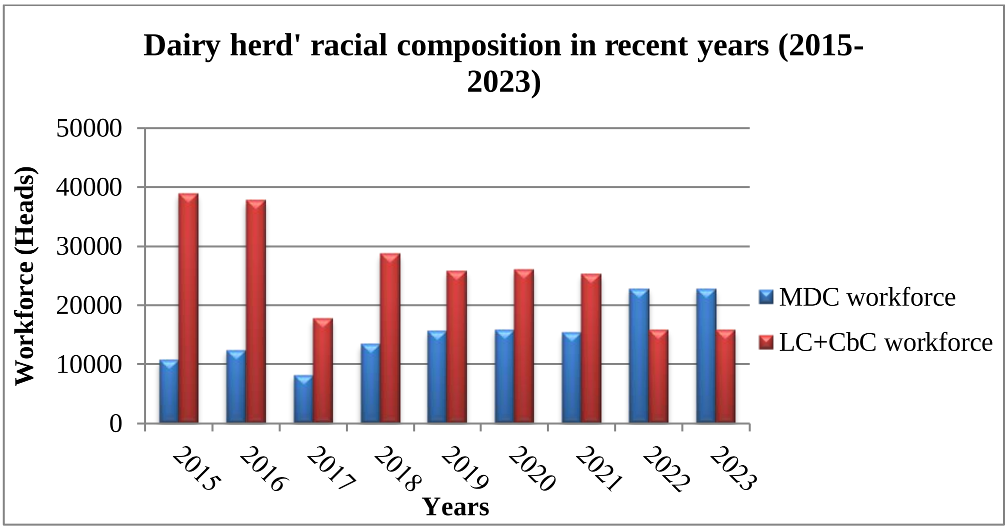


Figure 6: Souk Ahras' dairy herd' racial composition in recent years (ASDb, 2024)**.** MDC: Modern Dairy Cattle, LC: Local Cattle, CbC: Crossbred Cattle.

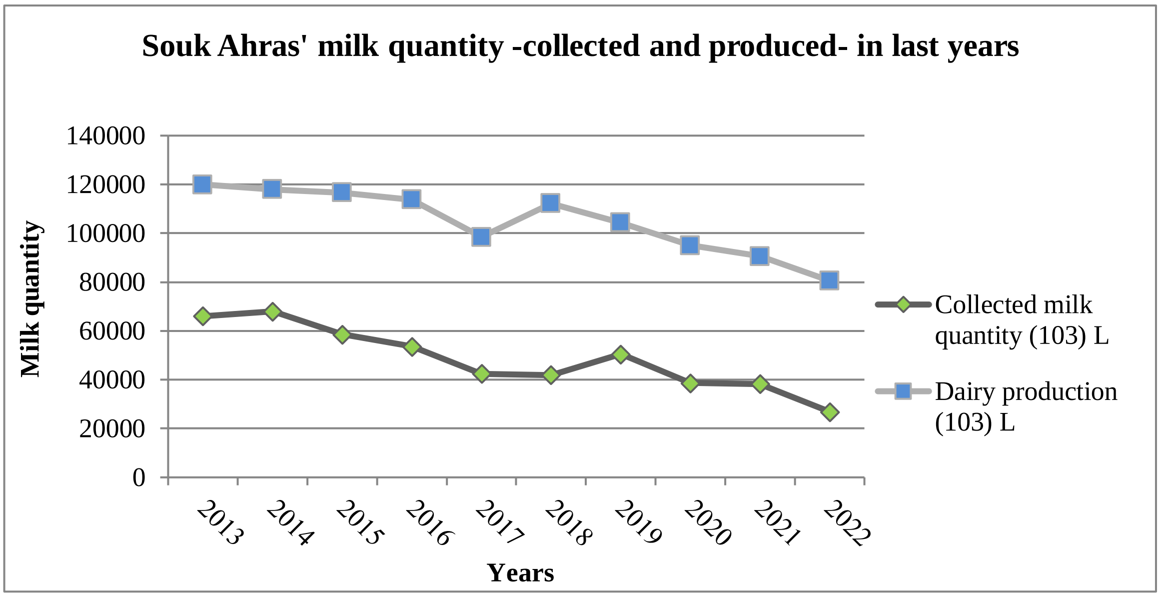


Figure 7: Souk Ahras' milk quantity -collected and produced- in last years (ASDb, 2024)**.**

Souk Ahras is located at 36° 17° 15° North and 7° 57° 15° East, characterized by dry and hot summers, contrasted by cooler winters, with an average annual precipitation of 550 mm and temperature exceeding 15°C (Bouroubi-Ouadfel *et al.*, 2016), was chosen as the study area due to its significant contributions to the country's raw milk supply, diverse bioclimatic environments (as shown in Figure 8), and ample sample size. Particularly, the southern part of semi-arid climate with an annual rainfall of less than 350 mm (Latreche *et al.,* 2019; Tlidjane *et al.,* 2019), that encompasses ten municipalities consisting of plains and pasture (Tlidjane *et al.,* 2019), can provide a comprehensive representation and allows for a better understanding of dairy cattle farming systems in the semi-arid zones.

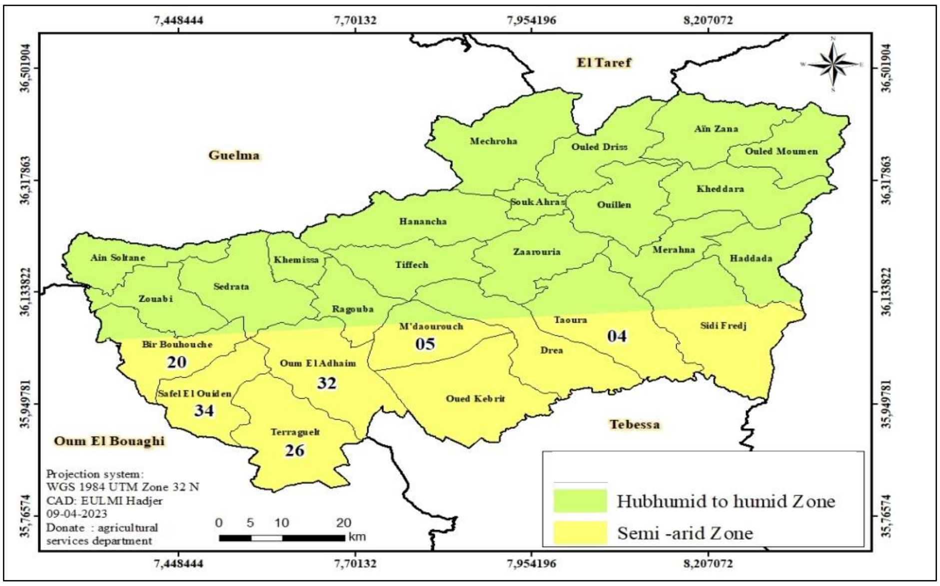


Figure 8: Souk Ahras' map (ASDb, 2020)**, plotted with sample distribution** (arcgis, 2019)**.**

II.2. Materials and Research Methodology

In order to achieve the objectives of this thesis and assess the distinct situations in both study areas, we employed a comprehensive four-step process:

II.2.1. Data Collection and Sample Determination

Our initial step involved gathering data from agricultural organizations such as agricultural services direction (ASD) and agricultural subdivisions. This enabled us to compile a list of livestock producers for our study sample and create a survey questionnaire.

To determine the representative sample size that survey will cover and should be adequate to represent the target population and provide sufficient statistical power, we utilized the formula below, developed by Thompson and Steven (2012) for an optimal random sample size, to ensure that our analysis would be both reliable and optimal.

$$\mathrm{n} = \frac{N \times p(1-p)}{[N-1 \times (d^2 + z^2] + p(1-p)]}$$

Knowing that: N= population size, n= sample size, p= estimated proportion of characteristic, d= desired precision (margin of error), z= confidence level.

With: reduced deviation corresponding to a confidence level of 95%.

Sampling error = 5% and *N* = population size which is 120 farm in arid region and 190 in the semi-arid.

It results n= 92 for the arid region and n=121 for the semi-arid region (n= sample size), dispersed as shown in Figures 1 and 8.

For our investigations, we developed an extensive questionnaire consisting of more than 80 questions (Annex 1). This questionnaire aimed to gather a wealth of information necessary for identifying, characterizing, categorizing, and comparing various livestock breeding types in the two regions. It was structured into five sections:

Socio-demographic Data of Breeders: This section covered details such as age, education level, primary occupation, and cattle breeding experience of the breeders.

Breeding Description (Animals, Land, and Buildings): This section focused on herd composition (size, breeds, etc.), environmental factors, and conditions affecting animal welfare.

Reproduction and Feeding Techniques: This section delved into aspects like feed types (fodder, supplements, concentrates), grazing practices, water availability, insemination methods, pregnancy and heat detection, and renewal practices.

Breeding Productivity: This section included metrics such as daily milk output, insemination rates, and calving intervals.

Limitations or Constraints Impacting Breeding Development: Here, we explored recurring diseases, feed-related issues, and obstacles in marketing.

II.2.2. Data Collection through Surveys and Site Visits

The second step entailed conducting surveys through direct interviews with farmers or managers and immediate observations of various aspects of randomly selected dairy farms, using the SVMSDS method (Single-Visit Multiple-Subject Diagnostic Survey), validated in accordance with ILCA (1991) standards. The interviews were conducted with local language, and questionnaires were completed during farm visits, taking into account factors such as the farm's primary goal (dairy production), the motivation of breeders to participate and ease of access during this process, and the geographical location of the farms. Over the agricultural seasons (October to February) of 2020–2021 and 2021–2022, we successfully examined 92 dairy farms in the municipalities of Biskra and Ouled Djellal, and 121 farms in the semi-arid municipalities of Souk Ahras.

II.2.3. Monitoring of Model Farms

The third phase entailed continuous monitoring of model farms throughout the year, encompassing all aspects of reproduction and milk production. This comprehensive approach enabled us to accurately assess real performance and select representative farms from each category in each region. Despite encountering logistical hurdles, we were able to successfully monitor at least a farm model per region.

The farms were selected based on the agreement of the farmers, ease of access, availability of information, and a minimum of ten dairy cows (our basic unit) to ensure the sustainability of the farm for at least the duration of our work.

During the visits, we meticulously observed the animals, their behaviour, and their health status, recording all relevant information. We also utilized breeding registers, individual cow records, and barn notebooks to monitor reproduction, production, and animal health.

The collected information was carefully reviewed, and only the most reliable data was retained. Throughout our investigations, we encountered challenges with accessing archives, as documents related to the cows' lifecycles were often unavailable, poorly organized, or poorly archived. Significant effort was made to establish a usable database.

II.2.3.1.General description of the studied farms

Geographic location

The SAR farm is situated in Gourbi Debbache and the second is in Gharbi Laayoune, within, respectively, Oum El Adhaim and Safl El Ouiden municipalities in the southern semi-arid region of Souk Ahras, Algeria. Situated in the crossroads of rural tranquillity and regional vibrancy characterized by a warm climate and fertile plains, this strategic location places them in the heart of the semi-arid region which offers a vantage to examine the interplay between climate, agricultural practices, and socio-economic factors.

The AR farm is situated in N'fidhet Ragma, a locality within Zribet El Oued municipality of Biskra, Algeria, situated in the southern arid region, making it suitable sample to examine the interplay between arid climate, agricultural practices, and socio-economic factors.

Animals

Herds' composition is illustrated in Table 1 and 2.

Table 1: Semi-arid region dairy cattle herd description

Cattle	Population	Type (parity)	Bred	Age	Status
Dairy Cows (DC)	39	• 18 (46.15%) Multiparous. • 21 (53.85%) Primiparous.	• 27 (69.2%) Purebred Montbeliarde. • 6 (15.4%) Purebred Holstein. • 1 (2.6%) Purebred Limousine. • 5 (12.8%) Crossbred (Mont).	• <4 Years: 10(25.6%). • 4-8 Years: 25(64.1%). • >8 Years: 4 (10.3%).	28 (71.8%) Pregnant.
Heifers	12	• 2 Pregnant. • 3 Non-pregnant. • 7 Young.	Crossbred (Mont).	• 3: 18Months. • 2: 1 Year. • 7: <1Year.	16.67% Pregnant.
Bull	2		• Crossbred (Mont). • Limousine	• 3 Years • 2 Years	
Calves	19		Crossbred (Mont)	<1 Year	

Table 2: Arid region dairy cattle herd description

Cattle	Population	Type (parity)	Bred	Age	Status
Dairy Cows (DC)	8	• 4 (50%) Multiparous. • 4 (50%) Primiparous.	• 3 (37.5%) Purebred (2/3Montbeliarde and 1/3 Holstein). • 5 (62.5%) Crossbred (Mont).	• 3 Years: 4 (50%). • 3-8 Years: 3(37.5%). • >8 Years: 1(12.5%).	8 lactating cows with 3 (37.5%) Pregnant
Heifers	7	• 5 Pregnant. • 2 Young.	Purebred Holstein.	• 5: 20-25 Months. • 2: < 1Year	71.4% Pregnant.
Bull	1		Crossbred (Mont).	2 Years	
Calves	6		Crossbred	<1 Year	

Breeding conditions

According to Figures 9, sheds in SAR farms are characterized by metal roofs and concrete walls adorned with windows that ensure natural ventilation and light. The sleeping area is mainly made of concrete bedded with straw (litter) which is changed daily by the farmer. This solid floor provided with evacuation channel for easier cleaning. Disinfection is performed annually in summer, using bleach and lime washing.

One corners of the shed is always dedicated to young calves.

Tethered for safety, the cows receive annual vaccinations according to the state program, including protection against Foot-and-Mouth Disease (FMD) and rabies.

Figure 9: Dairy cattle shed in semi-arid region (personal photos, 2023)**.**

In AR farm, as Figures 10 shows, the building diverges from the traditional concept of a shed known as Zriba with metal proof and compacted earth floor where cows are tethered at night. Litter is daily cleaned and building disinfection is carried out every year with lime. Cows are vaccinated annually according to the state program (FMD and anti-rabies).

Figure 10: Dairy cattle house in the arid region (personal photos, 2021)**.**

Breeding management

Reproduction

Natural mating remains the unique method of reproduction in both regions' farms, and heat detection is mainly based on visual observation; vaginal secretions, vulva colour, bellowing, behavioural changes and overlapping, since the breeder believes that it's the perfect choice as the farmer's permanent presence with the herd enables 24/7 constant observation of the herd.

Feeding

In SAR' farm, feeding is primarily manual and water is supplied ad-libitum from a private well. Each cow receives about 15kg of roughage (oats, alfalfa, corn silage, straw) with 10kg of concentrate (mixtures: barley/ wheat bran, DC18).

In spring, feed is based on pasture grazing on barley and grass and on cereal stubble pasture in summer.

While in AR' farm, feeding is primarily manual and water is supplied ad-libitum from a private well. Knowing that all cows receive the same quantities of feed, each cow receives 10kg of fodder (silage, straw, sorghum, oats) supplemented always by 2-5 kg/C/D of concentrate (wheat bran).

Feed is based on pasture grazing on 5 ha of barley and grass in spring and on cereal stubble pasture in summer complemented with 5kg/C/D of concentrate.

Milk production

Udders are cleaned with warm clean water before mechanical milking, with monthly milk checks.

Calves' age at weaning goes from 1.5 to 3 months and from 3 to 4 months in AR and SAR' farm respectively.

II.2.3.2. Data collection for Milk production and reproductive performances

Production performance

Monitoring production performance in a dairy herd is paramount for dairy farmers for several reasons. Firstly, it allows farmers to optimize efficiency by identifying areas for improvement and implementing strategies to increase milk yield while minimizing input costs. Secondly, it helps ensure the health and welfare of the herd by enabling early detection of health issues through changes in milk production or composition. Thirdly, efficient production directly impacts profitability, as it leads to increased revenue through improved milk yield and quality, reduced feed costs, and better reproductive outcomes. Moreover, production data supports breeding decisions by providing insights into superior production traits, thus enhancing the overall genetic merit of the herd. Finally, monitoring production performance aids in compliance with regulations and facilitates accurate record-keeping for farm management purposes. So that, monitoring production performance is vital for maintaining herd health, optimizing efficiency, maximizing profitability, supporting breeding decisions, and ensuring regulatory compliance in dairy farming operations.

The following parameters related to herd production performances were measured according to Gherissi (2019, 2024):

- Daily Milk Production (DMP): kg/Cow/Day (kg/C/D).
- Minimum Daily Milk Production (DMPmin): kg/C/D.
- Maximum Daily Milk production (DMPmax): kg/C/D.
- Peak Milk Yield (PMY): kg/C/D.
- Total Milk Yield/ Milk Yield per Lactation (TMY): calculated by the Fleischman method (Carre *et al.*, 1958).
- Persistence Coefficient (PC): this indicator is used to measures how well a cow maintains milk yield over an extended period following the initial lactation peak. Calculated as follow:

  PC = 100/N [(P1/Pmax) + (P2/P1) + (P3/P2) + ...+ (Pn/Pn-1)].With N: number of controls, Pmax: maximum production (peak), P1: production at the 1st control, P2: production at the 2nd control, P3: production at the 3rd control, Pn: production at the last control, Pn-1: production at the penultimate control (Chergui *et al.*, 2024).
- Lactation Length (LL): days.
- Dry-off (days).

Reproductive performances

The breeding report serves as a crucial element of the breeding monitoring. Its primary function is to define the extent and nature of the reproductive problem, to suggest additional tests if necessary, and to make specific recommendations for improvement.

Creating and interpreting a breeding report requires a variety of parameters, both general and/or specific. The choice of these parameters depends on the quantity and quality of data available. These parameters are directly or indirectly linked to quantifying and interpreting the infertility of an individual or a herd. In this context, infertility refers to the increase in the time required to obtain a pregnancy or calving, and also the number of inseminations required.

The following parameters were measured in accordance with the methodologies established in research by Hanzen (2009), Hanzen et al. (2013), Achemaoui and Bendahmane (2016), Gherissi (2019; 2024):

- Pregnancy rate PR (%): calculated as the ratio between the number of cows confirmed pregnant and the number of inseminated cows.

- Herd Reproductive Status (HRS): this index used to reflect excessive “days open” in open cows in relation to herd size to evaluate the herd’ reproductive level, calculated by the following rule:

  HRS = 100 - [(DO/TC) x 1.75], knowing that DO = sum of post-partum days >100 of cows not confirmed pregnant and TC = total cows in herd (milking and dry).
- Average age at 1st calving (*B-1stCI)* (days): It refers to the average time (measured in days) between birth of the heifer and its age at first calving. This interval is important in determining the animal's lifetime productivity on the farm.
- Inter calving interval (ICI): It refers to the average time (measured in days) between two consecutive calving, a key metric used to assess the reproductive efficiency of dairy animals.
- Waiting period (WP): time in days between calving and first service (mating).
- Reproductive period (RP): as the time in days between first mating to conception.
- Days open (DO): days between calving and conception for all cows in herd confirmed pregnant.
- Inter-estrus intervals (IEI)
- Conception Rate at First Mating (CR1stM): it measures the proportion of inseminated cows that become pregnant from the first insemination/mating. It is an indicator of the fertility and the effectiveness of the insemination.
- Services per conception (SPC).
- Apparent Fertility Index (AFI): Equals to the ratio between the total number of inseminations performed on pregnant cows and the number of pregnant cows.
- Total Fertility Index (TFI): Equals to the ratio between the total number of inseminations performed on cows and the number of pregnant cows.
- Proportion of cows requiring more three inseminations or more.
- Wood index: used to evaluate heat detection efficiency, calculated as: Average cycle length / Average interval between two consecutive heats) x 100.
- Abortion rate.

II.2.3.3. Data collection for economical efficiency evaluation

To assess dairy cow breeding costs, we considered a comprehensive range of factors. We calculated the total annual expenses by summing up the costs within each category of these:

- Food costs including purchases and on-farm feed production of forage and concentrates.
- Veterinary Care including veterinary treatment, medication, vaccines and testing costs/fees.

- Labour: Employee salaries and benefits.
- Housing and Infrastructure: includes construction, maintenance, ventilation, lighting, and waste management equipment.
- Reproduction: Costs associated with breeding (artificial insemination), sonography and obstetrical treatment.
- Utilities: Electricity bills, dairy operation, water usage for drinking and cleaning expenses.
- Equipment and Machinery: Purchase and maintenance of milking machine, tractors, trailers, and other farm equipment.
- Transportation: Fuel costs, farm vehicles, milk, animal, and supply transportation
- Insurance and taxes related to the breeding.
- Various other expenses like certification fees, training and professional development costs.

Then, to determine the total outputs, we considered revenue generated from both newborn calf sales and milk production.

Finally, to assess profitability, we calculated profit by subtracting total costs from total outputs. We then compared this profit figure with industry standards for similar breeding practices. This comparison helped us identify potential cost-saving opportunities.

II.2.4. Data Processing and Statistical Analysis

The final step involved data processing and statistical analysis. Given the diverse approaches in this study, we employed a variety of statistical tools. To describe and compare farms in each region, we utilized both qualitative and quantitative analysis with the SPSS Statistic 25 software. This involved utilizing various statistical methods, including the Chi-square test and the Student's T-test, to examine differences and similarities between the dairy farms in the two study regions (arid and semi-arid). We also conducted multiple correspondence analysis (MCA) followed by Ascending Hierarchical Classification using the SPAD 5.5 software (SPAD, 2002) to establish a typology and identify different farm types in both studied regions.

To summarize the different stages of our study process, we developed a diagram that illustrates our study chronological sequences.

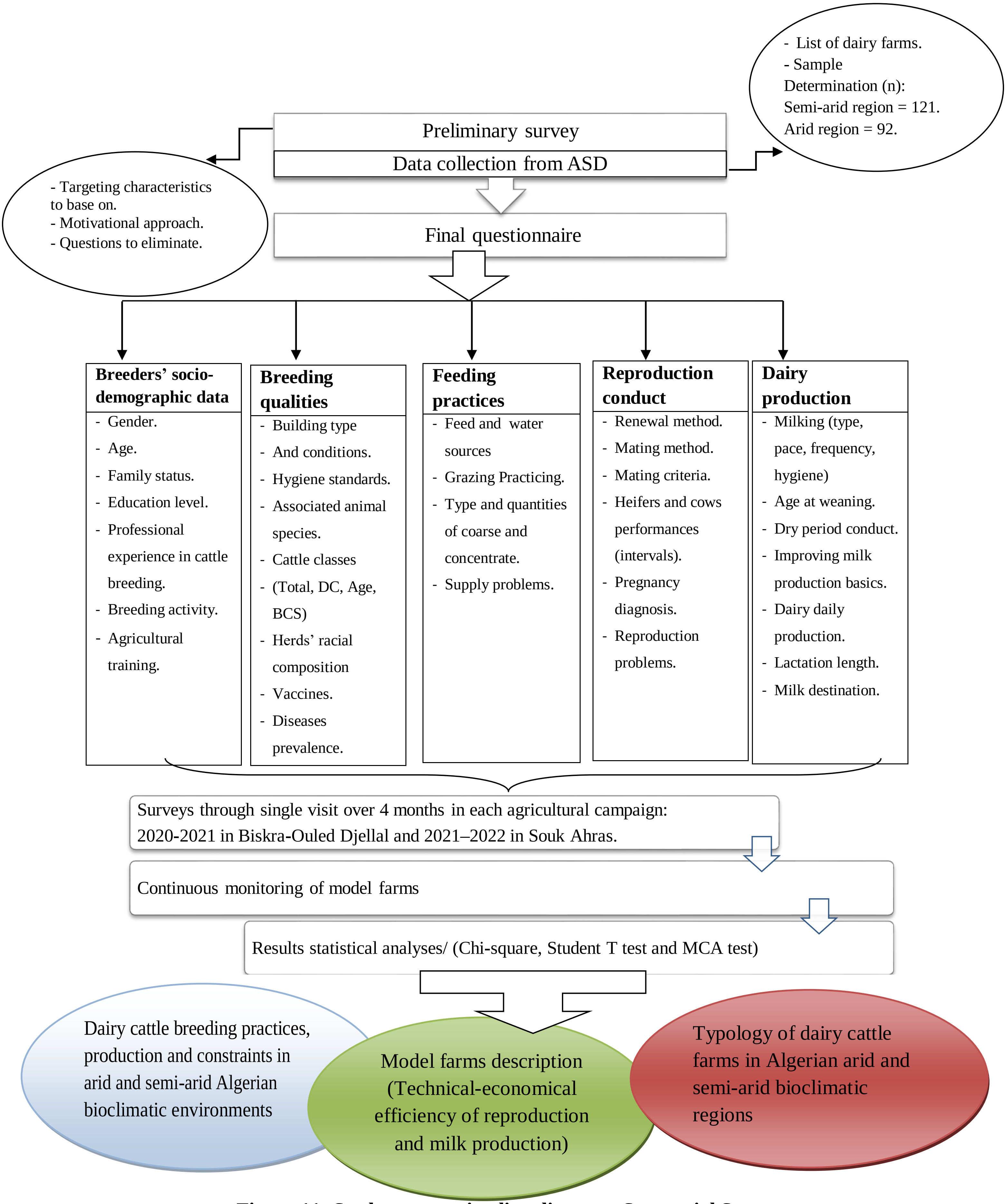


Figure 11: Study process timeline diagram: Sequential Stages.

