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Modeling of reproduction, growth and productivity performances of sheep farming in the semi-arid region of Algeria : *Case study of "Yehia Ben Aichouche farm"*

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I dedicate this work to my mother

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LIST OF ABREVIATIONS

ALB	Albumin
BBA	Bordj Bou Arreridj
BC	Body condition
BCS	Body condition score
BW	Birth weight
Ca	Calcium
CN AnGR	Commission nationale: animal genetic resources
d	difference
DM	Dry matter
F	Female
FAOSTAT	Food and Agriculture Organization of the United Nations
FSH	Folliculo-stimuling Hormone
g	gram
g/d	Gram per day
GGT	Gamma glutamyl-transférase
GH	Growth hormon
Glu	Glucose
GnRH	Gonadotrophines releasing Hormone
GREDAAL	Groupe de recherches et d'études pour le développement durable
h	hour
Ig G	Immunoglobulines G
K	Pottasium
Kg	Kilogram
kg/year/habitant	Kilogram per year par habitant
LBW	Lambs birth weight
LDH	Lactate dehydrogenase
LH	Luteinizing hormone
LSD	Least significant difference
LW	Live weight
m	meter
M	Male

MB	Maternal behaviour
min	minute
Mg	Magnesium
ng/mL	nanogram/milliliter
ng.mL-1	Nanogram/ mililitre -1
GLM	General Linear Model
Moy	Mean
µL	microliter
Nbre	Number
ONS	Office National of Statistics
P	Phosphorus
p	Threshold signification
PAL	Phosphatase alcaline
SE	Standard Error
SD	Standard deviation
SPSS	Statistical package for social science
TP	Total proteins
Trig	Triglycerides
IU	International Unit
IU/l	International Unit per liter
UNOTEC	Union Ovine Technique
X^2	Test Khi scare
%	Percentage
°C	Degree Celsius
° D	Dornic

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ملخص :

يعتبر التكيف مع الظروف الغذائية الصعبة في المناطق شبه الجافة من الجزائر ذوأهمية خاصة لتحسين أداء القطعان وإنتاجية المزارع الحيوانية. الأهداف من دراستنا هي : أولاً فهم و تقييم التباين في أداء التكاثر، النمو وأداء إنتاج الألبان لأغنام سلالة أولاد جلال ، ثم تحديد الأنماط العامة و نماذج للتباين في حالة جسم النعاج لفهم العلاقات بين الآليات الفسيولوجية لإدارة احتياطيات الجسم (EC) وأداء الحيوان. أجريت دراستنا في مزرعة "يحيى بن عيشوش" وضمت 696 نعجة و 737 حمل من سلالة أولاد جلال. تم تقييم أداء تكاثر النعاج ونمو الحملان حتى الفطام إضافة إلى نوعية اللبأ في كل حالة. تم قياس حالة احتياطيات الجسم (EC) أثناء التكاثر ، والحمل ، وفترات الرضاعة كما تم تحديد: الموسم ، العمر ، معدل إنجاب النعاج وكذا الجنس ، وزن الحملان عند الولادة ووضع الولادة كعوامل اختلاف. أتاحت نتائجنا تقدير أداء إنتاج الحيوانات وأظهرت أن حالة الجسم (EC) تؤثر بشكل كبيرعلى الخصوبة و القابلية للالقاح النعاج ونمو الحملان مع تحديد قيم العتبة (2.75 عند التناسل و 2.5 عند الولادة) لتحسين القدرات. تؤثر احتياطيات الجسم(EC) في وقت التناسل على الحالة البدنية للنعاج طوال دورة الإنتاج ، وبالتالي فهو مؤشر جيد لفهم آلية تعبئة الدهون لدى النعاج. أظهرت نتائجنا أيضًا وجود صلة بين الوزن الحي للنعاج و احتياطيات الجسم (EC)، تجعل من الممكن التنبؤ بوزن الحملان عند الولادة. أظهرت نتائجنا أن النماذج Gompertz و Logistique تمثل بشكل أفضل منحنيات النمو لأغنام أولاد جلال بينما تم استبعاد نماذج Verhulst و Mitcherlich و Monomolecular يمكن تحسين حيوية ونمو الحملان عن طريق استهلاك اللبأ ، وقد قيمت دراستنا الصفات البيوكيميائية والمناعية والفيزيوكيميائية لنعاج أولاد جلال. يحتوي لبأ غنم أولاد جلال على مستويات عالية من اللاكتوز والدهون والجلوبولين المناعي'G ' مقارنة بقائمة المراجع. تتأثر جودته بعمر النعاج ، و احتياطيات الجسم (EC) و الموسم. تؤثر جودة اللبأ بشكل كبير على نمو الحملان حتى عمر 30 يومًا ، ولكنها لا تؤثر على معدل الوفيات الذي يمكن تقليله وفقًا لنتائجنا ، عن طريق تناول الحملان اللبأ الأكثر ثراءً بعناصر الطاقة عوضا عن اللبأ الثري بالبروتينات . يتطلب تعزيز قطاع الأغنام في الجزائر حلولاً تتكيف مع أنظمة الإنتاج لدينا والتي تخضع بشكل متزايد لتأثيرات تغير المناخ . سيكون من الأفضل وضع مخطط اختيار وراثي للنعاج المرنة ذات القدرة على إدارة سلوك التغذية لمساعدتنا على تسييرا لإطعام بشكل ناجع من جهة، وضمان أفضل مستويات أداء و إنتاج مستدام من جهة أخرى.

