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VALUING BIODIVERSITY FOR SUSTAINABLE ECONOMIC DEVELOPMENT: THE CASE OF MOROCCAN SHEEP BREEDS' CONSERVATION

LA VALORISATION DE LA BIODIVERSITÉ POUR UN DÉVELOPPEMENT ÉCONOMIQUE DURABLE : LE CAS DE LA CONSERVATION DES RACES OVINES MAROCAINES

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Abstract

The sustainable management of animal genetic resources (AGRs) is important for future food, fertilizer and animal traction needs and enables farmers and pastoralists to adapt to the challenges of changing production conditions. In addition, sustainable management of animal genetic diversity requires national planning to ensure long-term availability of animal heritage. In order to optimize the sustainable management of animal genetic resources, this research aims at the economic evaluation of animal genetic biodiversity in Morocco. Thus, the economic values of five main sheep breeds were calculated and compared with each other. To do this, an economic weighting analysis was performed in which the marginal profit of the main breeds was evaluated. this work differentiates between the market value and the economic value of each observed sheep breed. The results showed differences between the breeds market value and their economic value relating to genetic polymorphism. Thus, the Dman breed has the highest economic value, about 3.3 MAD / kg, knowing that this race has the largest number of exclusive variants and a large effective population size. Overall, this work could be of interest to policymakers in guiding development programs and projects to sustainably improve the necessary productive capacity while ensuring the goods and services demanded by the market.

Keywords: Economic analysis, sheep breeds, private genomic polymorphism, economic value, Morocco.

Résumé

La gestion durable des ressources zoogénétiques est importante pour les besoins futurs en nourriture, en engrais et en traction animale et permet aux agriculteurs et aux éleveurs de s'adapter aux défis de l'évolution des conditions de production. De plus, la gestion durable de la diversité génétique animale nécessite une planification nationale pour assurer la disponibilité à long terme du patrimoine animal. Afin d'optimiser la gestion durable des ressources zoogénétiques, cette recherche vise l'évaluation économique de la biodiversité zoogénétique au Maroc. Ainsi, les valeurs économiques de cinq principales races ovines ont été calculées et comparées entre elles. Pour ce faire, une analyse de pondération économique a été réalisée dans laquelle le profit marginal des principales races a été évalué. Les résultats ont montré des différences entre la valeur marchande des races et leur valeur économique liée au polymorphisme génétique. Ainsi, la race Dman possède la valeur économique la plus élevée, environ 3.3 MAD/kg, sachant que cette race possède le plus grand nombre de variantes

exclusives et une taille effective de population très importante. Dans l'ensemble, ce travail pourrait intéresser les décideurs politiques pour orienter les programmes et projets de développement afin d'améliorer durablement la capacité de production nécessaire tout en garantissant les biens et services demandés par le marché.

Mots clés: Analyse économique, races ovines, polymorphisme génomique privé, valeur économique, Maroc.

Introduction:

Climate change is considered as the greatest future threat of animal production (Pardo & del Prado, 2020). Livestock biodiversity is the most important safeguard against this threat, ensuring sustainability and resilience of production systems (Andriamparany & al., 2021). The most important threats to biodiversity are related to the marginalization of traditional production systems and associated local breeds, mainly due to the expansion of intensive livestock production, often on a large scale and using a limited number of breeds (FAO, 2015). At the global level, erosion of animal genetic resources is rapidly occurring and genetic diversity is decreasing (Pizzi & al., 2016). As a result, many countries are losing their genetic resources, essential for both food security and sustainable economic development (Houessou & al.,2020). As new sheep breeds are developed and disseminated across markets, farmers are encouraged to invest in the latest, productive and available animal genetic resources and consequently abandon breeds adapted to local conditions! Although these decisions may be economically rational in the short term, they may be catastrophic in the long term for some areas given the non-market value of locally adapted genetic resources as a potential stock of adaptive alleles that have been developed over several millennia. Thus, the economic assessment of genetic diversity indicators including inferences of the adaptive potential of local breeds seem to be crucial in this context of climate change and global erosion of biodiversity and pastoral/forage resources.