RESULTS & DISCUSSION

I. Dairy cattle breeding practices, performance and limitation in Algerian eastern arid and semi-arid regions.

This study section aims, through the standardized survey questionnaire' data that was developed in collaboration with breeders and managers of 92 farms in the arid region and 121 farms in the semi-arid region randomly selected, to characterize and compare dairy cattle farming practices and performance metrics between the two regions. Collected data underwent rigorous analysis using SPSS Statistic 25 software; this process involved an integrated approach of qualitative and quantitative analysis. Quantitative data is presented as mean values ± standard deviation, while qualitative data is conveyed through frequencies and percentages. Statistical comparisons were performed using the Chi-square test with a significance level of $p<0.05$.

I.1. Dairy Cattle Breeders' Socio-economic Status

A statistical analysis of the socio-economic status of the surveyed dairy cattle breeders, as depicted in Figure 12, revealed that the majority of farms (77%) are managed by male farmers (98.6%) aged between 30 and 60 years. Furthermore, there is a significantly higher proportion ($p<0.05$) of single farmers in the Souk Ahras semi-arid region (SAR) (14.9%) compared to the arid region (AR) of Biskra-Ouled-Djellal (5.4%).

A significant disparity in educational attainment is evident between the two regions. In the arid region (AR), 40.2% of farmers have no formal education, with only 5.4% having obtained a university degree. Conversely, in the semi-arid region (SAR), only 16.5% of farmers lack formal education, while 78.5% have completed some level of education. Despite this, the majority of farmers in both regions have not received agricultural training, with only one farmer in the arid region and 5 (4.1%) in the semi-arid region have undergone cattle breeding training.

The results underscore a high significant difference ($p<0.001$) in the primary occupation of dairy cattle breeders. This occupation serves as the main source of income for a substantial majority of farmers (83.5%), while 47.8% of those in the arid region (AR) engage in additional or auxiliary activities.

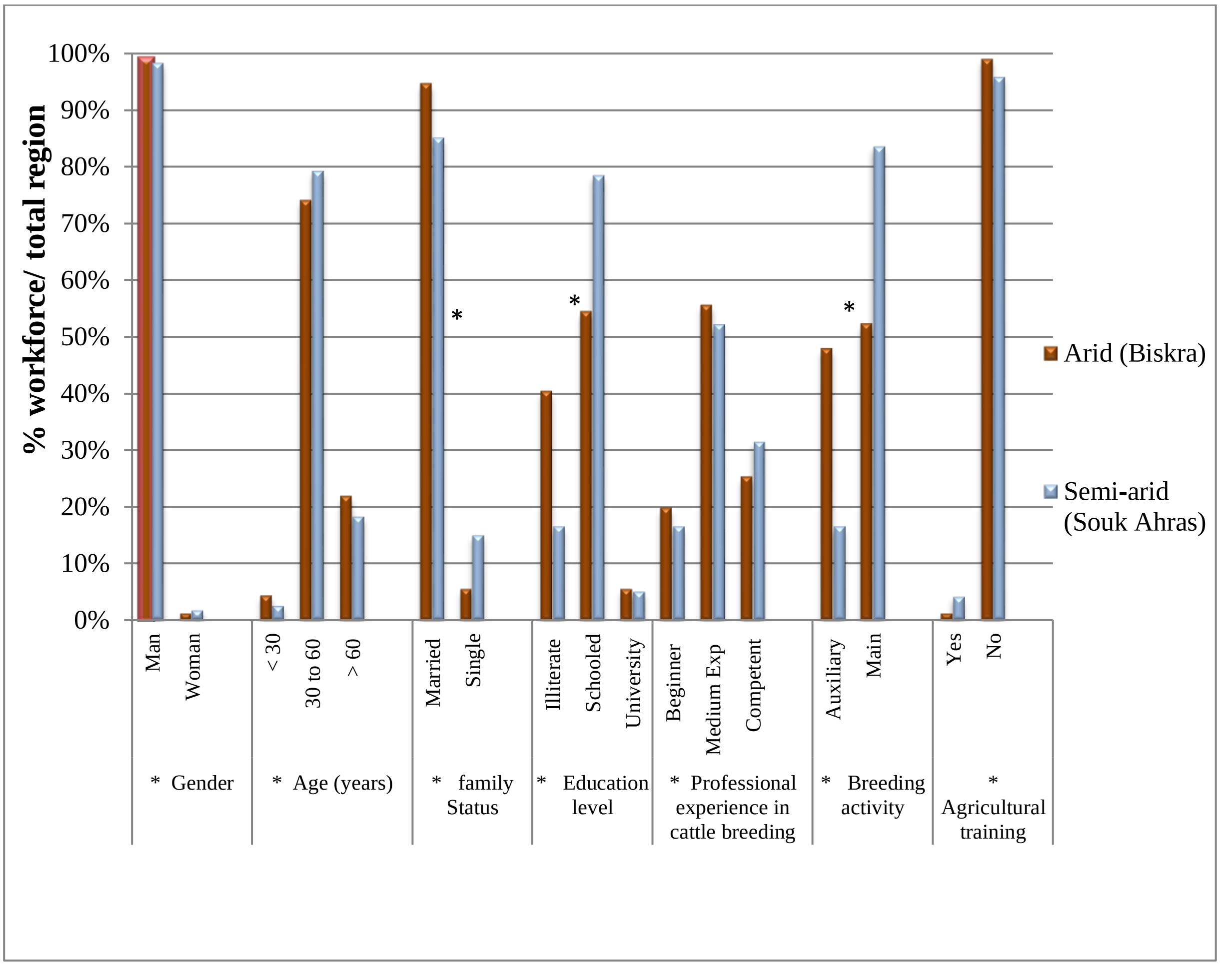


Figure 12: Socio-economic status (breeder's characteristics) in arid and semi-arid regions. (* = Statistical significance between regions: p <0.05).

I.2. Breeding qualities: traits and conditions

I.2.1. Land potentiality

Results reveal a significant difference (p<0.001) in land availability and usage between the two regions' farms; SAR farms benefit from both types of land (Used Agricultural Area (UAA) and pastoral area) encompassing a wide range of surface areas from 1 to 300 ha. In contrast, AR farmers predominantly rely on UAA (80.4%), typically with smaller surfaces that do not exceed 10ha in 21.7% of farms. Figure 13 below illustrates this difference, classifying farms into three groups based on their used land surfaces.

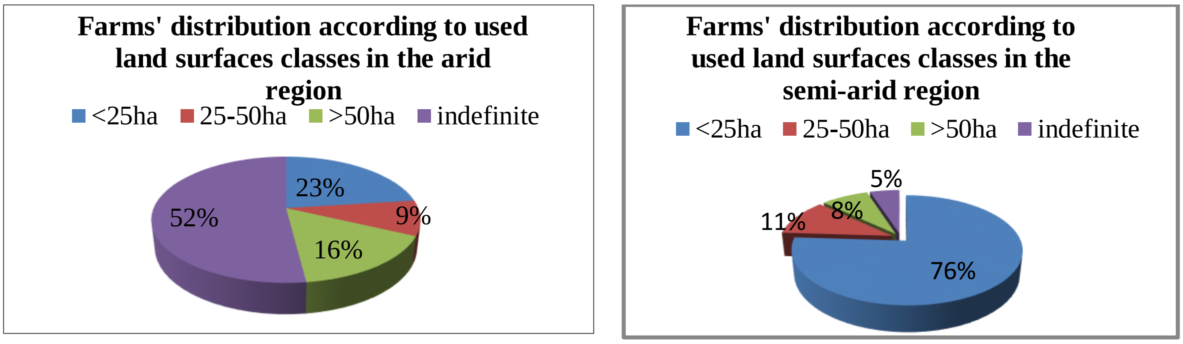


Figure 13: Dairy farms distribution in both regions (arid–Biskra-Ouled Djellal – and semi-arid – Souk Ahras– according to their used land surfaces classes.

I.2.2. Livestock shed

Results, represented in Table 3, reveal a high significant difference ($p<0.001$) among the sample buildings in terms of type, general characteristics, and hygiene conditions (cleaning and disinfection, etc.).

I.2.3. Cattle herd

According to Table 3, the dairy cattle farming is often combined with small ruminant breeding in both regions. The majority of farms maintain small herds, with over 75% of farms with less than 15 heads and only a small percentage (6%) with more than 25 heads. On average, AR farms maintain 13.2 ±9.4 head/ farm, while SAR farms have 7.9 ±4.6 head/ farm with 6.8 ±3 Dairy cows (DC)/herd.

In both regions, over 48% of animals are between 5-8 years old with an estimated BCS (Body Condition Score) of 2.5-3.5 in 83% of farms. All three cattle types are present in both regions, but with statistically significant differences ($p<0.001$). Crossbred cattle represent the largest proportion, accounting for 82.6% in AR and 59.5% in SAR. Purebred cattle are more prevalent in SAR (43.7%), while local cattle are more used in AR (6.5% vs. 0.8%).

Table 3: Dairy cattle breeding qualities and conditions in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Building type	Modern barn	1 (1.1%)	0 (0%)	0.000	1(0.5%)
	Shed	16 (17.4%)	57 (47.1%)		73 (34.3%)
	Traditional	25 (27.2%)	64 (52.9%)		89 (41.8%)
	No real Building	50 (54.3%)	0		50 (23.5%)
Building conditions	Bad	16 (17.4%)	11 (9.1%)	0.000	27 (12.7%)
	Poor	49 (53.3%)	101 (83.5%)		150 (70.4%)
	Good	9 (9.8%)	9 (7.4%)		18 (8.5%)
	No building	18 (19.6%)	0		18 (8.5%)
Compliance with hygiene standards	In the standards	10 (10.9%)	30 (24.8%)	0.014	40 (18.8%)
	Moderately within standards	27 (29.3%)	39 (32.2%)		66 (31%)
	Not up to standard	55 (58.8%)	52 (34%)		107 (50.2%)
Animal species associated	Alone	21 (22.8%)	41 (33.9%)	0.054	62 (29.1%)
	Small ruminants	71 (77.2%)	77 (63.6%)		148 (69.5%)
	Avian	0	3 (2.5%)		3 (1.4%)
Total workforce class	0-5	19 (20.7%)	22 (18.2%)	0.96	41 (19.2%)
	5-15	54 (58.7%)	71 (58.7%)		125 (58.7%)
	15-25	13 (14.1%)	21 (17.4%)		34 (16%)
	25-50	3 (3.3%)	4 (3.3%)		7 (3.3%)
	>50	3 (3.3%)	3 (2.5%)		6 (2.8%)
Dairy Cows class	0-5	45 (48.9%)	52 (43%)	0.91	97 (45.5%)
	5-15	40 (43.5%)	60 (49.6%)		100 (46.9%)
	15-25	4 (4.3%)	6 (5%)		10 (4.7%)
	25-50	1 (1.1%)	1 (0.8%)		2 (0.9%)
	>50	2 (2.2%)	2 (1.7%)		4 (1.9%)
Age Class (Years)	<5	40 (43.5%)	60 (49.6%)	0.31	100 (46.9%)
	05-8	46 (50%)	58 (47.9%)		104 (48.8%)
	08-12	4 (4.3%)	3 (2.5%)		7 (3.3%)
	>12	2 (2.2%)	0		2 (0.9%)
BCS Class	2-2.5	11 (12%)	20 (16.5%)	0.024	31 (14.6%)
	2.5-3	46 (50%)	76 (62.8%)		122 (57.3%)
	3-3.5	31 (33.7%)	24 (19.8%)		55 (25.8%)
	3.5-4	3 (3.3%)	0		3 (1.4%)
	4-5	1 (1.1%)	1 (0.8%)		2 (0.9%)
Herd's racial composition	Local Cattle	6 (6.5%)	1 (0.8%)	0.000	7 (3.3%)
	Local + Crossbred	0	5 (4.1%)		5 (2.3%)
	All breeds	0	1 (0.8%)		3 (0.5%)
	Crossbred	72 (78.3%)	53 (43.8%)		125 (58.7%)
	Cross+ pure bred	8 (8.7%)	38 (31.4%)		46 (21.6%)
	Purebred	6 (6.5%)	23 (19%)		29 (13.6%)
Type of land	UAA	74 (80.4%)	37 (30.6%)	0.000	111 (52.1%)
	Pastoral area	18 (19.6%)	3 (2.5%)		21 (9.9%)
	Both	0	81 (66.9%)		81 (38%)

I.3. Reproductive strategies and husbandry techniques

I.3.1.Feeding and Watering Practices

As indicated in Table 4, fodder, whether green or dry, serves as the primary roughage for all farms in addition to concentrate supplements provided with quantities ranging from 4 to 18 kg/cow/day, with a mean of 8 kg/cow/day. In the SAR, the concentrate used is typically special, destined to dairy cows and commonly known as "DC". However, AR farms predominantly use bran and mixtures. Figure 14 below offers a visualization of feed, particularly the concentrate type used in each region.

Regarding watering practices, in the arid region (AR), 53.3% of farms provide unrestricted access to water. In contrast, farmers in Souk Ahras implement stricter watering control, usually supplying water multiple times daily.

Figure 14: Different feed types (fodder and concentrate) used in arid (A) and semi-arid (B) regions (personal photos, 2021)**.**

I.3.2. Reproduction management

Table 4 reveals that natural mating is the primary method of reproduction employed in both regions.

Herd renewal strategies differ between the two regions. AR farmers favour self-renewal and cow purchases, while 48.8% of SAR farmers adopt a random herd renewal approach.

Regarding pregnancy diagnosis, SAR farmers primarily rely on the absence of heat within 45 days post-insemination. In contrast, AR farmers conduct pregnancy diagnosis at the 45th and 90th post-insemination day in respectively 41.3% and 25% of farms using rectal palpation as the primary diagnostic method.

Table 4: Reproductive strategies and husbandry techniques (feeding, reproduction and dairy production management) in arid and semi-arid regions' dairy cattle farms.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
		Feeding practices			
Watering frequency	1/Day +1/Day Ad-libitum	17 (18.5%) 26 (28.3%) 49 (53.2%)	10 (8.3%) 73 (60.3%) 38 (31.4%)	**0.000**	27 (12.7%) 99 (46.5%) 87 (40.8%)
Grazing Practice	Yes No	39 (42.4%) 53 (57.6%)	116 (95.9%) 5 (4.1%)	**0.000**	155 (72.8%) 58 (27.2%)
Coarse food	Green forage Dry forage Green + Dry forage	3 (3.3%) 14 (15.2%) 75 (81.5%)	2 (1.7%) 16 (13.2%) 103 (85.1%)	**0.669**	5 (2.3%) 30 (14.1%) 178 (83.6%)
Concentrate type	Bran DC(Special DC) Mixtures Whole mixtures (DC+ Mixtures)	35 (38%) 5 (5.4%) 42 (45.7%) 10 (10.9%)	28(23.3%) 33 (27.5%) 22 (18.3%) 37 (30.8%)	**0.000**	63 (29.7%) 38 (17.9%) 64 (30.2%) 47 (22.2%)
Concentrate individual daily quantity (Kg)	0-4 4-8 8-12 12-16 16-20	0 33 (35.9%) 52 (56.5%) 7 (7.6%) 0	2 (1.7%) 29 (24%) 69 (57%) 19 (15.7%) 2 (1.7%)	**0.054**	2 (0.9%) 62 (29.1%) 121 (56.8%) 26 (12.2%) 2 (0.9%)
		Reproduction management			
Renewal method	Purchase of cows Self-renewal Imported heifers No particular strategy	39 (42.4%) 34 (37%) 0 19 (20.7%)	22 (18.2%) 34 (28.1%) 6 (5%) 59 (48.8%)	**0.000**	61 (28.6%) 68 (31.9%) 6 (2.8%) 79 (36.6%)
Criteria for heifers mating	Weight Age Heat appearance No particular strategy	6 (6.5%) 30 (32.6%) 45 (48.9%) 11 (12%)	8 (6.6%) 65 (53.7%) 15 (12.4%) 12 (9.9%)	**0.000**	14 (6.6%) 95 (44.6%) 60 (28.2%) 23 (10.8%)
Mating method	Natural projection Natural P and/or artificial insemination	81 (88%) 7 (7.6%) 4 (4.8%)	97 (80.2%) 12 (9.1%) 13 (10.7%)	**0.2**	178 (83.6%) 18 (8.5%) 17 (8%)
Time of pregnancy diagnosis (D= day)	<45D 45-90D >90D	31 (33.7%) 38 (41.3%) 23 (25%)	110 (90.9%) 7 (5.8%) 4 (3.3%)	**0.000**	141 (66.2%) 45 (21.1%) 27 (12.7%)
Pregnancy diagnosis method	Heats cessation Cessation + rectal search Ultrasound Rectal search	32 (34.8%) 36 (39.1%) 11 (12%) 13 (14.1%)	112 (92.6%) 5 (4.1%) 1 (0.8%) 3 (2.5%)	**0.000**	144 (67.6%) 41 (19.2%) 12 (5.6%) 16 (7.5%)

Table 4: Reproductive strategies and husbandry techniques (feeding, reproduction and dairy production management) in arid and semi-arid regions' dairy cattle farms (continued).

Dairy production practices					
Milking type	Manual Milking robots	59 (64.1%) 33 (35.9%)	29 (24%) 92 (76%)	**0.000**	88 (41.3%) 125 (68.7%)
Milking Pace and Frequency	Morning Morning+ evening Evening	5 (5.4%) 82 (89.1%) 5 (5.4%)	14 (11.6%) 107 (88.4%) 0	**0.009**	19 (8.9%) 189 (88.7%) 5 (2.3%)
Milking hygiene	Bad Poor Poor to good Good	7 (7.6%) 53 (57.6%) 23 (25%) 9 (9.8%)	7 (5.8%) 63 (52.1%) 39 (32.2%) 12 (9.9%)	**0.68**	14 (6.6%) 116 (54.5%) 62 (29.1%) 21 (9.9%)
Calves' age at weaning of (M=months)	<1M <3M >3M	1 (1.1%) 2 (2.3%) 59 (64.1%)	4 (3.3%) 11 (9%) 104 (85.9%)	**0.25**	5 (2.3%) 13 (6.1%) 46 (76.5%)
Duration of dry period (M=months)	<45M 45-60M >60M	2 (2.2%) 44 (47.8%) 46 (50%)	12 (9.9%) 79 (65.3%) 30 (24.8%)	**0.000**	14 (6.6%) 123 (57.7%) 76 (35.7%)
Drying-off method	Brutal Progressive Not practiced	13 (14.1%) 45 (48.9%) 34 (37%)	1 (0.8%) 88 (72.7%) 32 (26.4%)	**0.000**	14 (6.6%) 133 (62.4%) 66 (31%)
Milk destination	Dairies Private Points (Pp Pp + self-consumption Self-consumption	18 (19.6%) 40 (34.5%) 5 (5.4%) 29 (31.5%)	102 (84.3%) 7 (5.8%) 1 (0.8%) 1 1(9.1%)	**0.000**	120 (56.3%) 47 (22.1%) 6 (2.8%) 40 (18.8%)

I.3.3. Dairy production practices

A significant difference ($p < 0.001$) in milking methods and drying-off practices between the two regions is highlighted in Table 4. Milking Methods: Manual milking remains the predominant method in AR farms, accounting for the majority of farms. Conversely, mechanical milking has gained widespread adoption in SAR farms, with mediocre conditions in both regions' farms, as Figure 15 shows.

Figure 15: Milking circumstances (udder health, hygiene score and milking equipment) in both regions (personal photos, 2021)**.**

Drying-off Practices: AR farmers exhibit a tendency to employ extended drying periods, with approximately 50% maintaining a drying phase exceeding 60 days and 37% neglecting implementing any formal drying-off procedures. In contrast, SAR farmers predominantly adhere to a physiological drying approach, gradually reducing milking frequency over a period of 45 to 60 days.

Also, the destination, marketing, and production objectives of milk are significantly different between the two regions (p<0.000). In Souk Ahras, milk is destined primarily to dairies (84.3%), self-consumption and private points. In the arid region, milk is primarily sold to private points and destined to self-consumption in second place.

I.4. Performances

I.4.1. Reproduction performance parameters

Age at mating and first calving

As indicated in Table 5, AR farmers typically inseminate their heifers between the ages of 12 and 15 months, guided by heat detection. In contrast, SAR farmers prefer to inseminate heifers at an older age, exceeding 15 months. Despite this difference in initiation of breeding, both regions maintain a similar calving interval, with the majority of farms achieving a Birth-First Calving Interval (B-1stCI) of 24-30 months.

Waiting period, days open and inseminations' number

In AR farms, there is typically a prolonged Waiting Period (WP) (calving to first insemination), often surpassing 60 days. This prolonged interval corresponds to the observed longer Days Open (DO) in AR farms, where 58.7% and 32.6% of farms report a DO of 60-90 days and over 90 days, respectively. Furthermore, AR farms tend to experience a lower success rate at first insemination, averaging around 3.3%. Multiple insemination attempts are often required to achieve fertilization, with 71.7% of farms requiring ≥2 inseminations and 9.8% necessitating ≥3 inseminations.

In contrast, SAR farms present a different reproductive pattern. Fertilization typically occurs within 60 days postpartum in 21.5% of farms and between 60-90 days postpartum in 47.1%. The average DO exceeds 100 days in over 58% of farms, indicating a shorter reproductive cycle compared to AR farms. Additionally, SAR farms achieve higher fertilization rates, with 92.6% of farms requiring 1-2 inseminations for cows' fertilization. Moreover, the Inter-Calving Interval (ICI) exceeds 400 days in 30.4% of AR farms, compared to only 12.4% of SAR farms.