الكلمات المفتاحية: التكيف ، أولاد جلال ، النعاج ، الحملان ، الأداء، التكاثر ،النمو، اللبأ ،احتياطات الجسم.

Résumé

L'adaptation des ovins aux conditions d'alimentation difficiles dans les régions semi-arides de l'Algérie revêt un intérêt particulier pour l'amélioration des performances des troupeaux et de la productivité des exploitations d'élevage. Les objectifs de notre étude sont: premièrement, de comprendre et d'évaluer la variabilité des performances de reproduction, de croissance et les performances laitières des ovins de race Oued Djellal, ensuite déterminer les schémas généraux et les modèles de variation de l'état corporel (EC) des brebis, pour enfin, comprendre les relations entre les mécanismes physiologiques de la gestion des réserves et les performances des animaux. Notre étude a été réalisée dans une ferme commerciale 'Yehia Ben Aichouche' en zone semi aride et a porté sur 696 brebis et 737 agneaux de race Ouled Djellal. Pour ces lots, les performances de reproduction des brebis et la croissance des agneaux jusqu'au sevrage ainsi que la qualité du colostrum ont été évaluées, l'EC a été mesuré pendant la reproduction, l'agnelage et la période de lactation. Nous avons déterminé: la saison, l'âge, la parité des brebis et le sexe, le poids à la naissance et le mode de naissance des agneaux comme facteurs de variation. Nos résultats ont permis d'estimer les performances de production des animaux et ont montré que l'EC agit significativement sur la fertilité et la fécondité des brebis et la croissance des agneaux avec la détermination de valeurs seuils (2.75 au moment de la lutte et 2.5 au moment de la mise bas) pour de meilleures performances. L'EC au moment de la lutte influence l'état d'embonpoint des brebis le long du cycle de production, et constitue donc un bon indicateur des mécanismes de la lipomobilisation des brebis. Nos résultats ont montré, également, une liaison entre le poids vif des mères et leurs EC, et qui permet de prédire le poids à la naissance des agneaux. Nos résultats obtenus ont indiqué que le modèle Gompertz et le modèle Logistique représentent mieux les courbes de croissance des agneaux Ouled Djellal alors que les modèles Verhulst, Mitcherlich et Monomoléculaire ont été exclus. La viabilité et la croissance des agneaux peuvent être améliorées en consommant du colostrum. Notre étude a évalué les qualités biochimiques, immunologiques et physico-chimiques du colostrum des brebis. Ce dernier présente des teneurs élevées en lactose, matière grasse et immunoglobuline G par rapport à la bibliographie. Sa qualité est affectée par l'âge des brebis leurs EC et la saison. La qualité du colostrum affecte significativement la croissance des agneaux jusqu'à 30 jours d'âge, mais n'influence pas le taux de mortalité qui peut être minimisé, selon nos résultats, par la consommation des agneaux d'un colostrum plus énergétique que protéique. Le renforcement de la filière ovine en Algérie nécessite des solutions adaptées à nos systèmes de production de plus en plus soumis aux effets des changements climatiques. Il serait judicieux de mettre un plan de sélection des brebis résilientes pour nous aider à mieux gérer la conduite alimentaire d'un côté, et à assurer de meilleures performances et des niveaux de production soutenus de l'autre.

Mots clés : Adaptation, Ouled Djellal, brebis, agneaux, performances, reproduction, croissance, colostrum, état corporel (EC).

Abstract

Adapting to the difficult feed conditions in semi-arid regions of Algeria has particular interest for improving animal performances and livestock breeding productivity. The objectives of our study are, first, to understand and assess the variability of reproduction, growth and dairy performances of Ouled Djellal sheep, then set up the general patterns and models of variation of ewes' body condition (BC), for finally, understand the relationship between physiological mechanisms of management of body reserves and animal performances. Our study was carried out in a commercial farm 'Yehia Ben Aichouche' in the semi-arid region, and involved 696 ewes and 737 lambs of Ouled Djellal sheep breeds. For these pens, the reproduction performances of the ewes and growth of lambs until weaning as well as colostrum quality were evaluated; (BC) was measured during reproduction, lambing, lactation periods. We determined: season, age, parity of ewes and sex, birth weight and little size of lambs as variation factors. Our results allowed us to estimate the animals' production performances and showed that the body condition (BC) affects significantly fertility and fecundity of ewes and growth of lambs with the determination of limit values (2.75 at breeding and 2.5 at lambing) for enhanced performances. Body condition (BC) at breeding influenced the nutritional status of ewes throughout the entire production cycle, and is therefore a good indicator of the lipomobilization mechanism of ewes. Achieved results also allowed us to find an association between ewes' live weight and theirs body condition score (BC), and makes possible to predict lambs' birth weight. Our results showed that Gompertz and Logistics models represented the best the growth curves of Ouled Djellal lambs, while the Verhulst, Mitcherlich and Monomolecular models were excluded. Viability and growth of lambs can be improved by consuming colostrum. Our study evaluated the biochemical, immunological and physicochemical qualities of Ouled Djellal ewes' colostrum, which had high levels of lactose, fat and immunoglobulin G compared to the bibliography. Its quality is affected by age of the ewes, theirs (BC) and season. The quality of colostrum significantly affected the growth of lambs up to 30 days of age, but didn't influenced the mortality rate which can be minimized, according to our results, by consuming of a more energetic colostrum than protein one. The strengthening of the sheep sector in Algeria requires adapted solutions to our production systems increasingly subject to climate changes effects. It would be preferable to set up a selecting program of resilient ewes to help us better manage feeding on one side and ensure the best performances and sustained production levels on the other.

