

# SHEEP BREEDS IN NORTH AFRICAN STEPPES: CASE STUDY OF THE BORDER REGION OF NAAMA (WESTERN ALGERIA)<sup>1</sup>

Ahmed Toufik Youcefi<sup>2</sup>, Abderrazak Marouf<sup>3</sup>

## Abstract

Localized in the west of Algeria, the region of Naama is the best known for its pastoral areas forged by the specific climate and available soil conditions that have characterized the region from time immemorial. Sheep breeding is the main activity on which the local economy is based. The main goal of this paper is to study the distribution of sheep breeds in herds of the border area of Naama. Used methodological framework for performed study is based on a field survey of 133 breeders from the municipalities of Kasdir, Ain Ben Khelil, and Sfisifa. The results show that the Ouled-Djellal breed dominates the sheep population in the study area, while it represents more than 90%. It is followed by the Daraa breed with a rate of 3.77% in overall structure, while the two breeds Hamra and Srandi represent 2.54% and 2.44% respectively. The rate of the last breed Rembi is 0.52%. Study also reveals some correlations (positive or negative) between sheep breeds and other ruminant species (mainly cattle and goat), as well as with the lifestyles practiced by farmers, or age of breeders.

**Key words:** Hamra, Sardi, sheep breeds, western Algeria, north African steppes.

**JEL<sup>4</sup>:** Q1, Q2, R1

## Introduction

The breeding of small ruminants is part of the most significant agricultural activities in the world (Ghassan, 2006). Its most indisputable role is to contribute the satisfaction

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- 1 The authors are thankful to the Naama Forest Administration and its staff who helped them in carrying out the field surveys.
  - 2 Youcefi Ahmed Toufik, Ph.D., Doctor of Agronomic Sciences, Salhi Ahmed University Center of Nâama, Institute of science, Sustainable management of natural resources in arid and semi-arid areas laboratory, Directorate of Forest Conservation of Naama, 45000 Nâama, Algeria, Phone: +213 673 672 545, E-mail: ahmed.youcefi@cuniv-naama.dz, ORCID: <https://orcid.org/0000-0002-3569-0959>, (corresponding author)
  - 3 Marouf Abderrazak, Ph.D., Professor of Biochemistry, Salhi Ahmed University Center of Nâama, Institute of science, Sustainable management of natural resources in arid and semi-arid areas laboratory, 45000 Nâama, Algeria, Phone: +213 772 543 166, E-mail: abderrazakmarouf@hotmail.com, ORCID: <https://orcid.org/0000-0002-6266-502X>
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of protein needs of human population. It contributes to food security by transforming spontaneous plants, agricultural and other residues into protein foods with a high nutrient content. Livestock farming contributes the fight against poverty among a large number of rural families by creating employment in the agricultural sector (FAO, 2016; FAO, 2018). It also contributes to the production of manure usable for soil improvement (Otte et al., 2012). North Africa is characterized by large territories of steppe land dominated by sheep farming, where the steppe was named “the world of sheep”, while the traditional valuation of the steppes was based on pastoralism (Bourbouze, 2000; Dutilly Diane, 2007). Livestock is the driving force behind the development of the agricultural sector, reflecting the social, economic and environmental changes linked to food systems around the world. It is usually a starting point for understanding issues related to sustainable agricultural development (HPLE, 2016; Youcefi, 2024).

Limited between the average annual isohyets of 100 mm and 400 mm, the steppes of northern Africa designate vast area that exceed 60 million hectares, while characterized by low and dispersed vegetation (Le Houerou, 1995). These steppes are expanding to the Maghrebians countries: Morocco, Algeria, and Tunisia, then shrink as a coastal strip in Libya and Egypt (Aidoud et al., 2006). Spread on over 20 million hectares, the Algerian steppes (located between the Moroccan and Tunisian borders) represent a territory with pastoral vocation typically dedicated to livestock (Youcefi, Marouf, 2023). In Algeria, livestock production accounts for a significant part (50%) of overall gross domestic agricultural output, with more than 21 million sheep, nearly 4 million goats, and about 1.7 million cattle (ONS, 2009).