Table 5: Dairy cattle breeding performances (reproduction and dairy production management) in arid and semi-arid regions' dairy cattle farms.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Heifers average age at mating (Months)	<12 12-15 >15	8 (8.7%) 67 (72.8%) 17 (18.5%)	6 (5%) 28 (23.1%) 64 (52.9%)	0.000	14 (6.6%) 95 (44.6%) 81 (38%)
Age at first calving (Months)	<24 24-30 > 30	8 (8.7%) 75 (81.5%) 9 (9.8%)	11 (9.1%) 71 (58.7%) 16 (13.2%)	0.000	19 (8.9%) 146 (68.5%) 25 (11.7%)
Inter calving interval (Day)	<365 365-400 >400	18 (19.6%) 46 (50%) 28 (30.4%)	74 (61.2%) 32 (26.4%) 15 (12.4%)	0.000	92 (43.2%) 78 (36.6%) 43 (20.2%)
Waiting Period (Days)	<60 60-90 >90	20 (21.7%) 63 (68.5%) 9 (9.8%)	46 (38%) 52 (43%) 23 (19%)	0.001	66 (31%) 115 (54%) 32 (15%)
Days Open (Days)	<60 60-90 >90	8 (8.7%) 54 (58.7%) 30 (32.6%)	26 (21.5%) 57 (47.1%) 38 (31.4%)	0.033	34 (16%) 111 (52.1%) 68 (31.9%)
Number of inseminations for fertilization	<3I ≥3I	83 (90.2%) 9 (9.80%)	116 (95.9%) 5 (4.1%)	0.16	189 (93.4%) 14 (6.6%)
Daily average quantity of milk	<10L 10-25L >25L	14 (15.2%) 74 (80.4%) 4 (4.3%)	18 (14.9%) 97 (80.2%) 6 (5%)	1	32 (15%) 171 (80.3%) 10 (4.7%)
Quantity at Peak	<10L 10-15L 15-20L 20-25L 25-30L >30L	0 12 (13%) 29 (31.5%) 29 (31.5%) 10 (10.9%) 12 (13%)	2 (1.7%) 7 (5.80%) 35 (28.9%) 29 (24%) 24 (19.8%) 24 (19.8%)	0.026	2 (0.9%) 19 (8.9%) 64 (30%) 58 (27.2%) 34 (16%) 36 (16.9%)

Table 5: Dairy cattle breeding performances (reproduction and dairy production management) in arid and semi-arid regions' dairy cattle farms (continued).

Lactation Length "Day")	<305 305-350 >350	90 (97.8%) 2 (2.2%) 0	67 (55.4%) 45 (37.2%) 9 (7.4%)	0.000	157 (73.7%) 47 (22.1%) 9 (4.2%)
Cow's productivity duration (Years)	< 5 < 10 > 10	2 (2.2%) 60 (65.2%) 30 (32.6%)	3 (2.5%) 55 (45.5%) 61 (50.4%)	0.015	5 (2.3%) 115 (54%) 91 (42.7%)

1.4.2. Dairy production

Table 5 highlights similarities and differences in dairy production between the two regions.

Milk Yield: the amount of milk produced by a cow daily, demonstrates no significant difference ($p>0.05$) between the regions. A majority of farms in both regions achieve 15-25 litres/cow/day (L/C/D), with an overall mean of 15±4 litres. During the spring season, milk production tends to increase, reaching levels of over 35 L/C/D, with a mean of 20±5 litres.

Lactation Length: exhibits a significant difference ($p<0.001$). AR farms predominantly experience shorter lactation periods, with almost all farms reporting a lactation length below 305 days. Nevertheless, in SAR, lactation length varies more widely; 55.4% of SAR farms have lactation periods shorter than 305 days, 37.2% achieve a moderate lactation length of 305-350 days, and 7.4% benefit from extended lactation periods exceeding 350 days.

Herd Replacement: In terms of herd replacement practices, farmers in both regions can be categorized into two distinct groups, each comprising 50% of the population. The first group prefers to keep their cows in the herd for an extended period, often exceeding 10 years, while the second group opts for early herd renewal, replacing cows before they reach the age of 10 years.

I.5. Disease Prevalence/ Breeding situation

Figures 16 and 17 illustrate dairy cattle farms situation and the prevalent pathologies affecting them in both regions.

In the AR, multiple pathologies exist, the most common of which is mastitis, followed by digestive and respiratory disorders. Reproductive diseases are significantly more common in SAR farms (19.8% of farms), mostly obstetrical, especially placental retention, digestive pathologies rank as the second most frequent pathologies.

Aside from water scarcity, inadequate infrastructure (tracks), limited availability of skilled inseminators and harsh climate (environment) in AR, the main constraint is food (both in terms of cost and availability) in both regions.

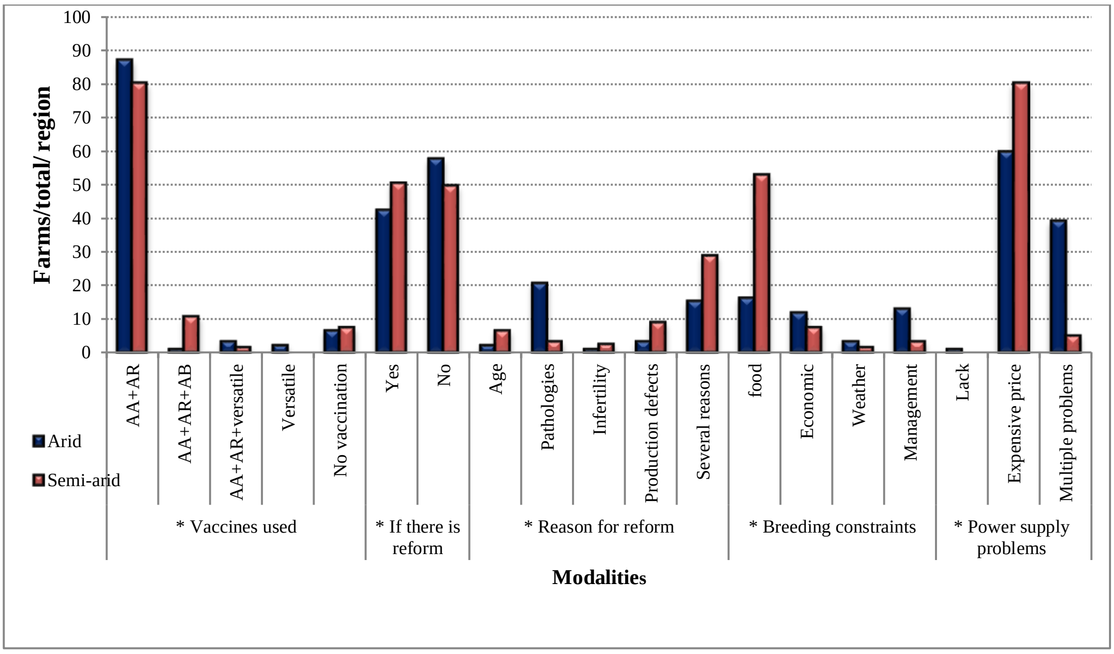


Figure 16: A multifaceted approach; addressing cattle breeding situation and constraints in both regions "Arid and semi-arid ".

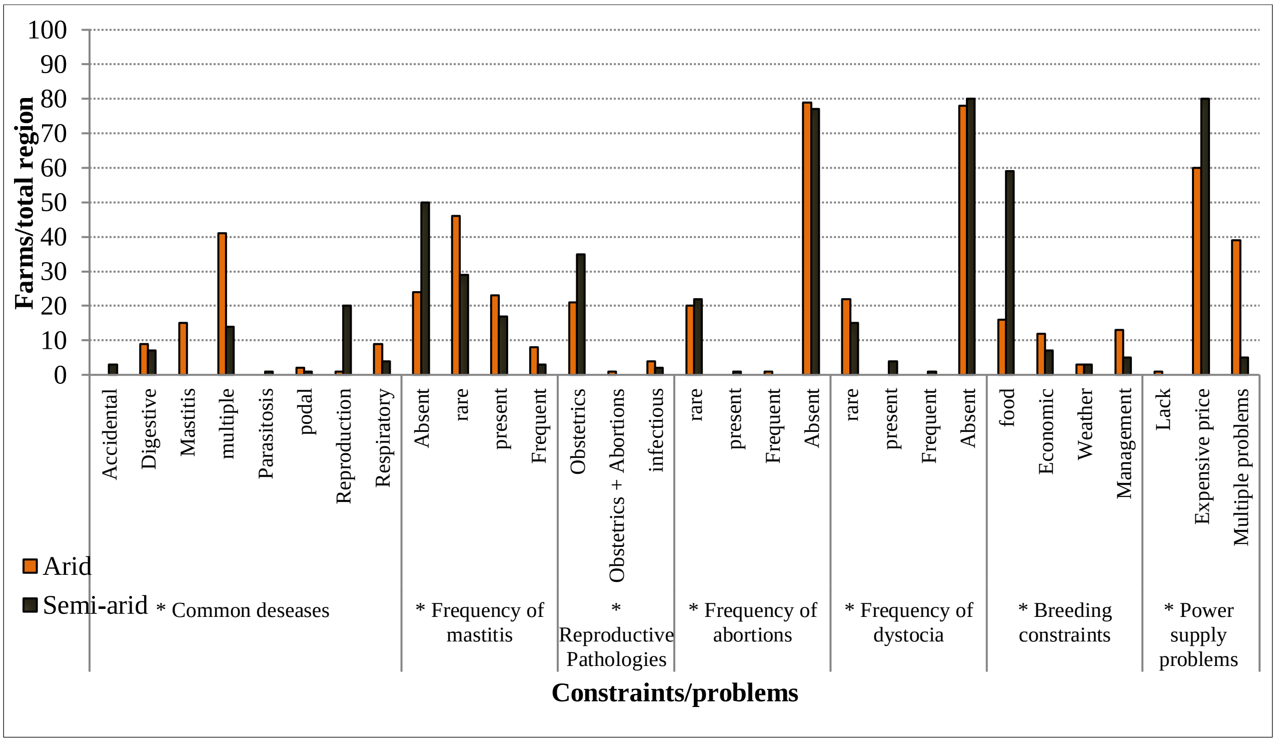


Figure 17: Major problems in both regions "Arid and semi-arid ".

I.6. Discussion

I.6.1. Dairy Cattle Breeders' Socio-economic Status

Farming is dominated by middle-aged managers/farmers; since younger individuals avoid it due to its harsh conditions and limited social status. Insufficient training levels, especially in AR, particularly in the context of agriculture, can lead to poor livestock management and have a negative impact on the adoption of new technologies and work techniques, such as artificial insemination, and can hinder the overall development of the sector (Paltasingh and Goyari, 2018; Mendonça, 2020). Therefore, it is crucial to ensure that training levels are adequate to support the proper management of livestock and the successful integration of new agricultural practices and technologies. These results are close to those obtained in sub-humid regions and SAR in Algeria (Relizane) (Meskini *et al.,* 2020), Tunisia (Mohamed-Brahmi *et al.,* 2022) and Senegal (Dassou *et al.,* 2017).

Furthermore, In the SAR, dairy cattle breeding indicates a greater reliance on this agricultural activity, conversely, nearly half of AR breeders (47.8%) income-generating activity alongside dairy cattle farming. This notable difference potentially reflects variations in socioeconomic conditions and income-generating opportunities between the two regions. Because Biskra is a date palm and greenhouse cultivation region (Amichi *et al.,* 2015), many breeders in this AR have an auxiliary occupation (agro-breeders).

I.6.2. Breeding qualities: traits and conditions

I.6.2.1. Livestock housing

Despite the relatively better state of buildings, particularly in terms of type, general characteristics, and hygiene conditions, in the semi-arid region (SAR) compared to the arid region (AR) where structures do not resemble recognizable cowsheds, they remain substandard in both regions. This situation significantly impacts farm performance, particularly in dairy farming, as the cowshed plays a crucial role (Wallet and Lagel, 2011). Poor building conditions can contribute to the spread of diseases such as mastitis, which is closely linked to rearing and milking conditions, as well as hygienic characteristics (Foughali *et al.,* 2019). Therefore, improving the design, construction, and hygiene of agricultural buildings is essential to ensure the welfare of livestock and the overall success of farming practices.

I.6.2.2. Land potentiality

Our findings unveiled a notable disparity in land utilization between the arid (AR) and semi-arid (SAR) regions. SAR farms benefit from both Utilized Agricultural Area (UAA) and pasture lands, facilitated by moderate rainfall (Latreche *et al.*, 2019), providing ample grazing areas. Conversely, in AR, farms predominantly rely on UAA with limited pasture lands. Faced with drier conditions, AR breeders utilize their own lands primarily through boreholes (Ouendeno, 2019). Other studies conducted in Algeria have reported varying agricultural land sizes, with an average of 8 hectares per farm in the SAR Relizane (Meskini *et al.*, 2020) and 42.7±101 hectares in the northern zone (Boukhechem *et al.*, 2019). In Tunisia, Amamoua et al. (2018) noted that over 50 hectares of agricultural land were found in only 10% of the surveyed farms, while 20% had 10–50 hectares, and 70% had less than 10 hectares.

I.6.2.3. Cattle herd

Small herds of less than 15 heads/ farm rule the roost in both AR and SAR, with an average of 13.2 and 7.9±4.6 heads per farm, respectively. Interestingly, the number of dairy cows per herd remains quite similar at around 6.8±3 DC (Dairy Cow) in both regions. These figures mirror national trends, as documented in studies from Tizi Ouzou, Constantine, and Mascara and other different locations in Algeria (Mouhous *et al.*, 2020; Foughali *et al.*, 2019; Yerou *et al.*, 2019; Mohamed-Brahmi *et al.*, 2022), with averages of 8-14 heads/farm, and 6-10.4 DC/herd respectively. Similar to Erbil (Iraq), where Raoof and Sartip (2022) found that most farms had <20 heads. In Tunisia, 65% of the farms have less than 10 dairy cows, while only 6% have more than 50 cows (Amamoua *et al.*, 2018).

While most farms in both regions rely on crossbred cattle, other studies have recorded that imported purebred are the most frequently encountered (Yerou *et al.*, 2019; Sahi *et al.*, 2021).

I.6.3. Reproductive strategies and husbandry techniques

I.6.3.1. Feeding and Watering Practices

Feeding practices in both regions deviated from recommended guidelines, as farmers did not employ standardized nutritional calculations or scientific resources.

Farmers in both regions relied on roughage (fodder) as their primary feed source. However, AR farms supplemented this with concentrates based on readily available ingredients like dates, wheat, and bran, often lacking a standardized approach to determine nutritional needs. In contrast, SAR farms heavily relied on grazing, taking advantage of available pastures, as observed in other Algerian regions like Setif and Mila (Sahi *et al.*, 2021). This grazing practice enriched their cows' rations and potentially improved their health and welfare (Beaver *et al.*, 2019).

I.6.3.2. Reproduction management

Reproductive management is one of the most important aspects of the cattle economy and cornerstone of profitable livestock farming as late fertilization and low fertility rates directly impact costs and lead to significant losses (Belhadia *et al.*, 2009; Fodor *et al.*, 2019).

Natural mating is the most prevalent mode of reproduction in both regions, with farmers in AR relying on it due to the lack of inseminators and those in SAR preferring to use their own bulls for religious and traditional reasons. Similar results have been observed in other arid regions, such as the M'zab Valley in the central Algerian Sahara (Bensaha and Arbouche, 2014) and Senegal (Dassou *et al.*, 2017), as well as in northern semi-arid region of Algeria (Boukhechem *et al.*, 2019). Artificial insemination is observed in 12% of farms, half of which combine it with natural mating. This is in contrast to other studies in Morocco (Sraïri *et al.*, 2005), Algeria (Kaouche-adjlane *et al.*, 2015), and Iraq (Raoof and Sartip, 2022), where artificial insemination is the main method.

The adoption of advanced reproductive technologies like artificial insemination and embryo-transfer can revolutionize livestock production, not only boosting overall efficiency but also yielding a greater number of high-performing offspring.

While AR farmers primarily rely on self-renewal and purchasing cows, nearly half of SAR farmers replace their herds randomly, i.e. without any particular strategy and depending on availability. This stands in stark contrast to Relizane, where 84% of dairy farmers prioritize raising heifers for future replacements (Meskini *et al.*, 2020).

From a managerial and economic perspective, pregnancy detection in cows is crucial. It is necessary to detect the non-pregnant cows as soon as possible since it minimizes the inter-insemination interval and decreases DO period (Gnemmi *et al.*, 2022). Rectal palpation or examination in AR and the absence of heat in most SAR farms serve as the test parameters. Both methods are less specific and less sensitive, which can affect performance. The adoption of more precise techniques and accurate procedures, like ultra-sonography, can increase performances, since this method can detect pregnancy up to 15 days earlier than rectal palpation with high sensitivities and specificities when performed between 21 and 35 days after insemination (Bagley *et al.*, 2022).

I.6.3.3. Daily production practices

Milking circumstances, including milkers' hands state, udder health, and hygiene score, as well as milking equipment state (FAO, 2014; Wallonie Elevages, 2013), are mediocre in most studied farms.

In the majority of AR farms milking is manual likely because of the modest herds size, which leads farmers to believe that manual milking is acceptable since the milk is being produced for household consumption rather than for sale as an excess commodity. This is in line with reports from Constantine (Algeria) and Senegal, respectively, by Foughali et al. (2019) and Dassou et al. (2017). Yet, there is a clear requirement to employ milking machines because of their benefits in the SAR (p<0.001), where dairies (marketing) represent the primary destination of generated milk. This shift towards mechanized milking in SAR likely reflects increased production volumes and a desire to improve labour efficiency because using milking machines can help streamline operations, enhance animal welfare, and meet the increasing demand for high-quality dairy products. Belkheir et al. (2015) and Djermoun et al. (2017) reported also that mechanical milking is the main method in respectively Tizi Ouzou and Cheliff.

It is common practice in both SAR and AR regions to reserve a portion of the milk produced for calves' consumption until late weaning, which is typically over three months. This practice is prevalent in many regions where breeders often favour late weaning; Abdelli et al. (2021), recorded that the majority of studied farms in Medea have a weaning age of more than three months, Boukhechem et al. (2019) recorded an average of 4.12 ±1.29 months in northern Algeria, also Mengistu et al. (2017) in Ethiopia reported an average of 9.27 ± 2.22 months. This might explain the detrimental consequences of late weaning that sounds good for the health of calves because late weaning allows for a more gradual shift in the ruminal and intestinal flora (Meale *et al.*, 2017). Additionally, late weaning has beneficial effects on growth and later consumption (Eckert *et al.*, 2015).

Drying-off, the period when milking is temporarily ceased to allow cows to rest and prepare for their next lactation, this practice aligns with the cow's natural physiological changes and aims to minimize stress and potential health complications.

The contrasting milking and drying-off practices underscore the distinct approaches taken by dairy farmers in each region. Drying-off strategies also reflect varying farm management styles and priorities. AR farmers may opt for longer drying periods to prioritize cow health and reduce potential mastitis issues, while SAR's adherence to physiological drying aligns with their focus on animal welfare and natural processes.

I.6.4. Performances

I.6.4.1. Reproductive performance parameters

Age at mating and first calving

In dairy farms, breeding heifers for replacement can be costly, as nutritional and managerial demands, including feed, treatments vaccinations, and general maintenance (among other necessary expenses) increase with the length of the non-productive time (Abuelo *et al.*, 2021). Therefore, in addition to feed cost optimization, minimizing the non-productive time by making early calfhood, a critical window for optimizing costs, can help reduce the overall cost of dairy farming and improve profitability.

The majority of farmers in the AR inseminate their heifers between the ages of 12 and 15 months, while in the SAR, farmers tend to wait until they are older, exceeding 15 months. This practice contradicts with the findings of Benidir et al. (2020) who reported that the majority of Setif breeders raise their heifers until 20 months for first conception service, leading to first calving at approximately 29 months, also Attia et al. (2019) reported an average age at first service in the El Taref sub-humid region of 24 months. However, our results are similar to those of Mohamed-Brahmi et al. (2022) who recorded an average age at first mating of about 15±3.5 months.

It is noteworthy that our breeders demonstrate exemplary heifer management by minimizing the age at first calving and expenses associated with raising their heifers. A lower age at first calving is linked to improved udder health, increased daily milk production, enhanced reproductive performance, and higher calving probability (Eastham *et al.*, 2018; Atachi *et al.*, 2021). Well-managed heifers also exhibit greater conception rates, resulting in reduced costs per pregnancy and per replacement heifer produced.

Waiting period, days open and inseminations' number

Fertility assessments in both regions indicate that a significant number of farms have waiting periods (calving to first insemination interval) longer than sixty days, which is against advised guidelines and recommended practices (Roelofs *et al.*, 2010). This aligns with Yahimi et al.'s observation that a vast majority (67%) of farmers only inseminated their cows over 70 days post-calving (Yahimi *et al.*, 2013). Furthermore, 71.7% of farms require at least two inseminations for fertilization, of which 9.8% require at least three, a greater rate than that reported by Mouffok et al. (2019).

The calving interval is extended as a result of excessively poor fertility features, especially in AR farms. Hanzen (Hanzen, 2009) defines a herd exceeding 30% cows with ICI above 400 days as seriously infertile. This can be attributed to poor heat detection, which is a critical component of dairy breeding, results in a cascade of losses: longer waiting and reproductive periods, reduced milk production, fewer calves, increased feed costs, and higher veterinary expenses (Roelofs *et al.*, 2010). Fertility rates may also decline as a result of the hot weather (Sammad *et al.*, 2020).

The majority of SAR farms require ≤2 inseminations for fertilization, translating a first insemination success rate of 35.5%. However, Mouffok et al. (2019) reported a rate of 64%.

SAR farms achieve fertilization within 60 days in 21.5% of farms and within 60–90 days postpartum in 47.1%. Similar SAR regions often report longer intervals; Haou et al. (2021) and Hammami et al. (2021) observed an average DO exceeding 100 days in over 58% of farms.

These disparities in reproductive performance parameters reflect the influence of environmental factors, management practices, and breed characteristics on animal reproductive efficiency.

In fact, our ICI findings are encouraging, better than many other studies in Algeria where higher percentages and intervals have been observed: 452.1 ± 31.7 days (Kaouche-Adjelane, 2015), 422.4 ± 88.7 days (Bouamra *et al.*, 2016), over 500 days (Mohamed-Brahmi *et al.*, 2022) and according to Haou et al. (2021), 39.7% of studied farms had a 400-day gap, while Abdelli et al. (2021) found about 83% of studied farms with an average interval of 420 days. Even abroad, Aboly et al. (2021) found a mean ICI of 428 ± 16.6 days in Ivory Coast, Hammami et al. (2021) found a mean ICI of 453 days in Tunisia. However, Semara (Semara, 2011) discovered an average of 351±43 days between consecutive parturitions.

Basically, the aim is to have an ICI of 365 days or less, ensuring one calf/cow/ year. This does not only ensure genetic progress but also impacts the number of lactations of a dairy cow. Therefore, effective fertility management strategies, including regular and accurate fertility evaluations, appropriate reproductive technologies, and management and nutrition conditions adapted to the periods of heat stress, are crucial for optimal reproductive performance and overall profitability.

I.6.4.2. Dairy production

Most farms in both regions report a milk yield level of 15–25L/C/D with an average of 15± 4 litres. This level reaches +35L/C/D in spring with an average of 20±5 litres, thanks to the feed availability and favourable climate conditions. Temperature and humidity extremes are known to negatively impact milk production (Hill and Wall, 2015).

These findings, which illustrate farms' practices and animals' welfare status that directly affect milk production (De-Vries *et al.,* 2011), are very similar to those in other studies whether in Algeria or Morocco; Belkheir et al. (2015) and Si-Tayeb et al. (2015) reported an average of respectively 14.5Kg/C/D and 15±5L/C/D in Tizi Ouzou. Boukhechem et al. (2019 noted an average of 14.3±4.77Kg/C/D in northern Algeria. Srairi et al. (2015) reported an average of 14 Kg/C/D in Morocco.

However, lower levels are recorded in Constantine and El Taref; 5–15L/C/D in 77.1% and 5–10 L/C/D in 78.9%, respectively for Constantine (Foughali *et al.*, 2019) and El Taref farms (Attia *et al.,* 2019).