Generally, economic assessment can identify and assess biological diversity components for the purpose of its conservation and sustainable use. However, the non-market disturbs the economist who, in response, resorts to the monetarization principle whose perfectible character calls for a renewed evaluation process (Goode, 1974). For genetic resources, which have no market value, their economic evaluation can only be done indirectly. The value indicator used is induced wealth, ie the wealth created by economic activities dependent on the existence of

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genetic resources (Brundtland & al., 2012). This economist perspective offers the advantage of considering conservation activity as an economic value.

The economic valuation of genetic resources is tantamount to attribute value on what is and what is not traded on the market. For this, there are several methods to give value to non-market economic goods (Baker & Ruting, 2014). These valuation methods are used to estimate the gains or losses that the socio-economic community may experience as a result of changes in biodiversity to inform policy discussions and decisions (Leveque & Glachant, 1992).

Total Economic Value (TEV), a common approach to identifying different types of values, can be applied in the case of livestock genetic resources. Total economic value is a concept that allows us to determine all the values generated by goods and services, both market and non-market (Dupra & al., 2013). Hence, all values affected by individuals must be assessed when a change occurs in the genetic resources involved (Govindaraj & al., 2015). Thus, the main objective of this research is to assess the economic value of five dominant sheep breeds raised in Morocco while including market and other non-market values related to their genetic diversity.

Methodology

1. Sheep farming in Morocco

In Morocco, animal production sector plays an important role in the economic, social and nutritional spheres: it provides 38% of the turnover of agricultural sector, 60% of agricultural jobs and contribute to the country's food security (MAPMDREF, 2014). Furthermore, sheep farming in Morocco is characterized by a great diversity of breeds well adapted to their natural environment, the evaluation of which is essential for their conservation. These breeds are located in areas called "cradles of breeds" delimited by regulation.

The number of sheep increased from 17.4 million head in 2008 to 19 million head in 2017 according to the National Office of Sanitary Safety of Food Products (ONSSA) and the number of sheep farmers in Morocco amounts to nearly 800,000 breeders. This number decreases significantly in drought years and is quickly recovering in normal years because it is highly dependent on climatic conditions.

The sheep heritage is distributed in all the regions and provinces of the country, with varying proportions according to regions. There are five so-called "ovine vocation" zones which account for more than 3/4 of the total population, distributed as follows: 19% in the central zone

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(Chaouia-Rhamna-Abda), 17.2% in the Oriental (Oujda-Figuig-Taza-Jerrada), 18% in the Middle Atlas, 13% in the High Atlas, 10.5% in the Rif and 23.8% for the rest of the areas (Boulanouar & Benlekhal, 1994) (Figure 1).