The sheep species is distributed throughout northern Algeria, with a remarkable concentration in the steppe regions and high plains that gathers about 80% of the total national population (Bekhouche Guendouz, 2011). Localized in the west of Algeria, the steppe rangelands in the Naama region have suffered continuous degradation in recent years, reducing biological potential by causing a disturbance of the ecological and socio-economic order (Youcefi et al., 2024). These disturbances also affected the diversity of sheep breeds, and their distribution, which causes a risk to crossing of some breeds by others, and losing some genetic traits that distinguish Algerian sheep breeds (Djaout et al., 2017). According to this, research tries to contribute in describing the numbers of sheep breeds and their status in a pastoral region known for its large livestock. More precisely, it is chosen the border zone of the Naama region localized in the extreme west of Algeria. Paper intends also to interpret any possible relationships between the sheep breeds and breeders in observed area, or performed techniques of breeding.

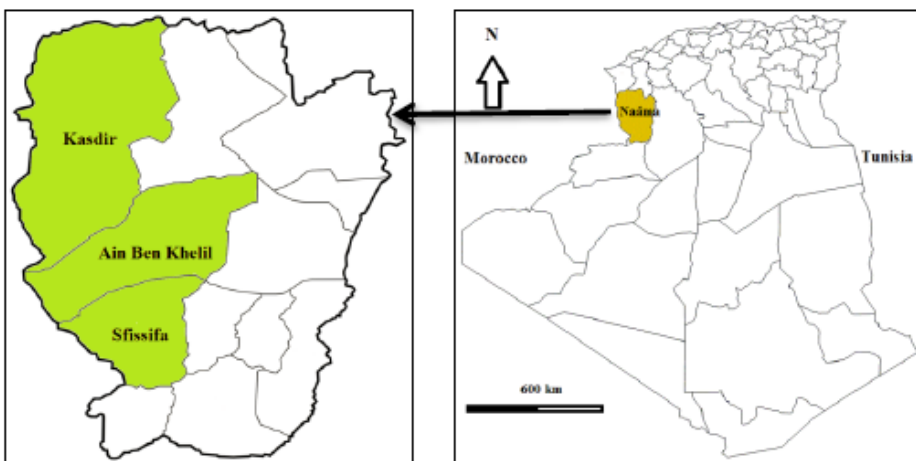
## Materials and Methods

Field survey has been chosen as a method of work, while it is based on semi-directive single-pass interviews (Dockes, Kling Eveillard, 2007). Sample consists of 133 respondents, while defined population could be considered representative, since it covers the whole study area (municipalities of Kasdir, Ain Ben Khelil, and Sfisifa), while it assumes breeders randomly encountered in the observed area. Comparing the size of selected sample with overall size of population studied reveals an error margin of 7%. The survey has been lasted around seven months (from May to November 2021), while it represents a part of larger research towards agro-pastoralism that is carried out in the Naâma region. The information sought are herd size, species composition of ruminants, structure in ovine breeds, rates of sheep categories in possession, the lifestyle of farmers, and age of breeder. The calculations and statistical processing were carried out using the free software R (version 4.2.1), (R Core Team, 2022). Research was based on the structure and classification of herds by breed, as well as existing correlations between the breeds, breeders and breeding techniques.

### *Study area*

The territory of Wilaya of Naama is located in the Algerian western steppes, (Figure 1.) covering a huge area of 29,819.30 km<sup>2</sup> (DPMD, 2021), while the steppe involves 74% of the overall area. Sheep rearing represents the main activity on which the local economy is based. Region is recognized for its agro-pastoral vocation (Youcefi, Marouf, 2024a).

**Figure 1.** Location of the study area



Source: Maps.com, 2024; Gifex.com, 2024.

The study area is composed of three border municipalities (Kasdir, Ain Ben Khelil, and Sfissifa) located at the extreme west of the region of Naama, more precisely on the Algerian-Moroccan border (Figure 1.). The data, describing the study area and number of sheep grown there are presented in detail in Table 1.

**Table 1.** Data from the study area

Municipalities	Surface area (in km <sup>2</sup> )	Number of sheep
Kasdir	6,386.46	268,103
Ain Ben Khelil	3,800.03	254,227
Sfissifa	2,438.61	145,527
<b>Total</b>	<b>12,625.10</b>	<b>667,857</b>

Source: DPMD, 2021.

The total number of sheep in Algeria is estimated at 26 million in 2018. (Sahraoui et al., 2023), while the sheep population in the Naama region is represented by more than 1.6 million heads in 2021. (DPMD, 2021), while more than 40% are grown in the border area (municipalities of Kasdir, Ain Ben Khelil, and Sfissifa).