Moreover, our results are clearly superior to those recorded in the arid zones of Africa, Kassa et al. (2016) and Mengistu et al. (2017) reported an average of 2 L/C/D in respectively Benin and Ethiopia.

Regarding longevity and reform, our results suggest that dairy production practices and outcomes are influenced by a combination of factors, including breed characteristics, management practices, and environmental conditions. While milk yield may not differ significantly between the regions, variations in lactation length and herd replacement strategies indicate adaptations to the specific contexts of each area.

I.6.5. Disease Prevalence/ Breeding situation

All herds in our sample benefit from the state vaccination program and the veterinarian is only present in the event of the occurrence of pathologies, which are the main reason for culling within the farms that practice it (half). Multiple pathologies are observed in the arid region, with mastitis being the most common in 25% of farms, followed by digestive and respiratory pathologies, this can be explained by heat load which usually favours those health problems (Lees *et al.,* 2019).

While semi-arid farms suffer much more from reproductive pathologies (in 19.8% of farms), mainly obstetrical pathologies that are dominated by retained placenta, followed by digestive. The absence of abortions and dystocia characterizes most farms, and even if present, they are rare. Mammeri et al. (2020) reports the same result in Constantine, where mastitis, foot diseases, dystocic calving, and neonatal diarrhea are the most common diseases. On the other hand, the study by (Sahi *et al.*, 2021) reveals that the most dominant pathologies in Setif and Mila are foot-and-mouth disease and pasteurellosis.

In AR region, the lack of water, the cost and availability of feed, the tracks, the absence of artificial insemination services and the harsh climate all hinder the exploitation of large areas and limit the ability of livestock farmers to develop dairy cattle farming and improve production in the region. These are the same problems encountered in Guerrera (Algerian Sahara) (Senoussi *et al.*, 2010).

According to both regions breeders, nutrition is the most important factor in improving dairy cattle production. They believe that providing cows with adequate amounts of high-quality feed (green forage and concentrate) is essential for maximizing milk production.

In addition to nutrition, some breeders believe that genetic potential is also important. They argue that using dairy breeds with high milk yields can lead to significant increases in production.

II. Typology of dairy cattle farms in each arid and semi-arid region.

This study part, using same variable of section one, which were grouped into five themes and analyzed separately, explores different dairy farms groups in the two regions: arid (AR) of Biskra-Ouled Djellal and semi-arid (SAR) of southern Souk Ahras.

Collected data, stemming from farmers' responses to various survey questions, were converted into categorical variables using quintile positions relative to their mean values. This transformation allowed the observation frequencies falling within quintiles less than 25%, between 25% and 75%, and greater than 75% of the mean value for each selected variable, as recommended by Solano et al. (2000). Consequently, all qualitative data and transformed quantitative data were utilized for multiple correspondence analysis (MCA), conducted using SPAD 5.5 software (SPAD, 2002).

These active structural variables used in the MCA are presented in Annex Tables (A1, A2, A3, A4 and A5). Subsequently, the first two factors derived from the MCA were incorporated into a hierarchical cluster analysis. The program identified the cluster with the least within-group variance and the highest variance between groups as the most appropriate output. Finally, mean indicators defining each group were computed.

Results in the form of Dendrogram and clouds allowed us to define the most interesting groups. In our case, we need to archive the first two axes, which account for more than 24% of the information.

II.1. Socio-economic characteristics

The multiple correspondence factor analysis (MCA) conducted on 121 breeders in the Southern Souk Ahras (SAR) and 92 in Biskra-Ouled Djellal (AR) led to the retention of a set of 5 active variables, encompassing 13 modalities as presented in Table A1. The combined contribution to the total inertia of the first seven components is 91.26% for SAR and 100% for AR. The first two factorial axes, having the highest variance percentages in comparison to the other axes, account for approximately 44.46% of the total inertia in SAR and 41.40% in AR. All factors were included in the ascending hierarchical classification, resulting in three distinct socio-economic profiles in SAR and two breeder socio-economic profiles in AR (Figure 18 and 19).

The general characteristics are as follows:

In Biskra-Ouled Djellal (AR), the first group comprises 68 farms (73.91%), characterized by middle-aged breeders (92.65% between 30-60 years old) with a moderate level of education (72.06%) and experience (64.71%). The second group consists of 24 farms (24.09%)

representing a classic group of older breeders (79.17% are above 60 years), predominantly illiterate (95.83%) but experienced (70.83% with at least 20 years of experience).

In Southern Souk Ahras (SAR), the first group encompasses 79.34% of the farms, primarily made up of untrained and unskilled farmers (95.83% illiterate and lacking agricultural training), but with significant experience (70.83% are experienced). The second group consists of 5 farms (4.13%) distinguished by breeders with agricultural training (100%). The third group comprises a total of 20 farms (16.53%), characterized by experienced breeders with a high level of education, including university degrees (80%).

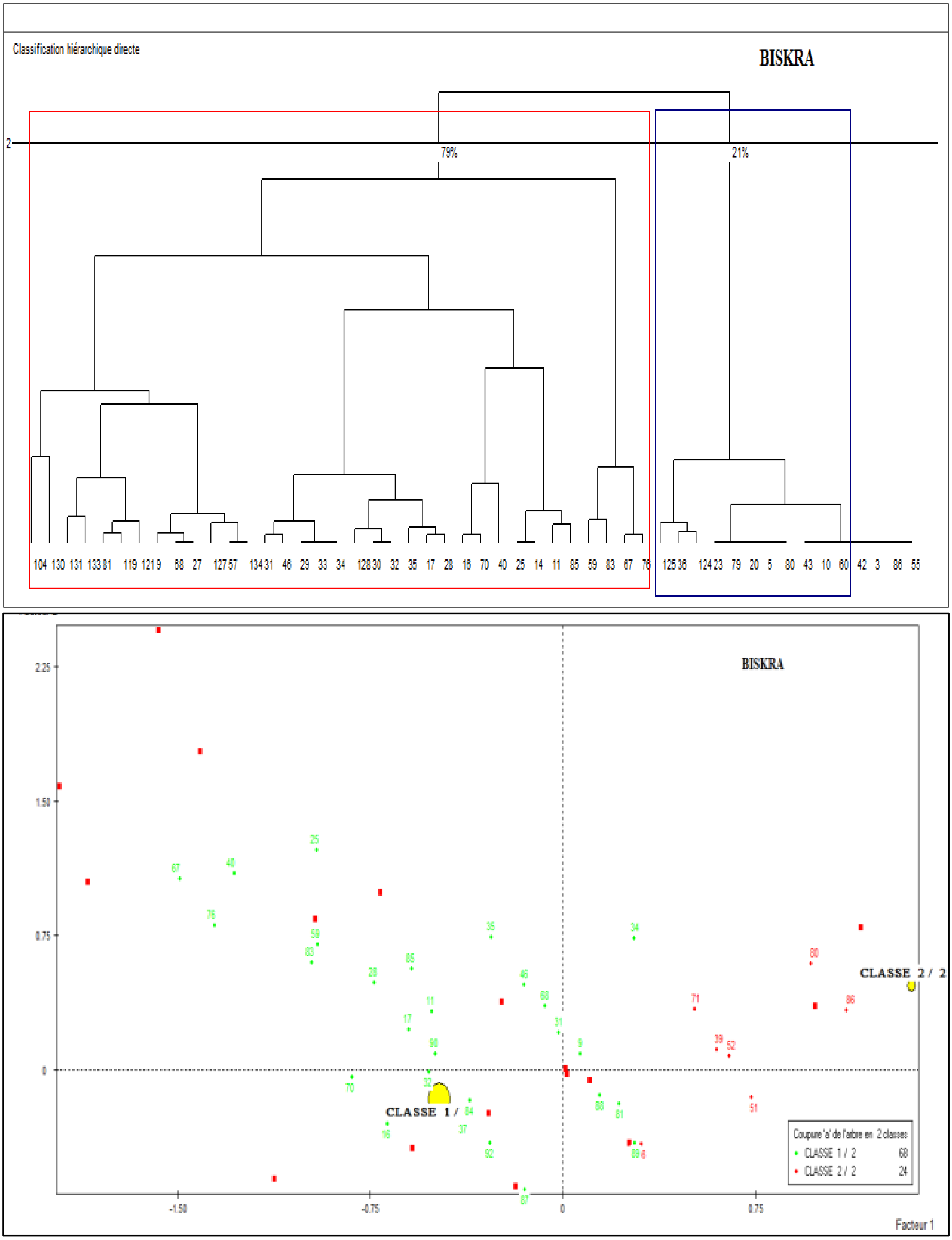


Figure 18: Graphic representation of modalities of breeders' socio-economic variables on axis 1 and 2 in the arid region (see Table A1 for variables and terms).

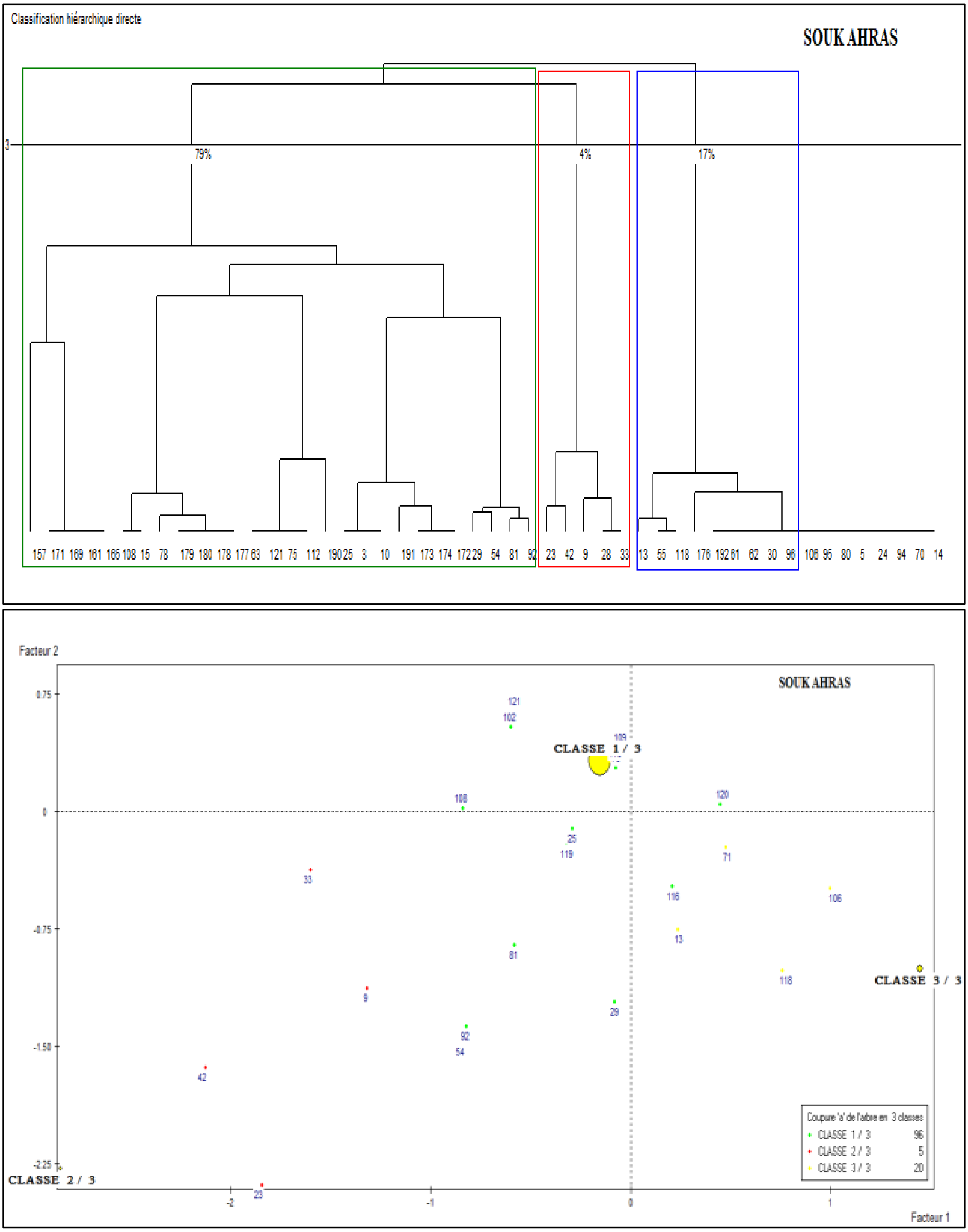


Figure 19: Graphic representation of modalities of breeders' socio-economic variables on axis 1 and 2 in the semi-arid region (see Table A1 for variables and terms).

II.2. Breeding Situation

The first two axes exhibit the highest percentages of variation, with inertia values of around 18.71% in (AR) and 19.56% in (SAR). The analysis allowed distinguishing 4 and 3 groups in the (SAR) and (AR) respectively (Figure 20 and 21).

In Biskra- Ouled Djellal (AR): the group 1 consists of 45 dairy farms (48.91%) which are characterized by poor building conditions (80% of farms) with an average number of cows of 5-15 in 75.56% of them. Food sources are based on UAA and boreholes for watering in 95% farms. The group 2 (34 farms, 36.96%) includes farms with a low cow number per herd (lower than 5 heads in 50%), reared in poor conditions (94% without buildings). Dairy cows have a Body Condition Score (BCS) lower than 2.5 (in 79.41%) which their feed is based on both types of pasture. The group 3 (13 farms 14.13%) includes farms with higher number of cows (more than 15 heads in 61.54% of farms), reared in sheds (84.62%) under satisfactory conditions (69.23%). Most cows (76.92%) have a BCS above 2.5.

In Southern Souk Ahras (SAR): we recorded 04 farm groups. The first group consists of 86 farms representing 71.07% of the studied dairy farms of this region. 98% of these farms are characterized by substandard buildings quality (hygiene and structure). The group 2, 3 and 4 are composed respectively of 11 farms (9.09%), 9 farms (7.44%) and 15 farms (12.4%) characterized by use of high-performance breeds under good circumstances within threshold norms, bundle farms that use hired labour, pastoral land and farms with bad-quality buildings, respectively.

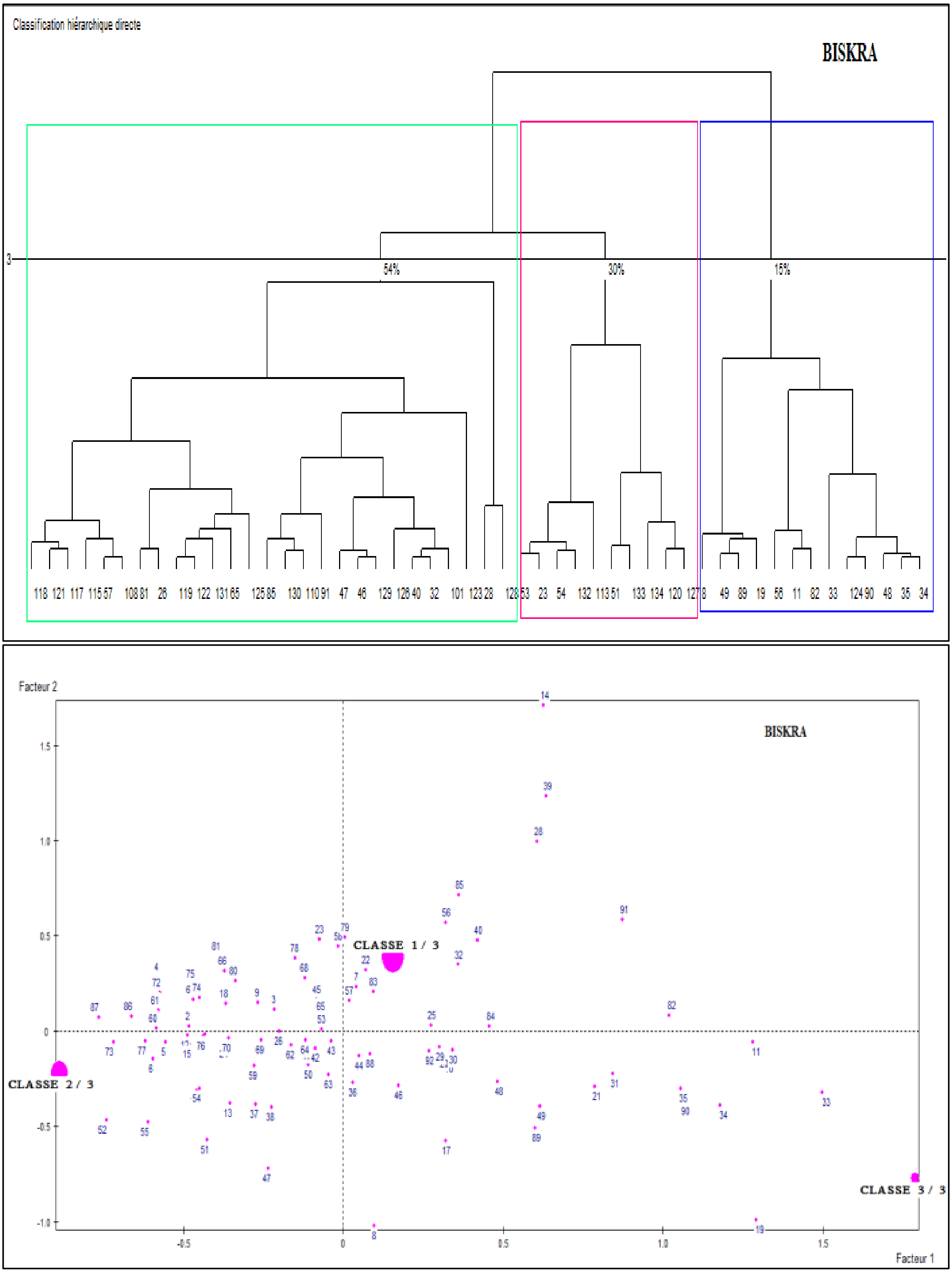


Figure 20: Graphic representation of modalities of the breeding situation variables on axis 1 and 2 in the arid region (see Table A2 for variables and terms).

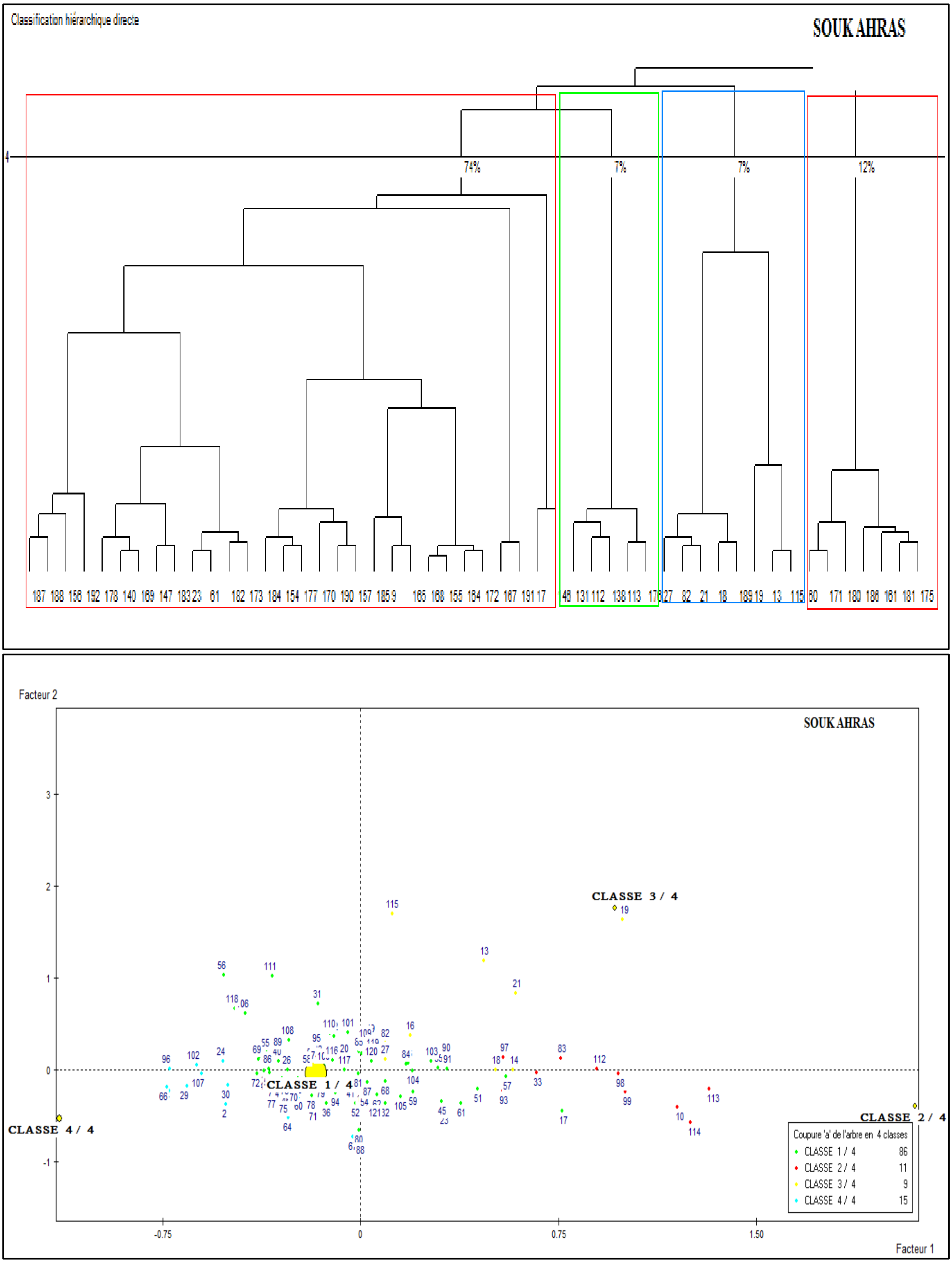


Figure 21: Graphic representation of modalities of the breeding situation variables on axis 1 and 2 in semi-arid region (see Table A2 for variables and terms).

II.3. Breeding techniques

Focused on the first two axes, which collectively represent 42.78% of the total inertia (21.04% in AR and 21.74% in SAR), our analysis, based on MCA and the subsequent ascending hierarchical classification presented in Figure 22 and 23, revealed the identification of 5 groups in AR and 4 groups in SAR.

In Biskra-Ouled Djellal (AR): Group 1 comprises 5 farms (5.43%) that primarily employ bran as the primary concentrate for their cattle. Group 2 includes 9 farms (9.78%) that utilize artificial insemination in addition to natural mating, ultrasound for pregnancy diagnosis, and predominantly (86.67%) mechanical milking under appropriate hygienic measures (observed in 44.4% of them). Group 3 consists of 15 farms (16.3%) that employ milking robots (77.78%) under conditions rated as mediocre to good. Additionally, these farms use DC (Dairy Cow concentrate) as a fixed component of the concentrate. Heifers' insemination in this group is primarily determined by age, as observed in 86.67% of cases, and pregnancy diagnosis relies on simple and traditional methods such as rectal search and heat cessation. Group 4, composed of 30 farms (32.61%), can be described as traditional; characterized by poor hygiene practices, a concentrate consisting solely of bran, and exclusively natural mating. Group 5 consists of 33 farms (35.87%), where milk production is primarily destined for self-consumption in roughly half of the cases. Consequently, practices in these farms are not highly modernized, with manual milking being the norm in 93.94% of farms, often conducted under poor conditions. Furthermore, in 60.6% of cases, the renewal of cows, which receive mixtures of wheat, barley, bran, and more as energetic feed, is based on purchase.