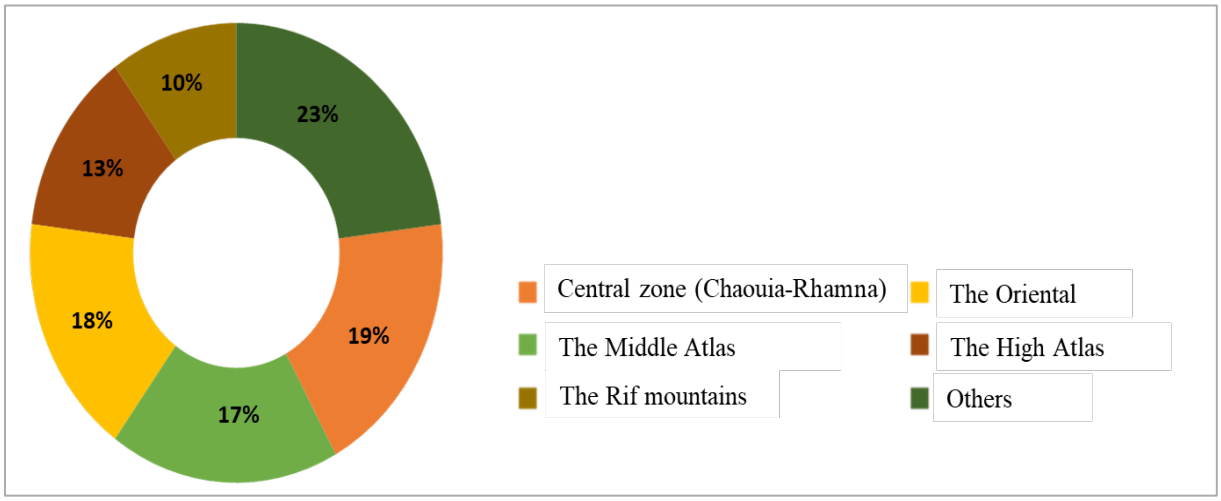

Figure 1: Geographical distribution of sheep population in Morocco

The sheep herd produces around 130,000 tonnes of meat a year, or 25% of the total red meat production (REF). It also supplies the country with sheep for the sacrifice of Eid Al Adha (about 4.5 million heads sacrificed) and raw materials for handicrafts and the textile industry: 17,000 tons of wool and about 24,000 tons of leather a year (MAPMDREF, 2020).

Among the main local breeds currently known and whose agropastoral location is well defined, we can mention five dominant breeds that are the subject of this research, including the "Sardi" at the level of plateaus and plains of the center, the race "Blessed -Guil "and" Oulad Jellal "in the Oriental region," Timahdite "in the Middle Atlas," Boujaâd "in the Khouribga region and" D'man "in the palm groves of Ouarzazate and Tafilalet.

In Morocco, there are several pastoral systems depending on the region, however the extensive system is the most dominant and faces a large variability of the food supply in terms of quantity and quality. In addition to the constraints linked to environmental factors variability, ia food demand is expressed by high animals nutritional needs not coinciding with the pastoral food supply (Bechchari, 2015). Thus, at periods of excess in food, there are periods of severe shortage or lack, which coincides with physiological stages demanding nutrients. All these

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constraints have given the livestock, a capacity of adaptation allowing it to survive thanks to an efficient management of his physical reserves.

2. Economic Analysis

In order to preserve genetic diversity of livestock, a socio-economic approach was adopted to compare the economic importance of indigenous animal breeds. In fact, the economic value must indeed take into account the influence of all the characters (Lionboui & al., 2021). However, some of these characters are difficult to quantify. In this study, genetic diversity indicators were used to evaluate the observed sheep breeds. These sheep breeds are among the most important in Morocco, namely: Dman, Sardi, Beni Guill, Oulad Jellal and Timahdite.

Indeed, two indicators of genetic diversity were used to evaluate each breed, namely the number of exclusive variants at the genome level and the effective population size. They were estimated at the level of each breed studied using the complete genome data of individuals (Benjelloun, 2015). The numbers of exclusive variants and the effective population sizes (Ne) were estimated at the level of each race studied using the complete genome data of individuals obtained under the EU FP7 project. The animals considered were sampled between 2008 and 2012 representing the maximum ecological and climatic diversity of the range of presence of each breed.

Exclusive variants were estimated from global genomic variants using the perl vcf-compare module of vcftools (Danecek & al., 2011). Current effective population sizes (Ne), which is the number of individuals in a population who contribute offspring to the next generation, were inferred through the PopsizeABC algorithm (Boitard & al., 2016).

For data on sales prices and production costs used, data collection was carried out in 2018 among farmers and organizations working in the sheep farming sector in Beni Mellal-khénifra, Sous Massa, Errachidia and the Eastern region of Morocco.

Subsequently, an analysis of the economic weights was performed in which the marginal profit of the breeds was evaluated. The economic importance of a character is expressed by the marginal profit resulting from the increase of one unit of the character above the average of the studied breeds (Mezgebe & al., 2019). The marginal profit was calculated using the difference between marginal revenue and marginal cost.

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Results and discussion

1. Genetic conservation indicators

The economic analysis aims to compare the economic value of major animal breeds. Two economic values were calculated. The financial market value of each breed in addition to another value related to private genomic polymorphism that contributes to the individual variations of each breed. The latter is illustrated by the number of private mutations in their genomes and used as a proxy for "adaptation value" in the context of environmental changes.