The climate in Naama region is semi-arid, characterized by dry summer season. The rainfall regime involves a long period of drought which extends from April to October (Guerine et al., 2020). The Algerian steppes are distinguished by their Mediterranean climate, marked by a dry and hot summer period, followed by a wet, cool or cold winter period (Nedjraoui, 2004; Nedjimi, Guit, 2012). Rainfalls in mentioned area are described as low, ranging from 100 to 450 mm annually, while average precipitation amounts 271 mm, while its irregular with usually significant spatial and temporal changes. The lowest average temperature in the coldest month is -0.5°C, while the highest average temperature in the warmest month is about 34.5°C. Meanwhile, pluviothermal coefficient ranges from 24.5 to 27.7 (Benabdeli, 2000).

### *The main sheep breeds in Algeria*

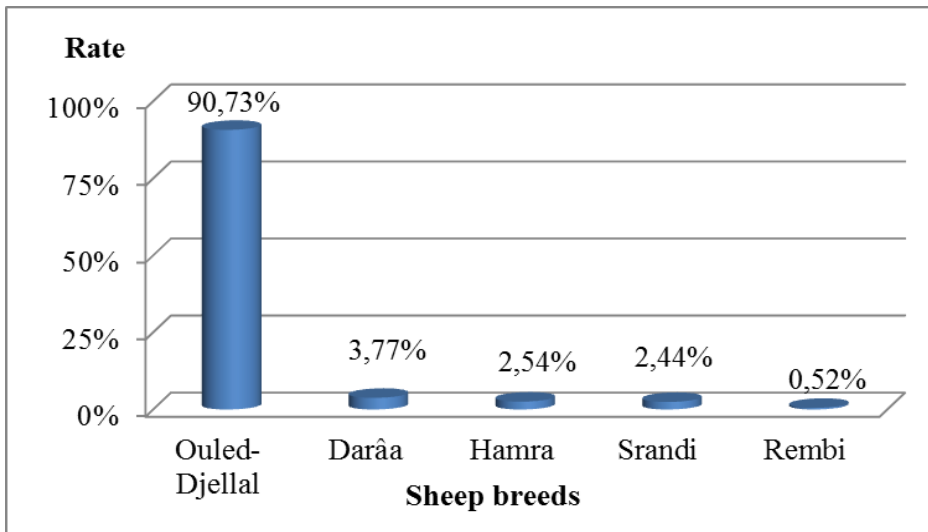
According to several studies on the richness of Algerian sheep breeds (Gaouar, 2009; Djaout et al., 2017; Belharfi et al., 2017; Ameur et al., 2018), as the main breeds are underlined Ouled-Djellal, Hamra, Rembi, Barbarine, Berbere, Taadmit, D'man, Sidaou, Daraa, Srandi, Ifilen, and Tazegzawt. Mentioned sheep breeds have been raised since ancient time in Algeria, mainly towards their characteristics compatible with arid and desert areas, or resistance to diseases, and achieving good production results.

## Results and Discussions

### *Structure of sheep breeds*

In order to study the rates of the breeds composing the livestock within the study area, there are drawn the histograms according to cumulative numbers of breeds held by surveyed breeders (Figure 2.). There re shown that Ouled-Djellal breed dominates in sheep population in the study area, as it represents more than 90% of overall population. As a second was ranked the breed Daraa with a rate of 3.77%, while it is followed by breeds Hamra and Srandi with more or less similar share, 2.54 and 2.44 respectively. The lowes share has breed Rembi, only 0.52%. In research the margin of error is set at around 7%.

**Figure 2.** Rate of sheep breeds in the study area



Source: according to Youcefi, Marouf, 2024b.

The study of the distribution of sheep breeds reveals that Ouled-Djellal has a high elasticity in the study area, as its morphological characteristics and its adaptation to the severe climate conditions are the main factors that encourage breeders to choose this breed. It is also well-known like the white breed Arab or Arbia. It is mostly bred in arid to semi-arid territories, while clearly preferred by breeders, thanks to its good reproduction quality and resilience to harsh production circumstances. Mentioned, primarily zootechnical characteristics contribute to the rapid increase in the number and size of herds, as well as in achievement of good results in meat production (Taherti et al., 2023).