In Southern Souk Ahras (SAR): The first group comprises 38 farms (31.4%) that rely on concentrate mixes based on DC. Group 2 consists of 33 commercial dairy farms, all of which export milk to dairies. These farms may import dairy heifers (observed in 15.15% of farms) and utilize a special dairy cow concentrate known as DC to enhance production. Insemination practices in this group may be either natural or artificial, depending on availability. Group 3 encompasses 22 farms (18.18%) that rely on mixtures as energetic feed (concentrate).The last group (Group 4) consists of 28 farms (23.14%) that exclusively utilize natural mating for reproduction, engage in manual or mechanical milking, and employ only bran as a concentrate. These findings offer valuable insights into the diverse management and feeding practices within dairy farms in these regions, highlighting varying degrees of modernization and breeding strategies.

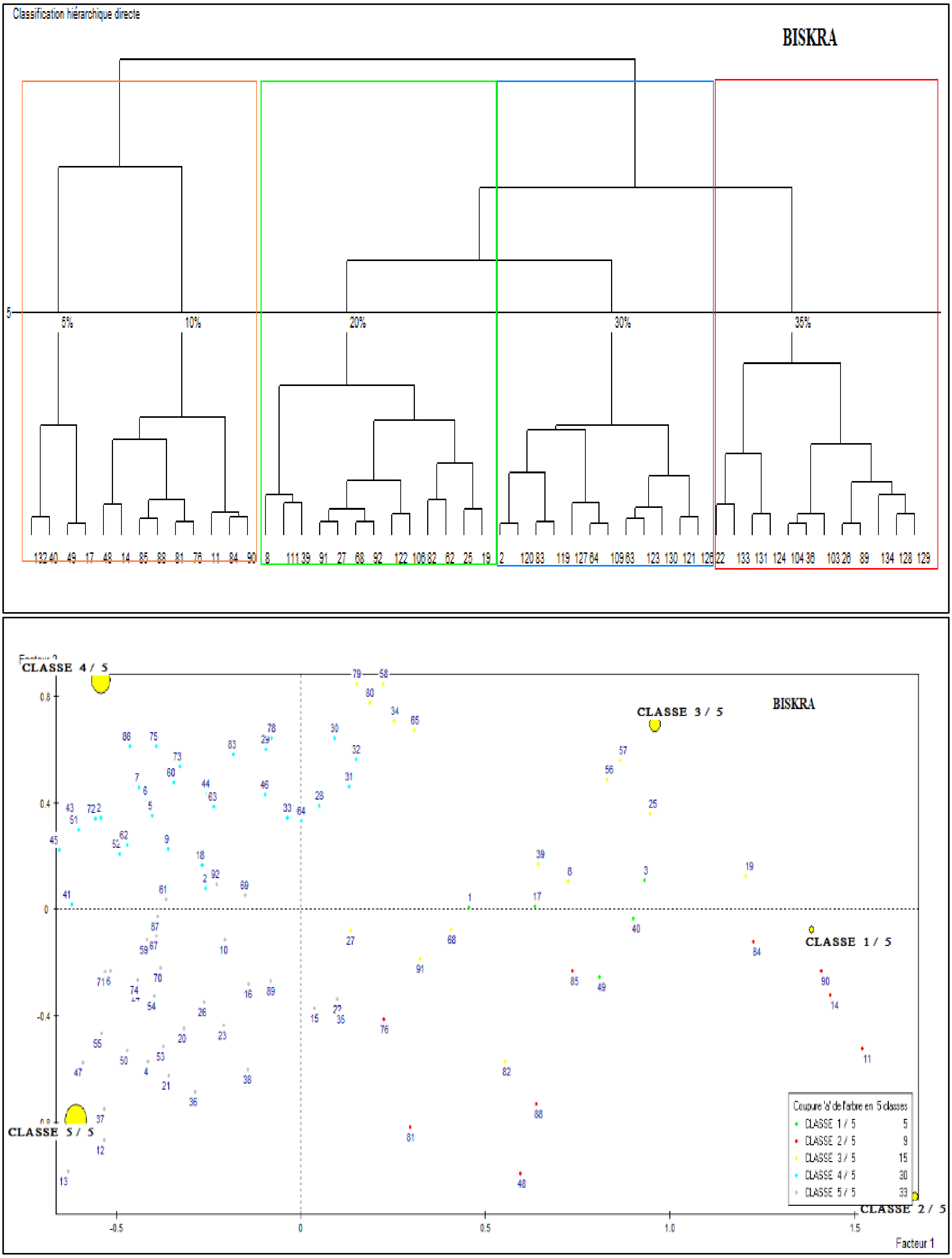


Figure 22: Graphic representation of modalities of breeding techniques variables on axis 1 and 2 in the arid region (see Table A3 for variables and terms).

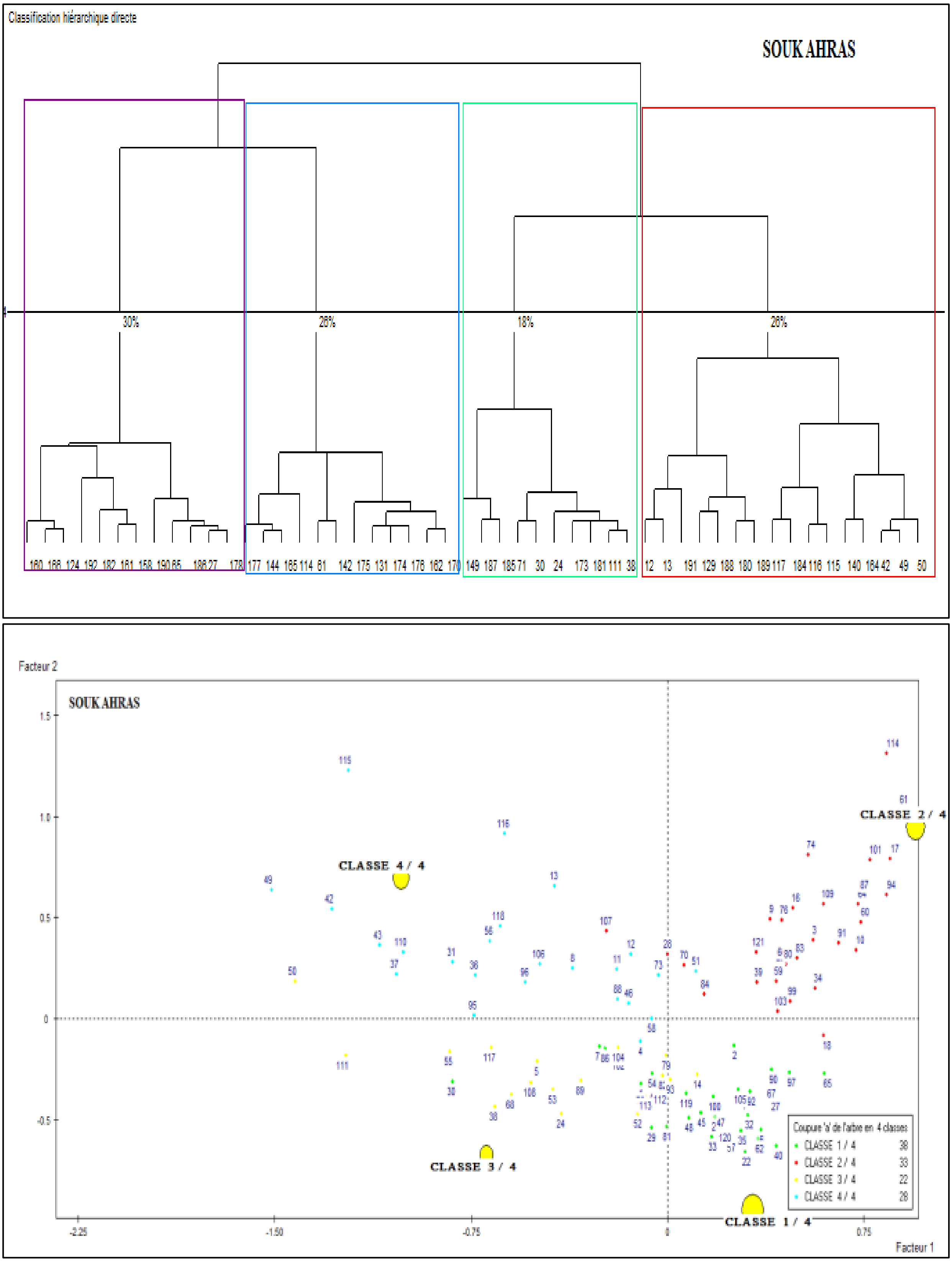


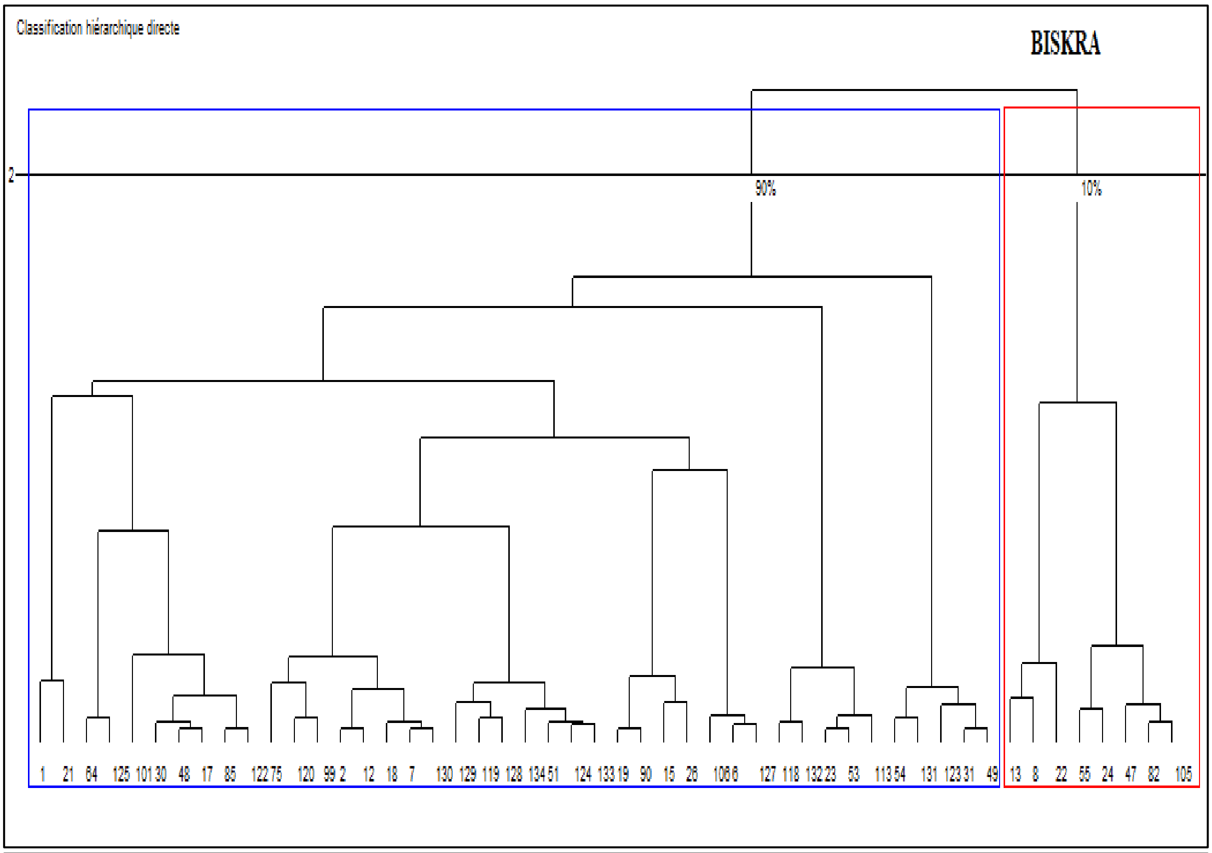
Figure 23: Graphic representation of modalities of breeding techniques variables on axis 1 and 2 in the semi-arid region (see Table A3 for variables and terms).

II.4. Farms productivity

The statistical analysis involving Multiple Correspondence Analysis (MCA) and ascending hierarchical classification resulted in the identification of 2 distinct groups in AR and 4 groups in SAR, as depicted in Figure 24 and 25. These groups are organized based on the first 2 axes, which collectively exhibit inertia of 21.8% in AR and 21.07% in SAR.

In the Biskra-Ouled Djellal region (AR), these groups are categorized as follows: the first group, consisting of 81 farms (90.22%), demonstrates a high fertility rate, typically requiring a maximum of 3 inseminations, with 50% of them needing only 2 inseminations. The second group, comprising 9 farms (9.78%), exhibits low-fertility rates, demanding more than 3 inseminations. This extended the Days Open (DO) to more than 90 days in 77.8% of cases.

In the Southern Souk Ahras region (SAR): Group 1 includes 32 farms (26.46%), where a majority of breeders prefer to inseminate their cows. In 84% of these farms, cows require an average of 2 inseminations for fertilization, typically after 2 months post-partum. This implies fertilization occurring after 90 days and an Inter-Calving Interval (ICI) ranging from 365 to 400 days, observed in 63% of the farms. Additionally, 44% of farmers commence mating their heifers at 12-15 months, resulting in calving within 24-30 months in 84% of the farms. The daily milk production in this group averages about 15-25 L/C. Group 2 comprises 10 farms (8.26% of the total) where breeders inseminate their heifers before their 12^{th} month, leading to the first calving taking place before the 2^{nd} year. Group 3 encompasses 23 farms that did not exhibit any distinctive qualities or special characteristics. In Group 4, which is the best-performing group, consisting of 56 farms (46.28%), cows are inseminated within two months post-partum, typically requiring two inseminations. Consequently, the Inter-Calving Interval (ICI) occurs in less than a year in nearly all farms within this group. Heifers have their first calving at 2 years of age because they are inseminated after 15 months, showcasing efficient reproductive management practices. These findings shed light on the diversity in fertility rates and reproductive management strategies within these regions, providing valuable insights for further agricultural planning and interventions.



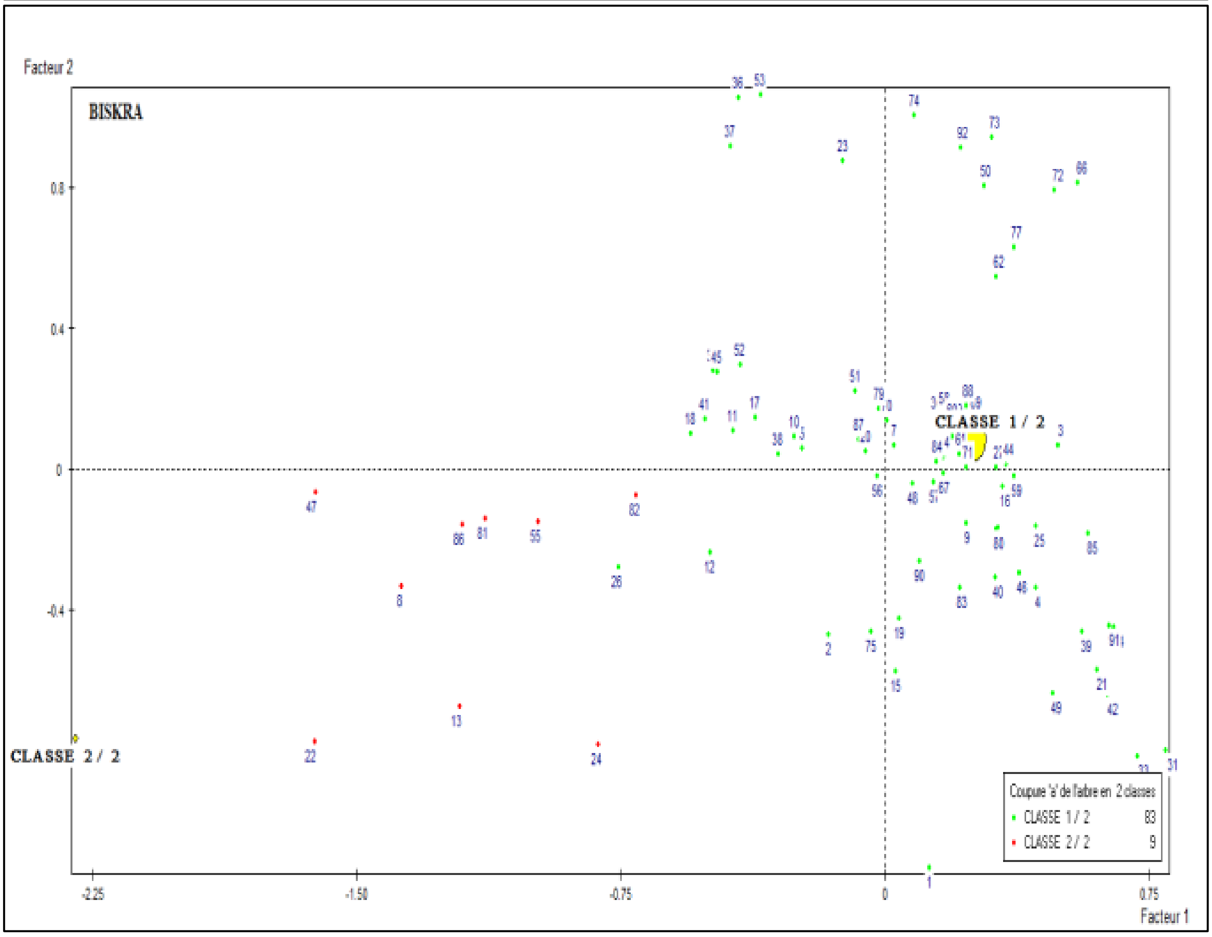


Figure 24: Graphic representation of modalities of farms' productivity variables on axis 1 and 2 in the arid region (see Table A4 for variables and terms).

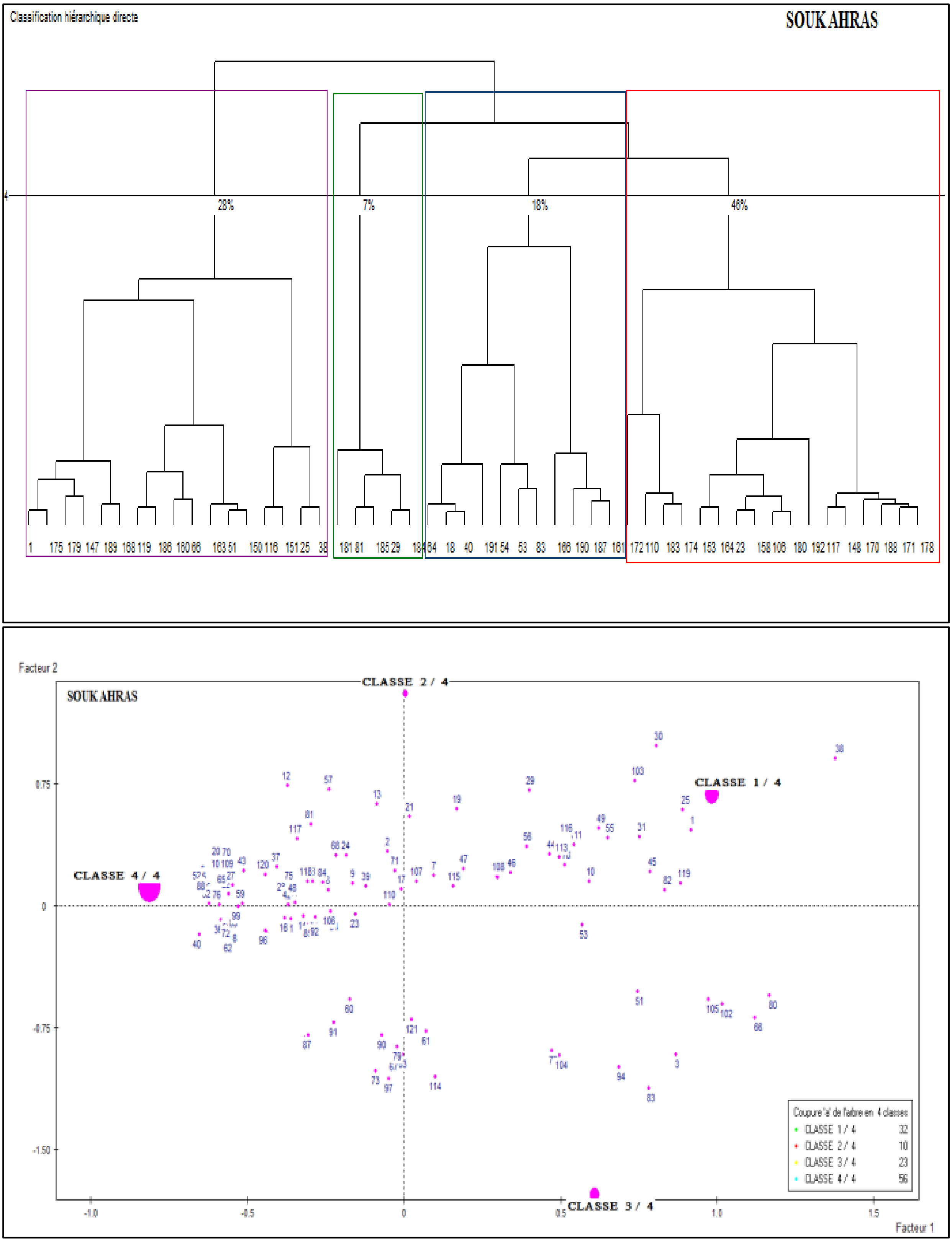


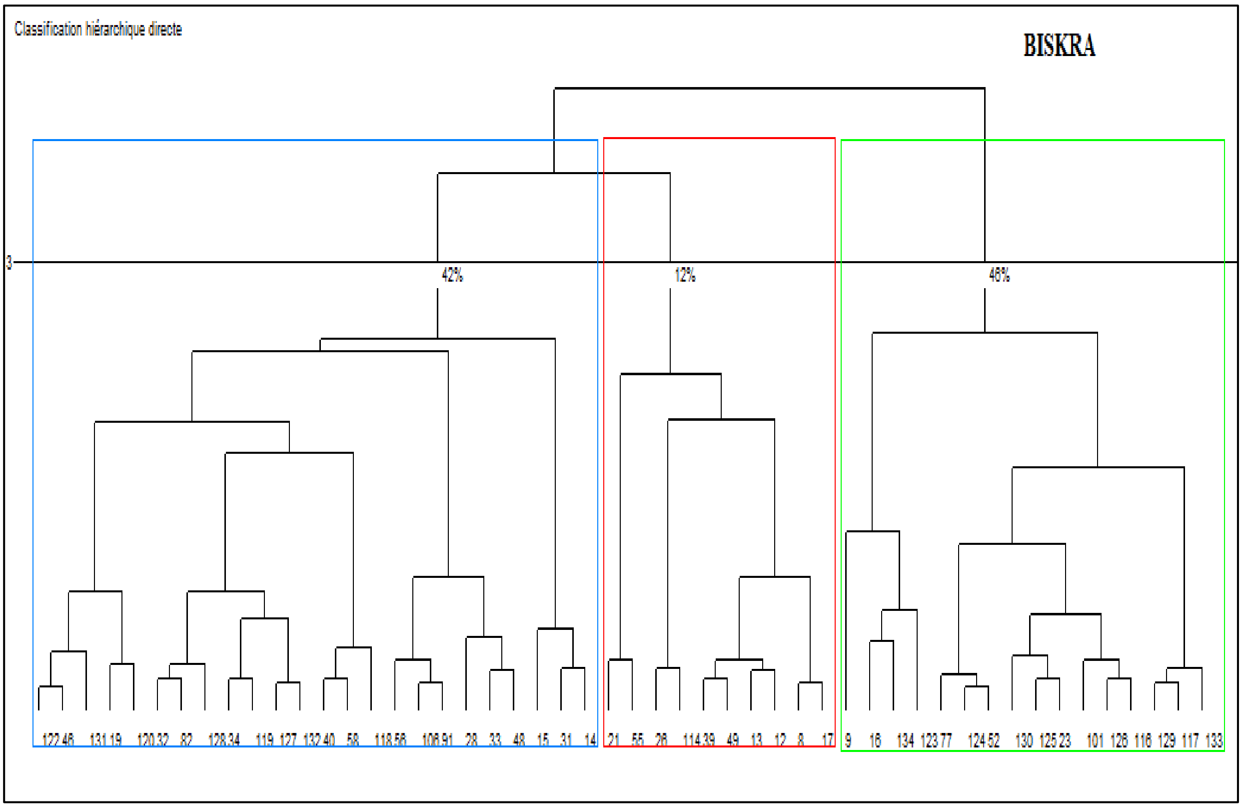
Figure 25: Graphic representation of modalities of farms' productivity variables on axis 1 and 2 in the semi-arid region (see Table A4 for variables and terms).