The advantage of this approach lies in the fact of combining both market values, such as cost or price, and non-market values such as genomic variation. Results showed that high levels of genomic diversity characterize all the studied breeds (Table 1).

Table 1: Exclusive variants and effective size of studied breeds

Sheep breed	Exclusive Variants	Effective Population Size (Ne)
Dman	1783651	30052
Sardi	1621728	28296
OuledDjellal	460461	26367
BeniGuil	341296	32223
Timahdite	934212	43781
Industrials	-	286

Genetic variants are unequally distributed among sheep breeds. These are distinguished by very characteristic allelic and haplotypic frequencies that can have a significant influence on the adaptive capacity of local breeds studied in this work. Thus, the exclusive variant numbers of the Dman and Sardi breeds, which are 1783651 and 1621728 respectively, far exceed those of other breeds. Similarly, the effective population size is one of the most important parameter in population genetics and conservation biology studied here. The result show that this parameter is very high for the studied breeds in comparison with “industrial” breeds. This is a major determinant of the high genetic diversity within studied sheep breeds.

2. The economic value of breed genetic traits

The profit calculation is based on an inventory of production costs and selling prices by breed. Costs include feeding costs, guarding, veterinary fees, and the value of lamb after weaning for each breed. Table 2 presents the average total cost estimates and the average selling price per breed reported per kilogram live weight.

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Table 2: Total cost and selling price by sheep breed

Sheep breed	Production cost (MAD/kg)	Selling price (MAD/kg)
Dman	31,8	38
Sardi	45,1	51
OuledDjellal	35,9	43
BeniGuil	34,7	41
Timahdite	34,1	40
Average	36,3	42,6

Marginal profit is calculated by the difference between marginal revenue and marginal costs of production inputs when selling each breed relative to other breeds observed (Table 3).

Table 3: Economic value according to calculation results

Sheep breed	Variation in marginal profit	Economic weighting according to genetic character (MAD/kg)		Economic value of genetic Character (MAD)	Economic value (MAD/Kg)
		Number of exclusive variants	Current effective size		
Dman	0,99	2,14	1,16	3,3	41,3
Sardi	0,93	1,72	0,96	2,7	53,7
Ouled Djellal	1,13	0,72	1,31	2,0	45,0
BeniGuil	1,00	0,42	1,27	1,7	42,7
Timahdite	0,94	1,01	1,52	2,5	42,5

Once the marginal profit was estimated, we inferred the economic value of genetic characters by multiplying the marginal profit and the weight of each character. The results show that the price of Dman breed will be affected by the greatest increase, despite the fact that this breed remains the least profitable on the market. This recorded increase was 3.3 MAD/kg considering that this breed has the most important number of exclusive variants and a very important effective population size. Then, Sardi breed with a recommended increase of its selling price of 2.7 MAD / kg. It is marked by a high genetic diversity uniqueness as Dman breed (Table 1) and also a very high economic profitability. Timahdit was third in term of its economic value with an increase value of its selling price of 2.5 MAD/kg, followed by Oulad Jellal and Beni Guill breeds with recommended increases of 2 and 1.7 MAD/kg respectively.

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Conclusion

Adaptive value indicates the adaptation of an individual to a given environment. It informs about the individual's fertility, its resistance to diseases and its tolerance to the main constraints of its environment. However, this adaptation remains a necessary but not sufficient condition to favor one breeds over another: it must also be the most productive in its environment. Thus, this research focused on comparing the economic value of five major sheep breeds in Morocco, namely Beni Guil, Ouled Jellal, Dman, Sardi and Timahdit. To calculate this value, we combined both market values, such as raising costs and selling prices, and non-market values such as the adaptive potential represented by two indicators, namely, the number of exclusive variants and the effective population size. The results showed differences in the economic value of adaptation between these breeds. The Dman breed, which is not enough supported by animal development projects, has been affected by the greater economic value of genetic diversity, followed successively by Sardi, Tmahdit, Oulad Jellal and BeniGuill. These results would provide guidelines for development programs and projects in the country to encourage sheep breeds that have significant economic values of adaptation in the current market context.

Conflict of interest

The authors declare no conflict of interest.

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