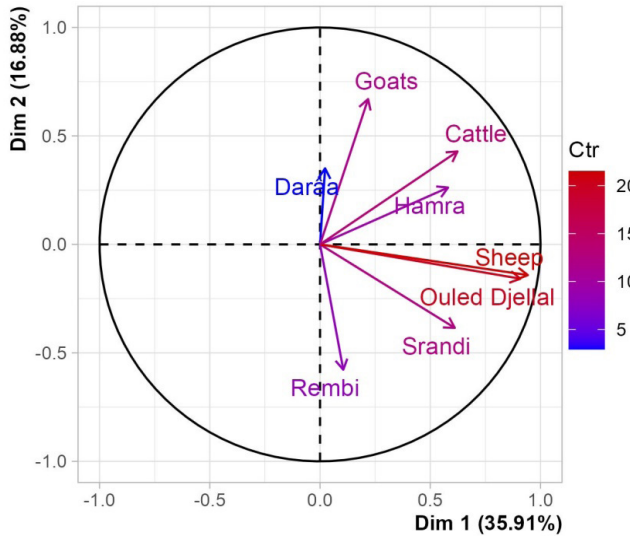
### *Principal component analysis*

Principal Component Analysis (PCA) is the usually performed method of multivariate data analysis. It allows the study of a multidimensional data set with quantitative variables. Method is used in biostatistics and many other fields (Greenacre et al., 2022). In this part of research, there are opted for data analysis in main components by reducing 8 variables (5 breeds, as are Ouled-Djellal, Daraa, Srandi, Rembi, and Hamra, and 3 species, as are Sheep, Cattle, and Goats) in only two axes. The objective of this analysis is to interpret trends in breed numbers as a function of the numbers of species that form the herds.

The first two analysis dimensions represent 52.79% of the total inertia of the dataset ( $35.91 + 16.88$ ), meaning that the plan explains 52.79% of the variability (Figure 3.). This share is relatively high, while the first plan well represents the data variability. The contribution of the variables is represented by colors. Red describes variable that contributes strongly to the analysis, and blue factor that contributes weakly. According to quality of their contributions, variables Ouled-Djellal and Sheep actively contribute to made study research. They are followed by the variables Cattle and Goats. At the end, variable Daraa has the lowest contribution. So, the variables Sheep and Ouled-Djellal have a perfect correlation,  $0.98 \approx 1$ , what seems logical because the Ouled-Djellal breed is the main component of the herds in the study area. According to the angles plotted by the vectors of the variables (Figure 3.), the correlation between the breed Daraa and the goats seems important, same remark could be for the correlation between the breed Hamra and cattle.

Analyzing the correlations between the sheep breeds grown in study area and other species that constitute the herds (goat and cattle, while all categories are combined) show existence of two more or less dominant associations. Small ruminant - Small ruminant association is composed of the Daraa breed and the goats, while the Small ruminant - Large ruminant is formed from the Hamra breed and cattle. The breed of Hamra is characterized by its small size, well recognized by high organoleptic qualities of meat, while it is distinguished from other breeds by color of its head and legs from dark-chestnut to red, or by its white wool with guard hair going from brown to russet-red (Gaouar et al., 2015). In addition to its small population, the Rembi breed has negative correlations with the other two species (goats and cattle), reflecting the poor adaptation of this breed to the general conditions occurred in livestock production in observed area. The Srandi (or Sardi) breed exists in Algeria with little herds, particularly in the Algerian - Moroccan borders' area. These measurements are close to Ouled-Djellal (size, color, and tail). Breed has white head without wool with black spots around the eyes, snout of ends of ears, paws and at the knees and hocks.

**Figure 3.** Graph of tested variables (sheep breeds/other species)



Source: according to Youcefi, Marouf, 2024b.

**Correlation sheep breeds – age of breeders**

After using statistical software R, in Table 2. are shown the different correlations between grown sheep breeds and age of breeders. Although these correlations are not really important, they give insight into the age trend of breeders related to grown sheep breeds. The Table 2. reveals the existence of three relatively distinct correlations. Moderately important correlation is varying from 0.33 and 0.29 respectively for the sheep breeds Ouled-Djellal, Daraa, and Srandi. Low correlation exists for Rembi breed, 0.12, while almost zero correlation occurs for the Hamra breed.

**Table 2.** Correlation between sheep breeds and age of breeders

Sheep breeds	Age correlation
Ouled-Djellal	0.33
Daraa	0.31
Srandi	0.29
Rembi	0.12
Hamra	0.05

Source: according to Youcefi, Marouf, 2024b.