II.5. Breeding constraints

The statistical analysis, as illustrated in Figure 26 and 27 (involving MCA and ascending hierarchical classification), unveiled the presence of 2 groups in SAR and 3 groups in AR, organized along the first 2 axes, which collectively account for 16.58% and 17.32% inertia, respectively.

In Biskra-Ouled Djellal (AR): Group 1 comprises 34 farms (36.96%) where culling is primarily conducted due to diseases, observed in 50% of these farms. Group 2, encompassing 11 farms (11.96%), faces economic difficulties, largely attributed to infectious disorders, with mastitis being the predominant issue (55%). Group 3 consists of 47 farms (51.09%) that report dystocia deliveries as the primary reason for culling, affecting a significant 91.5% of these farms.

In Southern Souk Ahras (SAR): The first group, composed of 60 farms (49.59%), does not practice culling as a management strategy. The second group consists of 61 farms (50.41%) that engage in culling for various reasons, reflecting the diverse approaches to culling within this region. These findings provide valuable insights into the factors influencing culling practices and the underlying motivations in different regions, informing potential interventions and improvements in the agricultural sector.



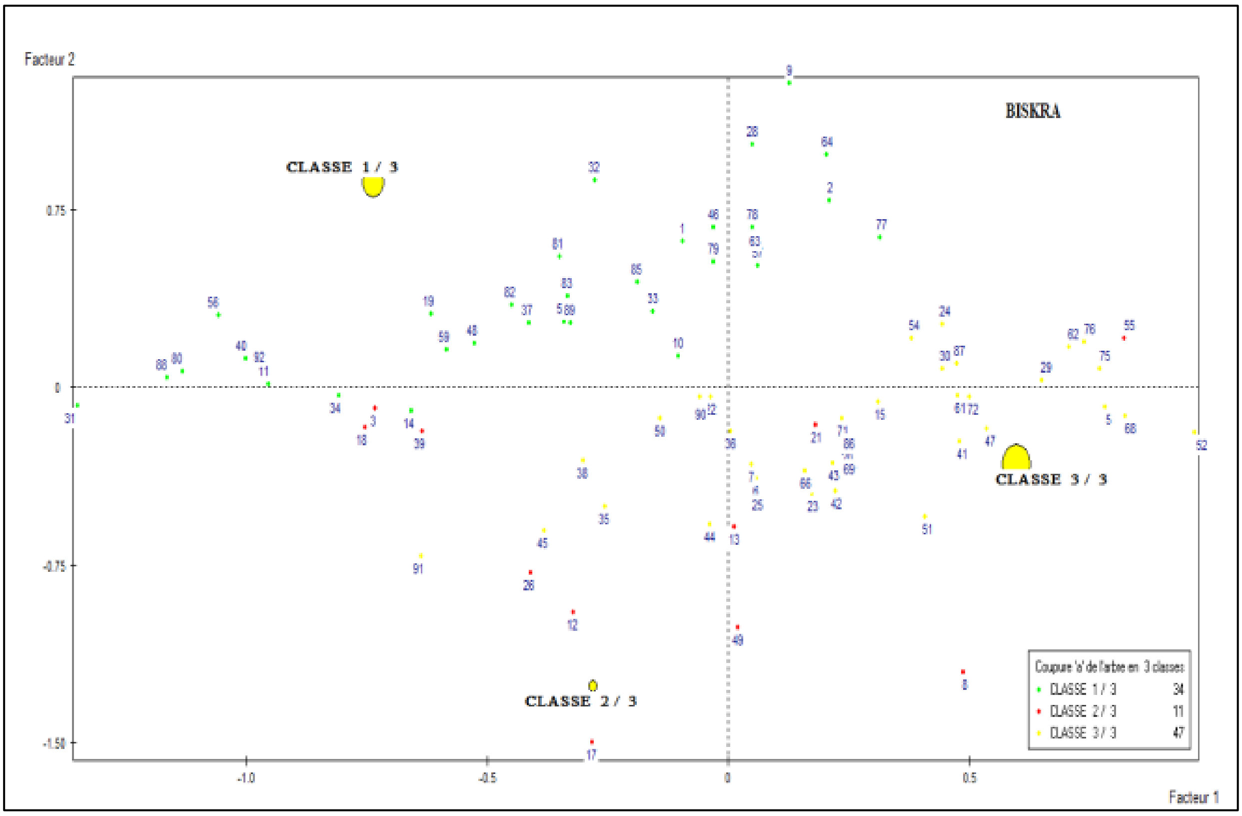


Figure 26: Graphic representation of modalities of breeding constraints variables on axis 1 and 2 in the arid region (see Table A5 for variables and terms).

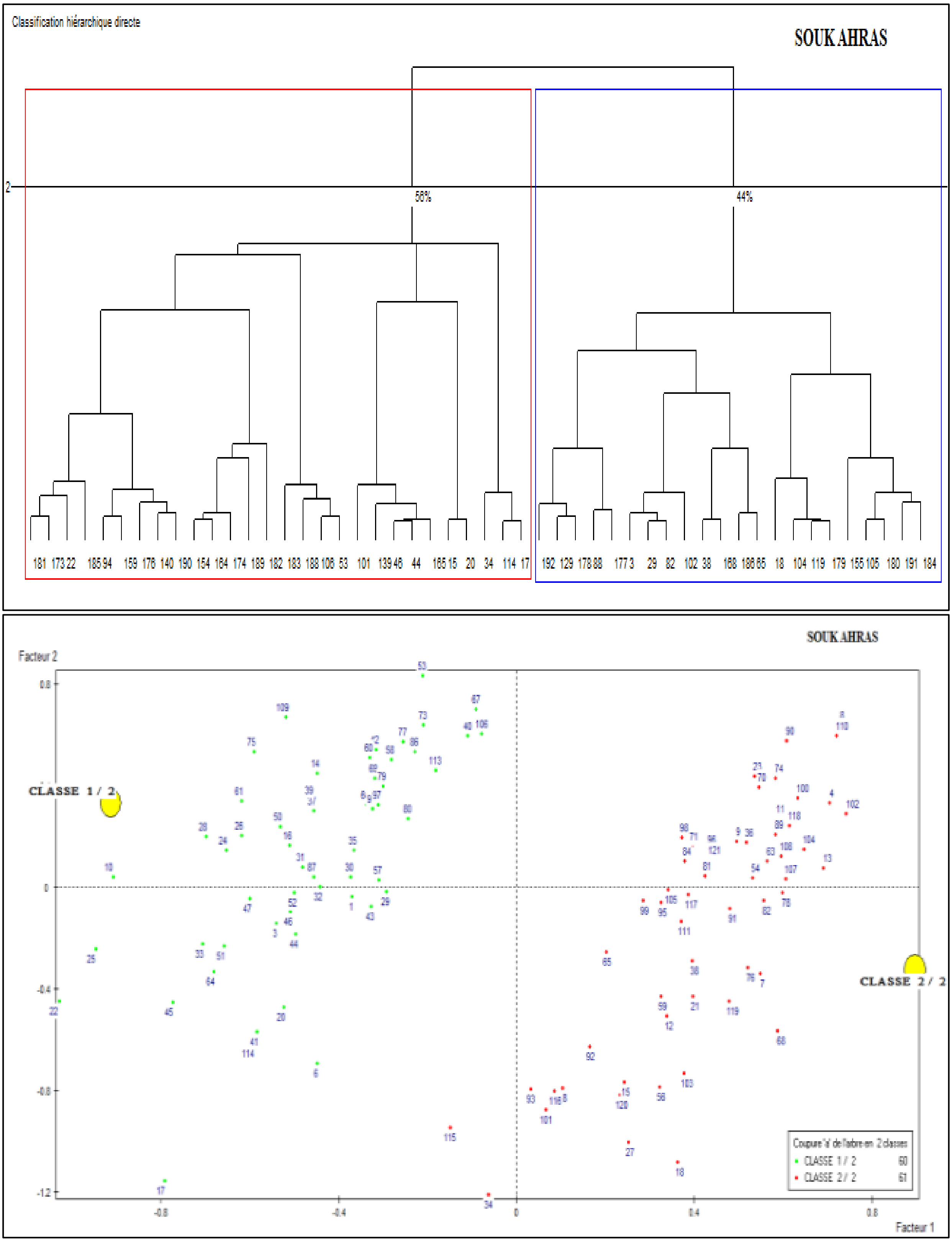


Figure 27: Graphic representation of modalities of breeding constraints variables on axis 1 and 2 in the semi-arid region (see Table A5 for variables and terms).

II.6. Discussion

Our survey covered the southern semi-arid region of Souk Ahras and the arid region of Biskra-Ouled Djellal, enabling us to consider a multitude of criteria and factors. Consequently, we conducted separate analyses for each section using MCA, resulting in the identification of numerous groups in both regions.

In the arid region (AR), we identified two breeder groups based on their socioeconomic status. The first and predominant group consists of breeders with moderate qualifications in terms of education, experience, and age. In this region, cattle breeding are a relatively recent practice, with a primary focus on small ruminants and camels (Abdelli *et al.,* 2021; Moula, 2023). In contrast, the semi-arid region (SAR), renowned for its dairy cattle breeding heritage (Meklati *et al.,* 2020), displayed three distinct breeder groups. The important group in SAR, similar to AR's second group, consists of aged, untrained but experienced breeders, which is in concordance with Mohamed-Brahmi et al. (2022)' Results obtained from north Algeria and Tunisia.

Regarding the breeding status, we categorized farms in AR into three groups, while SAR farms were divided into four. The smaller groups in both regions exhibited superior herd and housing conditions. Most farms in these areas had small herds, typically consisting of fewer than 15 head, and they often faced substandard housing and hygiene standards. Close results were reported in Constantine (Foughali *et al.,* 2019) and in the Erbil plain in Iraq (Raoof and Sartip, 2022). However, Youssao et al. (2013) recorded similar low breeding conditions, with a more substantial headcount in Benin.

Regarding breeding management, we identified four and five groups in SAR and AR, respectively. Productivity appeared more diversified in SAR compared to AR, where only two groups were identified. Two out of five groups in AR were considered to be effectively managed, employing mechanical milking with appropriate hygiene and nutrition standards, which could potentially improve output (Magan *et al.,* 2021; Bhakat *et al.,* 2022). The other groups, including the largest ones, relied on traditional techniques, which might have a negative impact on productivity. Close mediocre management and poor breeding conditions are recorded in Constantine (Mammeri *et al.,* 2020) and even in Ethiopia (Guadu and Abebaw, 2016), however in Turkey, better techniques and productivity were reported (Elmaz *et al.,* 2012). Conversely, SAR groups appeared to manage their farms more effectively, primarily using suitable rations with richer concentrates.

Fortunately, in both regions, the major groups exhibited better reproductive and dairy performance. Cows required an average of two inseminations for fertilization, which typically occurred within two months post-partum and ICI within norms, aligning with recommended practices (Consentini *et al.,* 2021).

These results closely aligned with those of Boukhechem et al. (2019) in northern Algeria, surpassing other studies in Algeria and Tunisia that reported longer ICI; 422.4 ± 88.7 days (Bouamra *et al.,* 2016), 453 days (Hammami *et al.,* 2021) and above 500 days (Mohamed-Brahmi *et al.,* 2022). For dairy production, one of the high-performing SAR groups stood out with a daily production of 15-25 L/C, indicating a highly productive dairy basin.

These results were consistent with previous findings in Tizi Ouzou and Constantine (Si-Tayeb *et al.,* 2015; Foughali *et al.,* 2019). Also, Dias and Fischer (2021) reported a similar average of 13.3 ±4.5 L/C in Brazil, while in South Africa, Erasmus and Van Marle-Köster (2021) indicated that farms are divided into two types: commercial with an average daily production of 18.9 L/C and smallholder farms with less than 10 L/C.

Regarding constraints affecting breeding productivity, AR farms were more afflicted by diseases, leading to the categorization of farms into three groups. The most significant group reported issues related to dystocia, while the second group faced challenges associated with mastitis, a common pathology in African dairy farms (FAO, 2014). Several factors contributed to these illnesses, including poor hygiene, management practices, and the hot climate, which had a detrimental effect on cattle welfare and increased the likelihood of infections (Lees *et al.,* 2019; Bhakat *et al.,* 2020; Zigo *et al.,* 2021).

Our typology revealed that small dairy farms in AR, managed by middle-aged, educated, and experienced breeders under substandard conditions, employing traditional techniques, represented the predominant group. Despite experiencing several diseases, this group benefited from high fertility. Conversely, in SAR, the dominant group comprised classic breeders, typically aged, experienced, and illiterate, managing their cattle under substandard conditions. However, they made efforts to enhance productivity by adopting more modern techniques and providing richer rations. These findings provide insights into the diverse agricultural practices in the two regions and offer guidance for potential interventions and improvements in the sector.

III. Technical-economical efficiency of reproduction and milk production in dairy herds in both agro-ecological regions

The breeding report plays a pivotal role in monitoring breeding activities. Its primary objective is to identify and assess reproductive issues, recommend additional tests if needed, and provide specific suggestions for improvement.

The creation and interpretation of a breeding report involve considering a range of parameters, both general and specific, which are chosen based on the available quantity and quality of data. These parameters are directly or indirectly related to quantifying and understanding infertility at either an individual or herd level. In this context, infertility refers to prolonged time to pregnancy or calving, as well as the number of inseminations required. Various fecundity and fertility parameters, as illustrated in the following tables, offer insights into the reproductive performance of a dairy herd.

Various fecundity and fertility parameters (illustrated in the following tables) help to get a general idea of a dairy herd's reproductive performance.

III.1. Reproductive performances

III.1.1. Reproductive performance in dairy heifers

Table 6 shows the reproductive performances of the heifers. The Herd Reproductive Status (HRS) for SAR heifers stands at 80, surpassing the established benchmark of 60-65 (Hanzen, 2009), indicating a potentially acceptable reproductive status. However, the observed PR of 66% falls below the desired target, suggesting avenues for improvement. While the abortion rate of 33% is deemed acceptable, it remains above the ideal levels of 15%, indicating a potential area for further optimization of reproductive management strategies.

An extended B-1stCI of 881 days (29.4 months) is observed in SAR heifers' herd, with a WP of 540 days exceeding the benchmark of respectively 730 and 460 days and reflecting the breeder's strategy. The breeder prefers employing a late-breeding strategy until the age of 18 months for heifers, prioritizing their development before first calving to ensure an ideal body weight to raise expected fertility rates. This approach aligns with the recommendation of Kasimanickam et al. (2021) of delaying mating to achieve 65% of mature body weight and potentially avoid negative effects on fertility rates. However, it is essential to evaluate the long-term economic implications of this extended WP (Dutta *et al.,* 2015). Similar findings have been reported in El Taref (Attia *et al.,* 2019) and Setif (Benidir *et al.,* 2020), where WP exceeds 18 months. This situation presents a complex trade-off between biological and economic considerations. Extending the B-1stCI in dairy cows may have drawbacks, including reduced lifetime productivity, increased replacement costs, heightened fertility risks, delayed returns on investment, and management challenges.

However, from a biological standpoint, delaying calving reduces the risk of dystocia (difficult childbirth) and calf losses, while potentially compromising calf quality, as suggested by Short et al. (2021). Therefore, determining the optimal WP requires careful evaluation considering both economic and biological criteria.

This extended WP, coupled with a RP of two months, significantly exceeding the standard of less than 30 days, explains the observed average DO and age at first calving mean. The observed extended IEI of 61 days (well above the recommended threshold of less than 30 days) and a low Wood's index of 41 (which ideally should be above 70) suggest heat detection failures, which may contribute to the extended DO period. However, reduced fertility may also play a role; the high number of SPC (TFI of 3) suggests potential fertility problems within the herd.

Table 6: Comparison of Heifers' reproductive traits between arid (0) and semi arid region (3)

Parameters	**AR**	**SAR**	**Objective** Hanzen (2009) Hanzen *et al.* (2013)
HRS	/	82.5	40-65
PR %	/	66.67	85
B-1st CI (days)	/	881.67±85.56	730
WP (days)	/	540 ±13.3	420
RP (days)	/	61±81	<30
DO (days)	/	600±65	460
IEI (days)	/	61±13.33	<30
CR1st M	/	66.67	>60
AFI	/	1	<1.5
TFI	/	3	<2.5
Wood's Index	/	41.18	>70
Abortion Rate %	/	33.33 (1/3)	<15
BCS	/	2.5	

HRS: Herd Reproductive Status, PR: Pregnancy Rate, B-1stCI: Age at first calving/ birth to 1st calving interval, WP: Waiting Period, RP: Reproductive Period, DO: Days Open, IEI:

Inter-estrus intervals, CR1stM: Conception Rate at First Mating, AFI: Apparent Fertility Index, TFI: Total Fertility Index, BCS: Body Condition Score.

III.1.2. Reproductive performance in primiparous dairy cows

According to Table 7, primiparous cows in the SAR herd exhibit reproductive parameters largely in line with objectives. With an ICI of 371 days, closely aligning with target WP and RP averages, alongside a high HRS exceeding 60 and a PR of 90%, overall fecundity appears favourable. Additionally, fertility parameters such as TFI and AFI <1.5, with 81% of CR1stM and only 9.5% requiring more than 3 mating per pregnancy, suggest an acceptable or optimal reproductive state. Similar findings were reported by Abdelli and Iguer-Ouda (2017) in Tizi-Ouzou dairy cows. However, there is a work to be implemented for improvement of heat detection efficiency, as indicated by the Wood's evaluation and a potentially extended IEI of 57 days, suggesting suboptimal performance that could be addressed through optimized heat detection strategies (Mičiaková *et al.*, 2018).

In contrast, primiparous cows in the AR farm display concerning reproductive performance, despite lacking statistical significance. Results reveal a significantly extended ICI of 541 days, with a high standard deviation (±299 days), far surpassing typical benchmarks. Furthermore, an average DO of 262 days, far above norms, indicates potential infertility issues. According to Hanzen (2009), such extended calving intervals can be classified as infertility, posing significant economic challenges for farms (Bellows *et al.*, 2002). Additionally, the low CR1stM of 50%, AFI, and TFI of 3.25, clearly above objectives, along with more than 3 mating requirements in 50% of cows, signal an infertility status within the primiparous herd in AR.

Table 7: Comparison of reproductive traits of primiparous cows between arid (4) and semi arid region (21)

Parameters	AR	SAR	**Objective** Hanzen (2009) Hanzen *et al.* (2013)	*p*-value
HRS	/	60.84	>60	
PR %	50	90.5	>60	1
ICI (days)	541.25 ±259.03	371.94 ±46.28	365	0.28
WP(days)	115 ±81.83	69.47 ±23.69	45-60	0.35
RP (days)	147.25 ±203.3	17.67 ±63.1	23-30	0.29
DO (days)	262.25 ±260.8	87.87 ±53.9	85	0.27
IEI (days)	44.28 ±26.96	57.08 ±14.2	<30	
CR1stM %	50	81.3	>45	0.25
SPC	3.25 ±3.3	1.19 ±0.4	<2.5	0.03
+3MR %	50	9.5	<15	0.08
AFI	3.25	1.26	<2	
TFI	3.25	1.5	<2.5	0.03
Wood's index	75.13	66.04	>75	
Abortion Rates	0	0	<24	
BCS	2.5	2.67 ±0.12		0.000

HRS: Herd Reproductive Status, PR: Pregnancy Rate, ICI: Inter-Calving Interval, WP: Waiting Period, RP: Reproductive Period, DO: Days Open, IEI: Inter-estrus intervals, CR1stM: Conception Rate at First Mating, SPC: Service/Mating per Conception, +3MR: Plus 3 Mating per conception Rate, AFI: Apparent Fertility Index, TFI: Total Fertility Index, BCS: Body Condition Score.

III.1.3. Reproductive performance in multiparous dairy cows

According to Table 8, although no statistical significant difference is registered between AR and SAR herds, the SAR multiparous cows exhibit better reproductive parameters. The AR herd faces reproductive concerns, with a significantly extended ICI of 420±114.63 days and DO exceeding 130 days, indicating potential infertility issues (Hanzen, 2009). Additionally, the high number of SPC (2.43) and the substantial proportion of cows requiring three or more inseminations (43%) suggest potential issues with either heat detection efficiency or fertilization success. Moreover, the low CR1stM (28%) reinforces this concern.

Regarding heat detection (Table 9), the AR farm presents a complex picture. While the Wood's Index remains within the optimal range and a high percentage of heats are detected within the desired 18-24 day window, a persistently high IEI of 40 days exceeds normal values. The heat distribution evaluation reveals a significant portion of heats falling into the 4th class (36-48 days), which can be linked to embryonic mortality. This could contribute to the extended calving intervals observed.

A low Pregnancy Rate (PR) of 42%, coupled with a high total replacement rate (53%) and a significant portion (38%) of replacements due to reproductive problems (as Table 10 indicates), presents a clear warning sign. Ghozlane et al. (2015) recorded similar results in another arid region (Ghardaia), highlighting the significance of these findings. Several factors contribute to these extended intervals and low fertility, climate, particularly heat stress, playing a significant role. Heat-stressed dairy cattle experience compromised welfare and reduced fertility through various mechanisms, including suppressed appetite, hindering weight and milk production, and affecting reproductive systems. Furthermore, ensuring a balanced diet tailored to the specific needs of dairy cattle at different stages is essential for reproductive success. Body Condition Score (BCS), particularly at calving and during early lactation, plays a crucial role in reproductive outcomes (Bisinotto *et al.*, 2012; Boudelal and Niar, 2020; Nazhat *et al.*, 2021). Health issues and reproductive disorders, especially mastitis, pose another critical factor affecting reproductive performance. Additionally, conditions like Anoestrus, abortion, metritis, and dystocia retained fetal membrane contribute to a drop in the herd's overall reproductive rate (Tagesu, 2018; Giannone *et al.*, 2023).

In contrast, SAR multiparous cows exhibit encouraging signs of reproductive performance. The average ICI of 387 days falls close to recommended norms of 365 days, supported by acceptable WP and RP averages. Fertility parameters also paint a positive picture, with cows requiring less than two inseminations on average to conceive, and a high PR and CR1stM. Heat detection appears to be well-managed in SAR farms, with Wood's evaluation index exceeding 92, indicating good detection practices. The heat distribution aligns with desired objectives, reinforcing this positive assessment. Overall, the performance of multiparous cows in the SAR farm is particularly impressive, further underscored by an HRS exceeding 75. Higher results were reported in other regions, emphasizing the importance of further research and potential regional variations in reproductive performance. It's crucial to consider the impact of bulls on fertility rates, especially in natural mating systems, where they play a critical role in maintaining herd fertility (Polo *et al.*, 2023). Careful management of bull health is essential to prevent the spread of infectious diseases and ensure optimal reproductive outcomes.

Table 8: Comparison of reproductive traits of multiparous cows between arid (7) and semi arid region (25)

Parameters	**AR**	**SAR**	**Objective** Hanzen (2009) Hanzen *et al.* (2013)	***p*-value**
HRS	/	75.98	>60	
PR %	42.9	92	>60	1
ICI (days)	420 ±114.63	387 ±58.3	365	0.49
WP(days)	59.86 ±31.54	70.08 ±32.56	60	0.47
RP (days)	77.86 ±117	28.17 ±47.82	23-30	0.31
DO (days)	137.71±107.06	102.29 ±58.74	85	0.43
IEI (days)	40.85 ±23.02	34.77 ±18.19	<30	
CR1stM %	28.6	56	>45	0.2
SPC	2.43 ±1.4	1.83 ±1.47		0.18
+3MR %	42.86	20	<15	0.2
AFI	1.15	1.59	<2.5	
TFI	1.77	2.36	<2	0.52
Wood's index	75.85	92.3	>75	
Abortion Rates	/	4	<30	
BCS	2.39 ±0.13	2.7 ±0.1		0.000

HRS: Herd Reproductive Status, PR: Pregnancy Rate, ICI: Inter-Calving Interval, WP: Waiting Period, RP: Reproductive Period, DO: Days Open, IEI: Inter-estrus intervals, CR1stM: Conception Rate at First Mating, SPC: Services/Mating per Conception, +3MR: Plus 3 Mating per conception Rate, AFI: Apparent Fertility Index, TFI: Total Fertility Index, BCS: Body Condition Score.

Table 9: Evaluation of heats distribution of multiparous and primiparous cows in both arid and semi arid region

	AR' Primiparous cows		**SAR' Primiparous cows**		**AR' Multiparous cows**		**SAR' Multiparous cows**		
	Observed number	%	Observed number	%	Observed number	%	Observed number	%	Objective %
<18	0	0	0	0	0	0	3	13	**15**
18-24	13	65	2	22	11	68.75	8	35	**55**
24-36	2	10	0	0	1	6.25	7	30	**15**
36-48	3	15	1	11	3	18.75	4	17	**10**
48-54	2	10	0	0	1	6.25	1	5	**5**
>54	5		6	67	4		4		

Table 10: Farms reproduction management constraints

	AR	**SAR**
Reform/Culling rate %	53.85	/
Reform for reproduction problem %	38.46	/
Mastitis prevalence	Present to frequent	Present to frequent
Hormonal treatment	Prostaglandin, gonadotrophine and Progesterone	Prostaglandin, gonadotrophine and Progesterone

III.1.4. Calving distribution

The Figure 28 indicates a yearly spread of calving but mostly in autumn and winter, which may reflect the absence of breeding policy, or the inability to respect it due to infertility or may be voluntarily to guarantee inputs all over the year (milk and calves production). However, calving season can have a direct (temperature) or indirect (nutrition) effect on the herd's reproductive potential (Souames and Berrama, 2020).

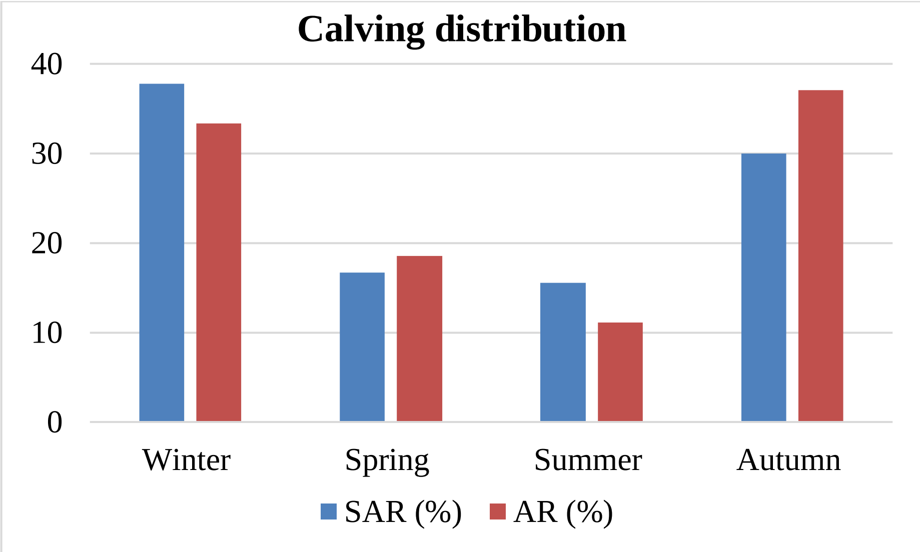


Figure 28: Calving distribution according to the seasons in the Semi-arid and Arid regions.

III.2. Lactation performance

Both farms' dairy parameters are represented in Table 11 and Figure 29 below:

Table 11: Dairy parameters in SAR and AR farms

Parameters	**SAR**	**AR**	***P value***
DMP (L)	16.58 ±2.98	10.7 ±1.82	0.000
DMPmin (L)	5	7	0.1
DMPmax (L)	35	22	0.000
PMY (L/C/D)	24.28 ±4	19.16 ±1.78	0.000
TMY (L/C/L)	5234.56 ±1102.2	3593.83 ±920.4	0.000
PC (%)	94.61	93.75	
LL(days)	318.22 ±53.91	349.73 ±104.56	0.4
Dry-off (days)	60.28 ±8.5	114.4 ±62.5	0.08

DMP: Daily Milk Production, DMPmin: Minimum Daily Milk Production, DMPmax: Maximum Daily Milk production, PMY: Peak Milk Yield, TMY: Total Milk Yield/Milk Yield per Lactation, PC: Persistence Coefficient, LL: Lactation Length.

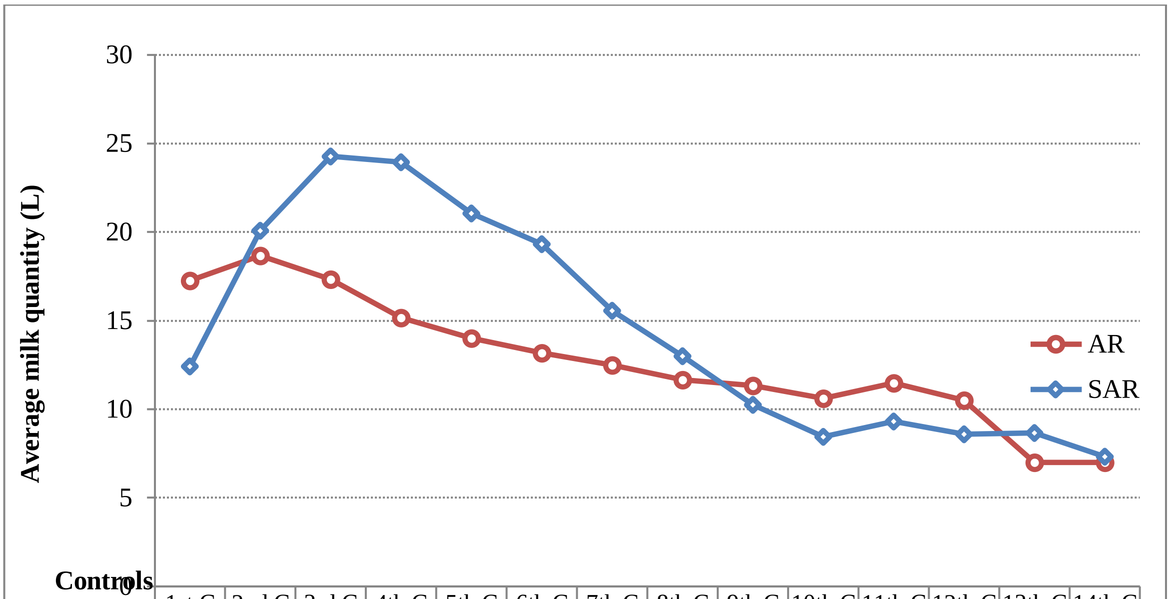
Table 11 shows a high significant difference (*p*< 0.000) between the two farms in terms of dairy yield/ milk production. In AR farm, daily production goes from 7 to 22 L/C/D, with an average of 10.7 ±1.82 L/C/D that reaches a peak lactation averaging 19.16 ±1.78 L/C/D, giving an overall yield per lactation of 3593.83 ±920.4 L. This production is comparable to the minimal one recorded by Medjahed et al. (2024) in western Algeria (6 to 25L with average of 10.77 kg/C/D), and lower than the one reported by Sraïri et al. (2014) in Morocco (14 kg/C/D). These results are clearly superior to those recorded in other African arid zones; 2.7 ± 1.4 kg/C/D in Niger (Adamou Karimou *et al.*, 2017), 2 kg/C/D in Ethiopia (Mengistu *et al.*, 2017).

In contrasts with the SAR farm, where milk yield level ranges from 5 to 35 L/C/D with an average of 16.58±2.98 L/C/D. SAR farm surpasses the AR farm's peak with an average of 24.28 ±4 kg/C/D, ultimately translating to a significantly higher overall TMY (5234.56 ±1102.2 L per lactation). Similar results were recorded by Kechroud et al. (2024) who found an average milk yield of 16.1 kg/C/D, in eastern regions of Algeria, also in western Algeria, Akkou et al. (2022) found a Peak milk yield of 24.3 ±2.12 kg/C/D and Meskini et al. (2023) reported an average daily milk production of 18.19 ±0.45 L.

The difference of the lactation performances between AR and SAR farms may stem from their management strategies, welfare conditions and environment effects. Since both farms provide approximately same feed, SAR farm' conditions could be better than AR farm's which aligns with De-Vries et al. (2011) highlights of welfare status direct effects on milk production. Additionally, extreme temperatures noted in AR farm negatively impact milk production. As shown by Tao et al. (2020) and Cartwright et al. (2023) heat stress, in particular, can significantly decrease milk yield by reducing feed intake.

Analysis of lactation length revealed no significant difference (p > 0.05) between the AR and SAR farms. An average 318.22 ±53.91 days with dry-off period of 60.28 ±8.5 days and an average 349.73 ±104.56 with 114.4 ±62.5 days as a dry-off period are registered in respectively SAR and AR farm. Meskini et al. (2023) reported a lower average period of 293.5 ±1.65 days.

Dairy production monitoring generates the following curve:



	1st C	2nd C	3rd C	4th C	5th C	6th C	7th C	8th C	9th C	10th C	11th C	12th C	13th C	14th C
AR	17.25	18.67	17.33	15.17	14	13.17	12.5	11.67	11.33	10.6	11.5	10.5	7	7
SAR	12.44	20.08	24.28	23.96	21.04	19.32	15.56	13	10.24	8.46	9.31	8.6	8.67	7.33

Figure 29: Lactation curves of the dairy cattle herds under arid and semi-arid conditions.

The average herds' lactation curves paint a clear picture of the differences between the lactation performances of the two farms, the subsequent lactation patterns diverge. The first check, conducted a week after calving, revealed a clear disparity in milk yield between farms. The SAR farm cows produced an average of over 17 L/C/D, whereas the AR farm cows averaged a lower 12.44 L/C/D.

The AR farm exhibits a rapid but short rise in production (44.83 ±16 days), with most cows reaching an average peak of 18.67 L. Notably, one cow in the AR farm with the lowest production even peaked at the first check. In contrast, the SAR farm follows a more classic model: a gradual rise in production over two months, leading to a significantly higher PMY of 24.28 L persisting for over a month. This difference extends beyond peak production. The AR farm struggles with a very short persistence phase, indicated by a lower persistence coefficient (93.75). Conversely, the SAR farm demonstrates a normal persistence phase with a standard coefficient (94.67). Finally, the decline phase appears to be the longest stage in the AR farm's curve (267.67 ±47.78 days) while in SAR farm it lasts for 225.96 ±45.88 days.

III.3. Farms' economical efficiency evaluation

Evaluating a farm's overall expenses goes beyond analyzing financial records, production data, and input costs; it allows calculating key metrics like profitability ratios and resource efficiency which helps identify areas where the farm can potentially save money. By understanding how efficiently resources are being used and where expenses can be controlled, farms can make informed decisions to improve their overall financial health and profitability.

Summary statistics; prices, outputs and inputs, are provided in Tables below.

To assess the financial status of farms, we collected data directly from farmers, including income, input costs, various production expenses, and whole-farm budgets. However, it's important to acknowledge that this data may be subject to inaccuracies due to underreporting or over-reporting.

As shown in Table 12, both farms reported identical total expenses, worth noting that feed and labor typically represent the most significant cost categories for both farms (respectively 7309400, 940 000 DZD in SAR and 2 331 000, 540 000 DZD in AR farm). Same finding were recorded in Tizi Ouzou, Algeria where Mouhous et al. (2020) found that feed represent 90% of farm costs. Akter et al. (2022) recorded same highlights in Bangladesh.

Table 12: Farms overall expenses

Expenses (DZD)	SAR		AR	
	Total expenses (DZD)	Expenses per cow (DZD)	Total expenses (DZD)	Expenses per cow (DZD)
Food	7309400	228 418,75	2 331 000	137 117,65
Vet services (health and reproduction)	430 000	13 437,50	260 000	15 294,12
Labour	940 000	29 375,00	540 000	31 764,71
Housing and Infrastructure	50 000	1 562,50	20 000	1 176,47
Utilities	105 000	3 281,25	300 000	17 647,06
Equipment and Machinery	50 000	1 562,50	60 000	3 529,41
Transportation	120 000	3 750,00	348 000	20 470,59
Insurance and taxes	25 000	781,25	23 000	1 352,94
Total expenses/cow/year		282 168,75		228 352,94
Total expenses/bull/year		120000		171 264,71
Total expenses/head/year		402 168,75		399 617,65
Average expenses/cow/day		**773,07**		**625,62**
Average expenses/Bull/day		**328,767**		**469,218**
Average expenses/head/day		**1 101,83**		**1 094,84**

Regarding outputs (Table 13), SAR farm shows higher profits related to higher performances; higher calves production represented by calf/cow/year ratio which is calculated by dividing inter-calving interval by 365 days. SAR farm boasts a significantly higher ratio of 0.96 compared to AR farm's 0.76 conducting to higher profits by newborn calves (178860.95 vs. 98725.2 DZD). Also, SAR farm demonstrates higher lactation yield, resulting in greater milk production benefits. Its milk revenue stands at 261728 DZD compared to AR farm's 179691.50 DZD. Contrary to our results, Sarica et al. (2022) found that milk sales income was the major contributor in dairy farms income in Turkey.

Table 13: Farms profits/outputs

Profits (DZD)	SAR	AR
Calf/ cow /year	0,96	0,76
Profits by newborn calves/cow	125 042,82	98 724,59
Calf/ heifer	0,41	/
Profits by newborn calves/heifer	53 818,32	/
Profit/calf /day	490,03	270,48
Average milk production /lactation (kg)	5 234,56	3 593,83
Price of 1 kg of Milk	50,00	50,00
Total benefits of milk production/lactation	261 728,00	179 691,50
Average lactation length (days)	318,22	349,00
Average benefits from milk/cow/day	822,48	514,88
Total benefits/cow/day	**1 312,51**	**785,35**

To assess farm efficiency, defined as the ability to maximize output while minimizing resources waste (Tirkaso & Hansson, 2024), we analyzed both input and output quantities. We then compared costs and revenues to calculate farm-level benefits and establish cost saving estimation.

Table 14 reveals a clear distinction in financial performance between the two farms. SAR farm demonstrates a strong financial position with a positive annual balance of 2460664.84 DZD. Conversely, AR farm faces financial difficulties, experiencing a negative annual balance of 1920380.36 DZD.

From Table 15, SAR farmer would require a cost saving of 1120040,70 DZD/year to attain the level of the most economically efficient. However, AR farmer would minimize losses to 1 312 014,39 DZD instead of 1 920 380,36 DZD/year (cost saving of 608 365,98 DZD/year)..

According to Bayiyana et al. (2019), economic principles dictate that only producers who achieve low cost production can survive over time by ensuring economic and management efficiency using the appropriate production technologies. Therefore, improvements are needed for both farms to reach optimal economic efficiency, basically by ameliorating fertility rates which would raise the profit margins.

Table 14: Farms benefits

Benefits (DZD)	SAR	AR
Profits-Expenses/cow/day	**210,67**	**- 309,49**
Profits-Expenses/cow/year	**76 895,78**	**- 112 963,55**
Profits-Expenses/herd/year	**2 460 664,84**	**- 1 920 380,36**

Table 15: Difference of economic balance compared to standard reproductive traits

Economic loss compared to standard reproductive traits				
	SAR		**AR**	
	Reproductive delay	Economic lose/animal	Reproductive delay	Economic lose/animal
AFC (days)	151,67 (881,67-730)	31 952,83	/	
CI (days)	14,47 (379,47-365)	3 048,44	115,63 (480,63-365)	**- 35 786,23**
Fertility	Constant fees calculated for bull breeding			
Total economic loss per cow/year	**35 001,27**		**- 35 786,23**	
Total economic loss per herd/year	**1120040,70**		**- 608 365,98**	
Likelihood of economic benefits from standard reproductive traits (DZD)				
/cow/year (DZD)	**111 897,05**		**- 77 177,32**	
/herd/year (DZD)	**3 580 705,54**		**- 1 312 014,39**	

DISCUSSION

Our research aims to evaluate the livestock conditions in two distinct biotopes – arid and semi-arid regions– of eastern Algeria to provide final recommendations that will contribute to breeding conditions and productivity enhancement. Through surveys and site visits, our proposed approach focused on a multifaceted analysis of breeding systems to identify distinct farm types, unravel the variability in performance outcomes, pinpoint limitations, and critically examine the impact of climate and breeding practices on both milk production and reproduction performances.

Our survey conducted in the southern semi-arid region of Souk Ahras and the arid region of Biskra-Ouled Djellal, enabled us to characterize and identify numerous groups of dairy cattle farms present in both regions. Then, we conducted a yearly close monitoring study of all aspects of reproduction and milk production parameters in a farm in each region to get deeper insights into dairy production and evaluate the actual performances and breeders' practices in these farms defined as models in each bioclimatic region.

Our surveys and monitoring results showed a high significant difference ($p < 0.000$) in dairy and reproductive performances between the two regions farms. SAR farms including the model farm displayed better results compared to the AR farms. SAR model farm showed higher average daily milk production and higher overall peak yield was registered, a shorter dry period combined with a shorter lactation length that reflects a shorter inter-calving intervals; a key indicator of better reproductive status in SAR dairy herds. Actually, AR herds experience concerning reproductive performances, with extended ICI, WP and DO, more than 3 inseminations requirement, low successful rates at first service besides higher TFI and AFI recorded in the model farm this point towards infertility issues.

This observed disparity between AR and SAR farms likely stem from their management strategies, animal welfare conditions and environment factors.

Since buildings state, even though most of both regions farms faced substandard housing and hygiene standards, SAR cattle buildings are relatively better than AR' where situation appears significantly worse; structures don't resemble a recognizable cowshed, as proven in the monitored farm. This situation significantly plays a major role in performance gap between regions, as the cowshed plays a crucial role (Wallet and Lagel, 2011); poor building conditions can contribute to the spread of diseases that contribute to a drop in the herd's overall reproductive rate as proven by Tagesu (2018) and lead to high culling rates as proven in AR model farm. It's worthy to note that mastitis, which is closely linked to rearing and

milking conditions as well as hygienic characteristics **(**Foughali *et al*., 2019), can significantly reduce reproductive performance in dairy cows as Bouamra et al. (2017) highlight, this aligns with our findings of higher dystocia and mastitis cases in AR farms.
Therefore, improving building design, construction, and hygiene is crucial for both animal welfare which directly affects milk production (De-Vries *et al.*, 2011) and overall farm success.

Feeding in AR farms is based on roughage supplemented with readily available concentrates like dates, wheat, and bran. This approach often lacked a standardized method for determining nutritional needs. In contrast, SAR farms utilized grazing on available pastures which according to Beaver et al. (2019) potentially enriches cow rations and improves animal health and welfare. This difference was reflected in Body Condition Score (BCS), a key indicator of feeding efficiency that plays a crucial role in reproductive success. Studies by Bisinotto et al. (2012); Boudelal and Niar, 2020); Nazhat et al. (2021) have shown that cows with an intermediate BCS at calving and the first insemination have better reproductive outcomes compared to those with either a low or high BCS. Interestingly, severe BCS loss leads to extended days open and reduced fertility**.**

Regarding milking practices, it’s manual in almost all AR farms. Despite its mechanical in the model farm, performances still far lower than that recorded in SAR model farms. However, SAR farms primarily utilized mechanical milking which according to Bhakat et al. (2022) and Magan et al. (2021) could potentially improve milk output especially when combined with hygiene and standardized nutrition.

Natural mating remained the dominant breeding strategy in both regions, with AR farmers relying on it more heavily. However, this approach raises concerns about bull selection and its potential impact on herd fertility. Bulls can play a significant role in spreading infectious diseases that negatively affect overall herd reproductive health. Studies by Polo et al. (2023) suggest that various bull borne infections can compromise sperm quality and reproductive potential. These infections, even in asymptomatic carriers, can be transmitted to females during mating, leading to a domino effect of infertility issues like late fertilization, abortions, and extended calving intervals. Ultimately, this translates to decreased production efficiency and economic losses for the farm.

These traditional breeding techniques, predominant in both regions and potentially restricting productivity, are likely due to two factors: breeder qualifications and infrastructure availability. Breeder qualifications were moderate in both regions, with even lower levels in AR where cattle breeding is a recent activity, with farmers primarily focused on small ruminants and camels breeding (Abdelli *et al.*, 2021; Moula, 2023) and managing date palm and greenhouse cultivation (Amichi *et al.*, 2015). Even though, SAR boasts a long-standing tradition of dairy cattle breeding (Meklati *et al.*, 2020), the majority of breeders are experienced but lack formal training. These limited qualifications, particularly in the context of modern agriculture, can hinder the adoption of new technologies and techniques, such as artificial insemination, modern heat detection and pregnancy diagnosis tools, hampering overall sector development (Paltasingh & Goyari, 2018; Mendonça, 2020) which is observed in our cases. Furthermore, additional limitations exist in AR, mainly lack of water, tracks, access to inseminators, and consistent food sources, which hinder farming improvement and ultimately, productivity.

Additionally, environmental factors, especially extreme temperatures observed in AR farms, negatively impact milk production. Studies by Tao et al. (2020) and Cartwright et al. (2023) highlight that heat stress, in particular, can significantly decrease milk yield by reducing feed intake. Also, Takahashi, (2011) and Khan et al. (2023) recorded that heat stress appears to be a major contributor to extended calving intervals and reduced fertility. It can compromise dairy cattle welfare and fertility by suppressing appetite, hindering weight gain and milk production, and negatively impacting the reproductive system.

CONCLUSION

To more understand the livestock global situation and to evaluate dairy cattle breeding in Algeria' arid and semi-arid regions, we started this study that aimed to exploredairy cattle farms in both biotopes of eastern Algeria; southern Souk Ahras which represents the semi-arid region and Biskra_Ouled-Djellal the arid region. Our primary objectives were characterizing these farms and identifying constraints that hinder their development, ultimately formulating effective strategies to enhance productivity.We then developed a typology for each region to categorize different types of farms and simplify the understanding of variability while preserving key characteristics. This allows for targeted interventions based on specific needs and challenges of each farm type.

Finally, we conducted a year-long monitoring study on model farms in each region, tracking reproduction and milk production parameters to gain deeper insights into dairy production and evaluate actual farm performance.