The correlation between the ownership of sheep breeds and the age of breeders shows that for older breeders first opt is the Ouled-Djellal breed, then Daraa, and Srandi. Concerning the two remaining breeds, Rembi and Hamra, their detentions have no relation with the age trend of the breeders. Breeds Ouled-Djellal, then Daraa, and

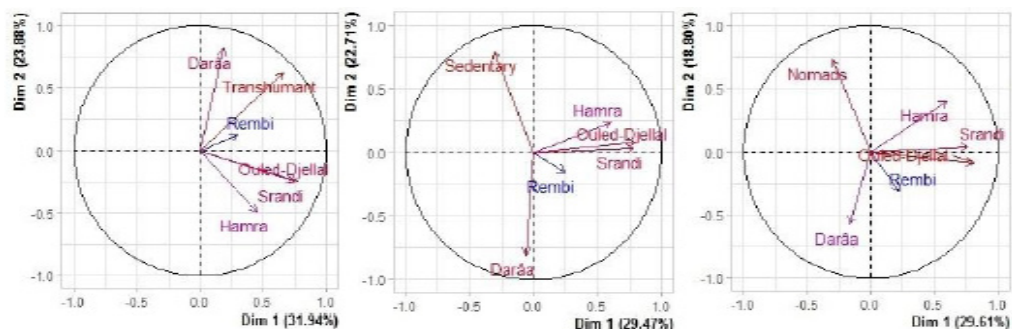
Srandi have large size and good weight growth compared to other observed breeds, meaning a production of significant amount of meat, or that older breeders are more experienced in obtaining the final product (meat).

### *Correlation sheep breeds - lifestyle*

In order to perceive the relationships that could exist between sheep breeds and envisaged lifestyles, there have been also made correlation circles based on survey data (Figure 4.). In figure are shown that the best representation of the variables is at transhumant, with a rate of 55.82%. It is followed by the sedentary, with 52.18%, and at the end by the nomads, with only 48.41%. It could be noted that the variable Rembi represents the least contributing factor for three circles drawn.

The Hamra breed has no correlation with all lifestyles practiced in the study area (transhumance, sedentary, and nomadism). The breeds Rembi and Daraa have a strong negative correlation with the modes sedentary and nomadic, and a significantly positive correlation with transhumance. Ouled-Djellal breed correlates positively with transhumance, as the breeders belonging to this mode have the largest number of sheep herds.

**Figure 4.** Circles of correlation (sheep breeds - lifestyles)



Source: according to Youcefi, Marouf, 2024b.

Possession of the Hamra breed in observed area is not based on technical parameters. Its presence does not meet any criteria, while is distributed randomly. Unlike, breeds Rembi and Daraa are much more present in transhumant, what can be justified by the favorable conditions offered by mentioned mode, especially the seasonal displacement to suitable areas in difficult conditions. Rembi breed is mostly grown in central territories between east of Algeria where Ouled-Djellal breed is grown and west of Algeria known for Hamra breed. Concerning the Daraa breed, it spreads all over the Algerian territory, but in little number of animals. Its head and limbs are totally black (there originate the name Daraa), covered by closed or semi-closed

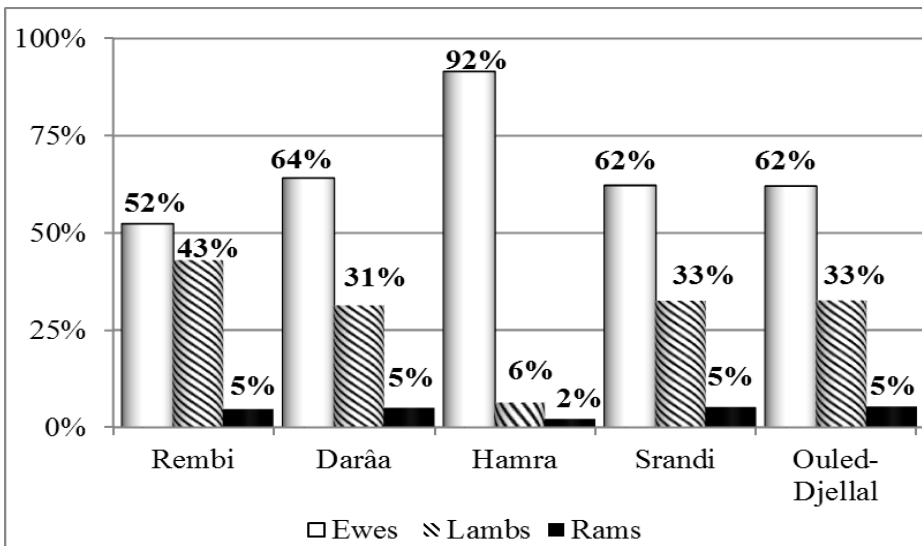


brown wool. The breed has medium long or long tail, while there are no horns at females, or they may exist at males (Mohammedi, 2023).

### *Herd structure by breed*

As a part of performed research, suitable histogram is made, representing the different categories of sheep (ewes, lambs, and rams) that constitutes the structure of herds by certain breed (Figure 5.). For three breeds, Ouled-Djellal, Daraa, and Srandi, it is noticed certain similarity in distribution of categories. The rate of ewes varies between 62-64%, lambs 31-33%, while the rate of rams is up to 5% for all three breeds. For Rembi breed, the rams' share respects 5%, while the rate for lambs seems to be more important, 43%, or for ewes it relatively decreases to 52%. Hamra breed scores purely outliers compared to other breeds, for ewes is 92%, for lambs is 6%, while for rams is only 2%. Shown results may occurred due to fertility issues of this breed.

**Figure 5.** Structure of the herd (sheep breeds / categories)



Source: according to Youcefi, Marouf, 2024b.

The share by category imposes level of fertility of certain breeds and further sustainability of breeding. Hamra breed, typical for the region, seems less productive compared to other breeds (due to minimal share of rams of 2%), or due to low fertility of the females, as it may result from breeding practices knowing that the crossing between Hamra females and Ouled-Djellal gives birth to individuals with phenotypes close to those of the Daraa breed, which probably justifies the high rate of lambs of the Daraa breed.

## Conclusion

The region of Naama represents an important part of Algerian territory used for the breeding of ruminants, particularly sheep. Derived study results showed that in border area of Naama there are generally five main sheep breeds grown, with dominance of the Ouled-Djellal breed, followed by Daraa, Hamra, Srandi, and Rembi breeds. Research shows existence of two more or less dominant associations (production systems) linked to animal growing, i.e. Small ruminant - Small ruminant association composed from Daraa breed and goats, and Small ruminant - Large ruminant, association formed from the Hamra breed and cattle. Observing the structure of sheep herds and lifestyle of producers, breeds Rembi and Daraa have a strong negative correlation with the modes sedentary and nomadic, while significantly positive correlation with transhumance. Ouled-Djellel breed correlates positively with transhumance, as breeders belonging to this mode of livestock production have the largest number of sheep herds. The share of heads of sheep by category within the single herd impose questions on fertility of certain breeds and the performing of breeding activity. Hamra breed, typical for the region seems to be less productive compared to other sheep breeds. According to mentioned issue, it is necessary to try to repopulate the endemic species of the region (Hamra breed) by encouraging its breeding and improving its fertility either by organizing campaigns devoted to artificial insemination, or by distributing healthy rams to ensure successful fertilization.

## References

1. Aidoud, A., Le Floc'h, E., Le Houerou, H. (2006). The arid steppe rangelands of Northern Africa. *Secheresse*, 17(1-2):19-30.
2. Ameer, A., Nezih, A., Benyoucef, M., Djaout, A., Azzi, N., Yilmaz, O., Cemal, I., Gaouar, S. (2018). New genetic identification and characterization of 12 Algerian sheep breeds by microsatellite markers. *Italian Journal of Animal Science*, 17(1):38-48, doi: 10.1080/1828051X.2017.1335182
3. Bekhouche Guendouz, N. (2011). *Sustainability assessment of dairy cattle farms in the Mitidja and Annaba Basins*. Doctoral thesis, National Higher School of Agronomy and Food Industries, Institut National Polytechnique de Lorraine, Nancy University, Nancy, France, p. 310.
4. Belharfi, F., Djaout, A., Ameer, A., Gaouar, S. (2017). Barymetric characterization of Algerian sheep Breeds in western Algeria. *Genetics and Biodiversity Journal*, 1(2):31-41, <https://doi.org/10.46325/gabj.v1i2.94>