Key Observations:

- The majority of farms, particularly in the arid region (Biskra_Ouled-Djellal), were characterized by small herds raised with inadequate infrastructure; substandard buildings compromised hygiene, animal welfare, and compliance with zootechnical standards. These harsh breeding conditions likely contributed to lower overall performance in the arid region.
- Traditional practices dominated farm management across both regions translating breeders' socio-economic status.
- Natural mating is the main mode of reproduction, with greater fertility rates in the semi-arid region where is recorded a fertility index of ≤ 2 in 92.6% of farms.
- Milking in most arid farms is manual, as compared to semi-arid farms, where it is mainly mechanical.
- These practices often lacked scientific foundation and limited overall productivity. Deficiencies were observed in feeding and reproduction management, resulting in underutilization of both available land and the genetic potential of the cattle. This ultimately constrained farm profitability.
- Higher rainfall in semi-arid region (SAR) grants a crucial advantage to SAR farms; they benefit from access to both agricultural lands (Used Agricultural Area UAA and pastoral area) with various surfaces ranging from 1 to 300 hectares, which is significantly different from those in AR that rely mainly on UAA with small surfaces.
- Feed availability was identified as a major constraint across all farms.

- Arid regions (AR) face several challenges that hinder dairy production, including water scarcity, tracks issues, lack of inseminators and harsh environment (heat stress periods).
- Moderate breeding qualities in the AR caused a variety of issues, most notably mastitis.
- Despite the numerous challenges faced by arid farms, a surprising finding emerged. Their average milk yield of 15 L/C/D was comparable to that of semi-arid farms with slightly better infrastructure.
- Model farms monitoring confirmed the overall findings; SAR farm consistently demonstrated significantly higher dairy and reproductive performance compared to AR farm. AR farm registered an average daily production of 10.7 ±1.82 L/C/D with a peak of 19.16 ±1.78 L/C/D, giving an overall yield per lactation of 3593.83 ±920.4L. Contrary to SAR farm, where the average milk yield is 16.58 ±2.98 L/C/D with a peak of 24.28 ±4 L/C/D, translating a significantly higher overall yield per lactation (5234.56 ±1102.2 L).

  Moreover, The AR herd is experiencing concerning reproductive performance, with extended intervals (ICI of 420 days and DO exceeding 130 days) while SAR cows exhibit encouraging signs of reproductive performance with average intervals falling close to the recommended norms (DO of 102 days, ICI of 387 days).

RECOMMANDATIONS

Based on these findings, we recommend to:

- Strengthen Research and Development Initiatives: Allocate resources to research aimed at understanding the unique challenges faced by dairy farmers in arid and semi-arid regions. Develop tailored solutions such as drought-resistant forage crops, heat-tolerant breeds, or innovative breeding techniques suitable for the climatic conditions.

- Promote Collaboration and Knowledge Sharing: Foster partnerships between research institutions, agricultural extension services, and local farming communities to facilitate the exchange of information and best practices. Encourage collaborative projects that address specific regional needs and promote sustainable agricultural methods.

- Invest in Infrastructure and Technology: Invest in improving infrastructure such as water management systems, shade structures, and cooling mechanisms to mitigate the impact of heat stress on livestock. Promote the adoption of technological solutions such as precision agricultural tools, remote monitoring systems, and data analytics to optimize resource utilization and improve productivity.

- Support Financial Incentives and Subsidies: Provide financial incentives, grants, or subsidies to encourage dairy farmers in arid and semi-arid regions to invest in modernizing their operations, adopting environmentally friendly practices, and improving animal welfare standards. Explore innovative financing mechanisms such as microloans or leasing arrangements to make investments more accessible to small-scale farmers.

- Strengthen Extension Services and Capacity Building: Strengthen extension services by training agricultural extension agents and veterinarians to provide personalized advice and support to dairy farmers. Offer capacity-building programs on topics such as animal nutrition, breeding management, disease prevention, and herd health monitoring to empower farmers with the knowledge and skills needed for success.

- Promote Market Access and Value Chain Development: Facilitate market access for dairy products from arid and semi-arid regions by establishing linkages between producers, processors, retailers, and consumers. Promote value addition initiatives such as dairy processing cooperatives or branding programs to enhance the competitiveness and profitability of local dairy businesses.

- Advocate for Policy Reforms and Regulatory Support: Advocate for policy reforms that address the specific needs and challenges faced by dairy farmers in arid and semi-arid zones. Encourage the development of supportive regulatory frameworks such as zoning regulations for livestock management, incentives for sustainable land management practices, and insurance schemes for climate-related risks to create an enabling environment for the dairy sector to thrive.

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ANNEXES

Annex 1 : Questionnaire

Information générales

Date de l'enquête: ……/……/……   N° d'élevage………………

Nom de la commune ……………………   Wilaya …………..……………..

Etage bioclimatique……. ………………

Information sur l'éleveur:

Sexe: ……….. Âge ….…… Statut familial …….………Niveau scolaire…..…………

Depuis quand exerce-il l'élevage bovin :………ans

Formation agricole : Oui /Non

Information sur l'élevage

Animaux:

Bovin seul☐ bovin + ovin☐ bovin+caprin ☐ bovin+ aviaire ☐

Activité agricole:

Elevage seul ☐ élevage-culture ☐ autre☐

Foncier:

SAU☐ surfaces pastorales ☐

Type d'exploitation:

Laitière ☐ mixte ☐

Main d'œuvre:

Familiale☐ salariée ☐ saisonnière ☐

Conduite du cheptel bovin laitier

Effectif bovin ☐

Nombre des vaches laitières ☐ **âge moyen** ☐ **BCS**☐

Sont-elles identifiées? Oui/ non

Type d'identification:

Boucle auriculaire ☐ marquage sur la robe ☐ autre……………

Composition raciale:

Bovin Local ☐ Bovin Amélioré ☐ Bovin Moderne ☐

Critères du choix ………………………………………………………………….
……………………………………………………………………………………

Equipement:

Habitat:

Air libre ☐ parc de nuit ☐ étable ☐

Bâtiment d'élevage :

	Structure		Etat général			Type du bâtiment		
	Capacité	Dimensions	Mauvais	Médiocre	Bon	Etable moderne	Hangar	traditionnel
Bat 01								
Bat 02								
Bat 03								
Bat 04								

Mode de conduite

Stabulation ☐ pâturage ☐ pâturage et stabulation ☐

Stabulation:

Entravée ☐ libre ☐ semi-entravée ☐

Allottement: Oui/Non

Selon : Stade physiologique ☐ niveau de production ☐ autre ☐

Type d'aération:

Mécanique ☐ naturelle ☐

Air de couchage:

Sol ☐ sol paillé ☐ béton ☐ béton paillé ☐

Hygiène:

Fréquence de nettoyage du sol

Désinfection: Oui/Non fréquence produit utilisé :…………..

Recours aux : **Traitements vétérinaires**: Oui/ Non

Vaccination: Oui/Non

Quels sont les **vaccins utilisés** ?…………………………………..………………..

Maladies courantes………………………………………………………………..

La **réforme**, existe-elle ? Oui/Non •

Motifs de réforme ?

Age☐ • Pathologie☐ Infertilité☐ Défaut de production ☐

Si âge, à quel âge ? ☐

Conduite de l'alimentation:

Abreuvement:

Source propre (puits, forage, …..)☐ Réseau d'alimentation en eau ☐

Matin☐ midi☐ soir☐

Pâturage: Oui/Non

Durée ☐ surface ☐ période ☐

Mode d'alimentation:

Par rationnement ☐ à volonté ☐

Comment estimer le niveau alimentaire des vaches :

La production ☐ l'état corporel ☐

La ration est-elle en rapport avec l'état physiologique de l'animal ? Oui/Non

Est-ce que le changement d'alimentation est basé sur:

État corporel ☐ stade physio ☐ production ☐ ressources disponibilité ☐

Il ya de différences d'alimentation des vaches en début de lactation et en fin: Oui/ Non

Rationnement:

	Stade	Ration de base	Complémentation	R.Supplémentaire
Hiver	En L			
	Fin Gs			
	Tarie			
Automne	En L			
	Fin Gs			
	Tarie			
Printemps	En L			
	Fin Gs			
	Tarie			
Eté	En L			
	Fin Gs			
	Tarie			

Les concentrés utilisés dans l'alimentation :

Préparé dans l'exploitation ☐ provient des unités privées ☐ spéciale VL ☐

Sa quantité est distribuée selon :

Besoins ☐ disponibilité ☐ standard ☐

Subissent-ils des changements périodiques : Oui/Non

Critères de changement : technique ☐ économique ☐

Le **stockage** des aliments se fait :

dans : une grange ☐ coin du bâtiment d'élevage ☐ autre…………………..

Support : au sol ☐ sur des palettes ☐ autre……………

Problèmes d'alimentation :

Manque d'alimentation ☐ Difficulté de stockage ☐ prix ☐

Quelle période…………………………………………………………

Autres……………………………………………………………………………………….

Conduite de la reproduction:

Disposez-vous un registre de suivi de la reproduction ? Oui/Non

Si oui : linéaire ☐ rotatif ☐ informatisé ☐ Cahier d'étable ☐ Fiche d'élevage ☐

Renouvellement du troupeau:

Achat ☐ Propre-troupeau ☐ génisses importées ☐

Critères de sélection:

Production laitière de la mère ☐ GMQ ☐ développement mammaire ☐
Performance de reproduction de la mère ☐ poids ☐ race ☐

Autre ………………………………………………………………………………

Critère de mise à la reproduction des femelles

Poids ☐ croissance ☐ âge ☐ apparition des chaleurs ☐

Quel est l'âge moyen de la mise à la reproduction des génisses ? ☐

Quel est en moyenne l'âge au premier vêlage? ☐

La détection des chaleurs : Oui/Non

Combien de fois? ……../jour

Quelle est la durée par observation?.........min

Lieu d'observation :

Salle de traite ☐ étable ☐ pâturage ☐ Indéfini ☐

Signes d'identification des chaleurs :

Ecoulement vulvaire ☐ beuglement ☐ chevauchement ☐ agitation ☐
- acceptation du mâle ☐ Tuméfaction de la vulve ☐ Rougeur de la vulve ☐
- Autres……………………………………………………………………………….

Type de saillie :

Saillie naturelle ☐ insémination artificielle ☐

Si artificielle, réalisée par : un inséminateur ☐ Vétérinaire ☐ l'éleveur ☐

Si saillie naturelle, **Race** du taureau ………………., de l'éleveur/ extérieur

Critères du choix de taureau :

L'âge☐ le poids☐ la race☐

Le diagnostic de gestation :

Moment du diagnostic de gestation après l'insémination :……………………………

Diagnostic établi par : Eleveur☐ Technicien ☐ Vétérinaire ☐

Moyen de diagnostic:

Cessation des chaleurs☐ Dosage de progestérone ☐ Echographie☐ Fouiller R☐

Autre……………………………………………………………

Le post-partum :

La durée du repos :…………………………………..

Le délai moyen pour une première insémination après mise-bas: ……………jours. •

Les problèmes d'avortement : Oui/Non

Rares☐ présents ☐ fréquents ☐

Ya t'il des difficultés de vêlage ? Oui/Non

Rares☐ présents☐ fréquents ☐

Les performances de reproduction :

Intervalle V-V:……………………………………

Intervalle V-IA:……………………………………

Intervalle V-IAF:…………………………………..

Problèmes rencontrés :

………………………………………………………………………………………
……………………… ……………………………………………

Remarques et notes personnelles sur l'élevage et la région :

………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
……………………………………………………………………………………

La production laitière

Moyenne de la production :

Race	effectif	rang	QMJ/ lactation	Q pic	Temps pic	Saison
BL						
BA						
BM						

TTrp : quantité totale journalière du troupeau T.Trp :

QMM : quantité moyenne mensuelle QMM :

La traite:

Manuelle☐ mécanique ☐

Fréquence☐

Rythme de traite: matin☐ matin et soir☐ soir ☐

- Présence de salle de traite: oui/non

-Les premiers jets sont- ils éliminés avant la traite? Oui/non

-Examen systématique des premiers jets: oui/non

-Pratiquez- vous l'égouttage? Oui/non

Hygiène de la traite:

Les trayeurs se lavent-ils les mains avant la traite: oui/non

Nettoyage de la mamelle: avant traite☐ après traite☐

Produits utilisés:

Eau☐ eau et détergent☐ eau javellisée☐ ☐ antiseptique

Nettoyage de la machine:

A chaque utilisation☐ 1/jour☐ 1/semaine☐ 1/mois☐

Produit utilisé :

Eau tiède☐ Eau et détergent☐ Eau et eau de javel☐ ☐ Désinfectant

Contrôle de la machine à traire: mensuel☐ annuel☐

Fréquence de renouvellement des manchons de la machine☐

Les mammites

Fréquence :

Absentes☐ Rares ☐ présentes ☐ fréquentes ☐

Diagnostic :…………………………………………………………………………

Rang de traite des vaches mammiteuses:

Début de traite☐ fin de traite☐ aléatoire☐

Lactation:

Durée moyenne de lactation ☐

La variation dépends de :

Race☐ âge☐ saison de vêlage☐ alimentation ☐

Autres ………………………………………………………………………

Tarissement

Durée☐

Pratiqué? Oui/ non

Méthode: brutale☐ progressive☐

Stade de tarissement :

6ème mois☐ 7ème mois☐ • 8ème mois☐

Orientation du lait:

Laiterie☐ vente aux privés ☐ autoconsommation ☐

Changez-vous l'acheteur ? Oui/Non

Le lait est ramassé : une fois/J☐ deux fois /J☐

Moyen de transport du lait :

Camionnette ☐ citerne de collecte ☐ voiture ☐

Autre ……………………………………………………………………………

Le **contrôle laitier** existe-il? Oui/non

Rôle des revenus de la production laitière:

Majeur ☐ mineur ☐

Durée de productivité de la vache……….. ans

Bénéficiez-vous d'aide d'état: oui/non **suffisant**: oui/non

Est-ce que l'élevage est rentable? oui/non

Les contraintes de l'élevage bovin laitier dans la région

………………………………………………………………………………………
………………………………………………………………………………………

L'amélioration de la production laitière est basée sur quoi à votre avis?
………………………………………………………………………………………
………………………………………………………………………………………

Table A1: Modalities of breeders' socio-economic variables used for typology

		AR « Biskra-Ouled Djellal »			SAR « Souk Ahras »			
Variable	**Terms**	**G1** (n= 68) 73.91%	**G2** (n=24) 26.09%	**TOTAL**	**G1** (n=96) 79.34%	**G2** (n=5) 04.13%	**G3** (n=20) 16.53%	**TOTAL**
Age (years)	< 30	05.88%	0%	4.35%	-	-	-	-
	30-60	92.65%	20.83%	73.91%	-	-	-	-
	> 60	01.47%	79.17%	21.74	-	-	-	-
Education level	Illiterate	20.59%	95.83%	40.22%	95.83%	-	0	78.51%
	Schooled	72.06%	4.17%	54.35%	04.17%	-	0	04.96%
	University	07.35%	00%	05.43%	0.00%	-	100	16.53%
Professional experience in cattle breeding	Beginner	26.47%	00%	19.57%	20.83%	-	00%	16.53%
	Medium	64.71%	29.17%	55.43%	56.25%	-	20%	52.07%
	Competent	8.82%	70.83%	25.00%	22.92%	-	80%	31.41%
State's aid	Yes	23.53%	00.00%	17.39%	-	-	-	-
	No	76.47%	100%	82.61%	-	-	-	-
Agricultural training	Yes	-	-	-	0%	100	-	4.13%
	No	-	-	-	100	0.00	-	95.87%

Table A2: Modalities of breeding situation variables used for typology

		AR « Biskra-Ouled Djellal »				SAR « Souk Ahras »				
Variable	**Terms**	**G1** (n= 45) 48.91%	**G2** (n=34) 36.96%	**G3** (n=13) 14.13%	**TOTAL**	**G1** (n=86) 71.07%	**G2** (n=11) 09.09%	**G3** (n=09) 07.44%	**G4** (n=15) 12.40%	**TOTAL**
Building type	No Real Building	40.00	94.12	0.00	54.35	0.00	0.00	0.00	0.00	0.00
	Traditional	48.89	5.88		27.17					
	Shed		0.00	84.62	17.39					
	Modern barn									
Building conditions	Bad		44.12		23.91	0.00			73.33	9.09
	Poor	80.00	29.41		54.35	98.84	27.27		26.67	83.47
	Good	0.00		69.23	9.78	1.16	72.73			7.44
	No Building		26.47		11.96					
Ventilation type	Natural					0.00	0.00	0.00	0.00	0.00
	Mechanical					100	100	100	100	100
Compliance with hygiene standards	Not up to standards		88.24	0.00	52.17		0.00			42.98
	Moderately within standards	44.44	11.76		27.17					
	Within standards		0.00	92.31	20.65	17.44	100			24.79
Land Type	UAA	95.56	58.82		80.43					
	Pastoral area	4.44	41.18		19.57					
	Both									
Litter quality	Clay	35.56	88.24		53.26	0.00			60	9.09
	Straw Clay	48.89	11.76		31.52					
	Concrete					61.63			6.67	52.89
	Straw Concrete									
Total workforce class	[0-5[	4.44	50		20.65					
	[5-15[	75.56			58.70					
	[15-25[			61.54	14.13					
	> 25									
DC Workforce class	[0-5[		79.41	7.69	48.91					
	[5-15[		20.59	76.92	43.48					
	[15-25[									
	> 25									

Table A2: Modalities of breeding situation variables used for typology (continued)

Basics of improving milk production	Feed									
	Genetic potential					0.00	0.00	0.00	0.00	0.00
	Management	44.44			29.35	0.00	0.00	0.00	0.00	0.00
	Ne response	28.89	79.41		53.26					
Drinking water sources	Own source	95.56	67.65		84.78					
	Supply system		32.35		15.22					
Milk analysis	Yes		91.18		72.83					
	No		8.82		27.17					
BCS (DC)	< 2.5		79.41	23.08	61.96					
	> 2.5		20.59	76.92	38.04					
Stall Type	Hindered					1.16		66.67		5.79
	Free					98.84		22.22		93.39
	Semi-restrained			38.46	11.96					
Herd's racial composition	Crossbred						0.00			43.80
	Purebred						72.73			19.01
Type of labour	Family							44.44		85.12
	Employee							55.56		14.05

Table A3: Modalities of breeding techniques variables used for typology

		AR « Biskra-Ouled Djellal »						SAR « Souk Ahras »				
Variable	**Terms**	**G1** (n=05) 5.43%	**G2** (n= 9) 9.78%	**G3** (n=15) 16.30%	**G4** (n=30) 32.61%	**G5** (n=33) 35.87%	**TOTAL**	**G1** (n=38) 31.40%	**G2** (n= 33) 27.27%	**G3** (n=22) 18.18%	**G4** (n=28) 23.14%	**TOTAL**
Concentrate type	Bran		44.44		100	0.00	10.87	0.00	0.00	0.00	100	23.14
	DC(Special DC)	100					5.43	0.00	100	0.00	0.00	27.27
	Mixtures				0.00	100	45.65	0.00	0.00	100	0.00	18.18
	Whole mixtures			26.67			5.43	76.32	0.00	0.00	0.00	23.97
	(DC+ Mixtures		33.33				5.43	21.05				6.61
Renewal method	Purchase of cows					60.61	42.39					
	Self-renewal											
	Imported heifers	0.00	0.00	0.00	0.00	0.00	0.00		15.15			4.96
	No particular strategy											
Pregnancy diagnosis method	Heats cessation											
	Lab test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ultrasound		100		0.00	0.00	11.96					
	Rectal search											
	Heats cessation+ rectal search		0.00	73.33			39.13					
Mating method	Natural projection		0.00		100		88.04		57.58		100	80.17
	artificial insemination		44.44				4.35		33.33			10.74
	Both		55.56				7.61					
Milking hygiene	Bad					18.18	7.61					
	Poor			6.67	83.33		57.61					
	Poor to good			86.67		6.06	25					
	Good		44.44				9.78					
Milking type	Manual		22.22	13.33		93.94	64.13				53.57	23.97
	Milking robots		77.78	86.67		6.06	34.78				46.43	76.03

Table A3: Modalities of breeding techniques variables used for typology (continued)

Criteria for heifers' mating	Weight											
	Age			86.67			32.61					
	Heat appearance			6.67			48.91					
	No particular strategy											
Drying-off method	Brutal											
	Progressive			80.00		30.30	48.91					
	Not practiced			6.67		54.55	36.96			5		26.45
Milk destination	Dairies								100			84.30
	Private Points (Pp											
	Self-consumption			0.00		51.52	31.52					
	Pp + self-consumption											

Table A4: Modalities of farms productivity variables used for typology

		AR « Biskra-Ouled Djellal »			SAR « Souk Ahras »				
Variable	**Terms**	**G1** (n= 83) 90.22%	**G2** (n=09) 09.78%	**TOTAL**	**G1** (n=32) 26.45%	**G2** (n=10) 08.26%	**G3** (n=23) 19.01%	**G4** (n=56) 46.28%	**TOTAL**
Number of inseminations for fertilization	<3I	100	0.00	90.22	84.38				95.87
	>3I	0.00	100	9.78	15.63				4.13
Number of inseminations for fertilization	1								
	2	50.60	0.00	45.65	37.50				17.36
	3	0.00	55.56	5.43					
	4	0.00	33.33	3.26					
Calving-fertilization interval (Day)	<60				0.00			37.50	21.49
	60-90				18.75			62.50	47.11
	>90	27.71	77.78	32.61	81.25			0.00	31.41
Inter calving interval (Day)	<365				6.25			92.86	61.16
	365-400				62.50			7.14	26.45
	>400				31.25			0.00	12.40
Calving-first insemination interval (Day)	<60				6.25			62.50	38.02
	60-90								
	>90				46.88			0.00	19.01
Age at first calving (Months)	<24					100		0.00	9.09
	24-30				84.38	0.00	0.00	78.57	58.68
	> 30								
	No response				0.00		100	0.00	19.01
Heifers average age at mating (Months)	<12					60.00			4.96
	12-15				43.75		0.00		23.14
	>15					0.00	0.00	82.14	52.89
	No response				0.00		100	0.00	19.01
Daily average quantity of milk	<10L								
	10-25L				96.88				80.17
	>25L								

Table A5: Modalities of breeding constraints variables used for typology

		AR « Biskra-Ouled Djellal »				SAR « Souk Ahras »		
Variable	**Terms**	G 1 (n= 34) 36.96%	G 2 (n=11) 11.96%	G 3 (n=47) 51.09%	TOTAL	G 1 (n=60) 49.59%	G2 (n=61) 50.41%	TOTAL
If there is reform	Yes	100		0.00	42.39	0.00	100	50.41
	No	0.00		100	57.61	100	0.00	49.59
Reason for reform	Age					0.00	13.11	6.61
	Pathologies	50.00		0.00	20.65			
	Infertility							
	Production defects					0.00	18.03	9.09
	Accident	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other	38.24		00.00	15.22	0.00	57.38	28.93
	Several reasons	0.00		100	57.61	100	0.00	49.59
Power supply problems	Lack					0.00	0.00	0.00
	Expensive price							
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Multiple problems							
Common diseases	Digestive							
	Respiratory							
	podal							
	Reproductive							
	Accidental	0.00	0.00	0.00	0.00			
	Mastitis					0.00	0.00	0.00
	multiple							
	Parasitosis							
Frequency of abortions	Absent					66.67	86.89	76.86
	rare							
	present	0.00	0.00	0.00	0.00			
	Frequent							
Mastitis frequency	Absent							
	rare		0.00		45.65			
	present							
	Frequent		54.55	0.00	7.61			

Table A5: Modalities of breeding constraints variables used for typology (continued)

Reproductive Pathologies	Obstetrics							
	infectious		36.36		4.35			
	Abortions							
	Obstetrics + Abortions							
Dystocia	Yes		36.36	91.49	78.26			
	No		63.64	8.51	21.74			
Breeding Constraints	food							
	Economic		36.36		7.61			
	Management							
	Weather							