5. Benabdeli, K. (2000). *Assessment of the impact of new farming methods on space and the steppic environment. Municipality of Ras El Ma (Sidi Bel Abbes - Algeria), (Evaluation de l'impact des nouveaux modes d'élevage sur l'espace et l'environnement steppique: Cas de Ras El Ma (Sidi Bel Abbes - Algérie))*. In: Bourbouze, A., Qarro, M. (eds.) *Rupture: nouveaux enjeux, nouvelles fonctions, nouvelle image de l'élevage sur parcours, Options Méditerranéennes: Série A, no. 39*, pp. 129-141, CIHEAM, Montpellier, France, <http://om.ciheam.org/om/pdf/a39/CI000353.pdf>
6. Bourbouze, A. (2000). Pastoralism in North Africa: The silent revolution. *Fourrages*, 161:3-21.
7. Djaout, A., Afri Bouzebda, F., Chekal, F., El Bouyahiaoui, R., Rabhi, A., Boubekour, A., Benidir, M., Ameer, A., Gaouar, S. (2017). Biodiversity State of Algerian Sheep Breeds. *Genetics and Biodiversity Journal*, 1(1): 1-18, <https://doi.org/10.46325/gabj.v1i1.74>
8. Dockes, A., Kling Eveillard, F. (2007). Representations of the animal and welfare by French breeders. *INRA Productions Animales*, 20(1):23-28.
9. DPMD (2021). *Statistical Yearbook of the Wilaya of Naâma 2020*. Directorate of Programming and Budget Monitoring (DPMD), Wilaya of Naâma, Algeria, pp. 132.
10. Dutilly Diane, C. (2007). Pastoral economics and marketing in North Africa: A literature review. *Nomadic Peoples*, 11(1):69-90, doi: 10.3167/np.2007.110105
11. FAO (2016). *Livestock Contribution to Food Security in the Near East and North Africa*. In: Regional conference for the Near East (33<sup>rd</sup> session), 9-13<sup>th</sup> May, 2016, FAO, Rome, Italy, retrieved at: [www.fao.org/family-farming/detail/en/c/897879/](http://www.fao.org/family-farming/detail/en/c/897879/), 21<sup>st</sup> June 2024.
12. FAO (2018). *Shaping the future of livestock: Sustainably, responsibly, efficiently*. In: 10<sup>th</sup> Global Forum for Food and Agriculture (GFFA), FAO, Berlin, Germany, retrieved at: [www.fao.org/3/I8384EN/i8384en.pdf](http://www.fao.org/3/I8384EN/i8384en.pdf), 21<sup>st</sup> June 2024.
13. Gaouar, S. (2009). *Study of biodiversity: Analysis of the genetic variability of the Algerian «breeds» and their phylogenetic relationships by using microsatellites*. Doctoral thesis, Oran University of Science and Technology (USTO), El Mnaouar, Algeria.
14. Gaouar, S., Kdidi, S., Tabet Aouel, N., Ait Yahia, R., Boushaba, N., Aouissat, M., Saidi Mehtar, N. (2015). Investigation of Genetic Relationships Among Hamra and Béni-Ighil Sheep Breeds Based on Microsatellite Markers. *Wayamba Journal of Animal Science*. 2015(1427278602):P1089-P1094.

15. Ghassan, S. (2006). *Sustainable improvement of small ruminant farming systems*. Doctoral thesis, Agricultural sciences national polytechnic, Institute of Lorraine, Lebanon, p. 291.
16. Gifex.com (2024). *Municipalities and wilayas of Algeria*. Retrieved at: <https://gifex.com/fr/fichier/carte-vierge-de-la-wilaya-de-naama/>, 2<sup>nd</sup> July 2024.
17. Greenacre, M., Groenen, P., Hastie, T., d'Enza, A., Markos, A., Tuzhilina, E. (2022). Principal component analysis. *Nature Reviews Methods Primers*, 2(1):100, <https://doi.org/10.1038/s43586-022-00184-w>
18. Guerine, L., Belgourari, M., Guerinik, H. (2020). Cartography and Diachronic Study of the Naama Sabkha (Southwestern Algeria) Remotely Sensed Vegetation Index and Soil Properties. *Journal of Rangeland Science*, 10(2):172-187.
19. HPLE (2016). *The sustainable agricultural development for food security and nutrition: what roles for livestock? Report of the High-Level Group of Experts on Food Security and Nutrition*, Rome, Italy, p. 158.
20. Le Houerou, H. (1995). *Bioclimatologie et biogéographie des steppes arides du Nord de l'Afrique: Diversité biologique, développement durable et désertisation*. Options Méditerranéennes: Serie B: Etudes et Recherches, no. 10, p. 396, CIHEAM, Montpellier, France.
21. Maps.com (2024). *Carte of Algeria (People's Democratic Republic of Algeria)*. Portal Maps.com, Goleta, USA, retrieved at: [url:https://d-maps.com/carte.php?num\\_car=34315&lang=fr](url:https://d-maps.com/carte.php?num_car=34315&lang=fr), 1<sup>st</sup> July 2024.
22. Mohammedi, K. (2023). *Phenotypic characterization and growth performance of sheep populations in North-eastern Algeria*. Doctoral thesis, University of Mohamed Khider, Biskra, Algeria.
23. Nedjimi, B., Guit, B. (2012). The Algerian steppes: Causes of imbalance (Les steppes Algériennes: causes de déséquilibre). *Algerian journal of arid environment*, 2(2):50-61.
24. Nedjraoui, D. (2004). *Evaluation of the pastoral resources of the Algerian steppe regions and definition of indicators of degradation (Evaluation des ressources pastorales des régions steppiques algériennes et définition des indicateurs de dégradation)*. In: Ferchichi, A. (ed.) *Réhabilitation des pâturages et des parcours en milieux méditerranéens*, 62:239-243, CIHEAM, Zaragoza, Spain, Cahiers Options Méditerranéennes, <http://om.ciheam.org/article.php?IDPDF=4600165>
25. ONS (2009). *Social Statistics, Economic Statistics. Algeria*. Office National des Statistiques (ONS), Algiers, Algeria, retrieved at: <https://www.ons.dz>, 26<sup>th</sup> April 2024.

26. Otte, J., Costales, A., Dijkman, J., Pica Ciamarra, U., Robinson, T., Ahuja, V., Ly, C., Roland Holst, D. (2012). *Livestock sector development for poverty reduction: An economic and policy perspective (Livestock's many virtues)*. UN Food and Agricultural Organization (FAO), Rome, Italy, retrieved at: [www.fao.org/4/i2744e/i2744e00.pdf](http://www.fao.org/4/i2744e/i2744e00.pdf), 21<sup>st</sup> June 2024.
27. R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria, retrieved at: <https://www.R-project.org/>, 23<sup>rd</sup> June 2024.
28. Sahraoui, H., Abbas, L., Ibrahim, B., Benalia, Y., Mohamed, L. (2023). Economic and ecological constraints on sheep management in the Algerian steppe. *Research Square*, <https://doi.org/10.21203/rs.3.rs-2501846/v1>
29. Taherti, M., Ait Issad, N., Khelef, D., Mimoune, N. (2023). Reproduction characteristics of Ouled Djellal rams in a semi-arid area in Algeria. *Kafkas Univ Vet Fak Derg*, 29(6):717-726, doi: 10.9775/kvfd.2023.30329
30. Youcefi, A. (2024). *Integrated approach to agro-pastoral development and sustainable management of the steppe area: Case study of the Wilaya of Naâma*. Doctoral Thesis in Agricultural Sciences, Salhi Ahmed University Centre of Naâma, Naama, Algeria, p. 222.
31. Youcefi, A., Khiri, M., Sahnoun, A., Marouf, A. (2024). The Contribution of Purified Wastewater in the Valorisation of Degraded Steppe Rangelands Case Study of the Mécheria Region (Western Algeria). *Natural Resources and Sustainable Development*, 14(1):129-140, doi: 10.31924/nrsd.v14i1.155
32. Youcefi, A., Marouf, A. (2023). Structure and age dynamics of breeders in the western Algerian steppes (region of Naâma). *Ikonomika i upravljenje na selskoto stopanstvo*, 68(1):32-37.
33. Youcefi, A., Marouf, A. (2024a). The valorisation of agro pastoral products and by-products: Case of the wilaya of Naâma (western Algeria). *Economics of Agriculture*, 71(1):253-261, <https://doi.org/10.59267/ekoPolj2401253T>
34. Youcefi, A., Marouf, A. (2024b). *Sheep breeds of Naama (Western Algeria)*. Internal (survey) data, Salhi Ahmed University Center of Nâama, Institute of science, Sustainable management of natural resources in arid and semi-arid areas laboratory, Directorate of Forest Conservation of Naama, Algeria.