Key words: Adaptation, Ouled Djellal, ewes, lambs, performance, reproduction, growth, colostrum, body condition (BC).

INTRODUCTION

INTRODUCTION

Sheep farming systems in the semi-arid cereal-growing regions of Algeria are 'low input' agropastoral systems. They are based on the valorization of cereal crop co-products and on spontaneous annual vegetation of natural pastures and rangelands; sheep farming, together with the farming of other ruminants, are the only ones able to valorize all of this type of resources, which are available on a rather large territory, constituting 9% of the total surface of the country **(FAO, 2015)**. Animal feeding in these systems is often poorly controlled, the amount of feed ingested is unknown and nutritional plans suffer from low resources **(Boudebza et al., 2016)**; this induces weight losses affecting the performance of the animals and, subsequently, their productivity and farm profitability. However, despite these difficulties, animals manage to maintain acceptable and fairly constant production levels by showing exceptional adaptive capacities and exceptional reserve management mechanisms **(Moula, 2018)**.

Adaptation to under nutrition in the case of our extensive livestock systems is of particular interest for the sustainability and development of production systems **(Blanc et al., 2006)**, so its improvement implies increasing the efficiency of feed use and understanding the management mechanisms of animals under environmental constraints. However, ration quality and feed intake are often unknown. As an alternative, there are several techniques that can be tools to measure the nutritional status of animals, such as the measurement of the body condition (BC) or body condition scoring (BCS); it is an indirect method of measuring reserves, reliable and highly responsive **(Abdel-Mageed, 2011)**, it is used to estimate the nutritional status of ewes **(Atti and Ben Hammouda, 2004**) and assess its change over time.

Several authors have shown that a good management of body reserves at different periods of the production cycle is a fundamental element for obtaining good performance (**Pryce et al., 2001**; **Oikonomou et al ., 2008**; **Ólafsdóttir., 2012**; **Dawod et al., 2014**; **Corner-Thomas et al., 2015**; **Stefańska et al., 2016**; **Stadnik et al., 2017**; **Widiyono et al., 2020**). More specifically, in sheep, the measurement of BC is commonly used (**Morel et al., 2016**) considering its effect: on the reproductive performance of ewes (**Al-Sabbagh et al., 1995; Kenyon et al., 2004a**; **Caldeira et al., 2007** and **Oldham et al., 2011**), on their dairy performances (**Banchero et al., 2006**), on birth weight of newborns **(Sezenler et al., 2011),** lamb growth (**Kenyon et al., 2004b**), on viability (**Steinheim et al., 2008**), and even on ram performance (**Oujagir et al., 2011**). Combining BC with weight gains, at the time of breeding

(**Staykova et al., 2013**) or at other periods of the production cycle (**Karakus and Atmaca, 2016**) allows for a better indication of the nutritional status of animals.

BCS is also an indicator for animal health according to **Berry et al. (2007)**; **Manzoor et al. (2018)** and allows for an assessment of the ability to cope with external stressors and survival in nutritionally restricted environments (**Ollion et al., 2016**).

In the context of the scarcity and variability of food resources as well as the difficult climatic conditions that characterize our sheep farming systems in semi-arid region, the modalities of accumulation of reserves and their mobilization in ewes are proving to be a determinant element of flock performance and productivity of livestock farms. The BC measurement tool would be recommended with the fundamental objective of establishing feeding strategies with practical recommendations based on limit scores related to each phase of the production cycle (**Gibon, 1981; Bocquier et al., 1988; Frutos, 1997 and Calavas et al., 1998**) to guarantee the sustainability of the production systems in question.

From this global context, our objectives are:

- To determine the global evolutions and the patterns of variation of the BC of Ouled Djellal sheep in the Algerian semi-arid region.

- To understand the mechanisms of its action on the reproductive, growth and dairy performances of animals.

- To study the sources of variability of the BCS of the animals.

Our intention is to initiate the production of knowledge on the characteristics of the most efficient BC management profiles of ewes in our current breeding systems. We seek to better understand the types of animals that best adapt to our difficult breeding conditions and also manage to produce acceptable performances to be able, later, to better valorize them through selection schemes that allow them to be integrated into the framework of more resilient production systems, adapted to the available resources and capable of improving the productivity of the breeding operations.

To meet these objectives, we had to set up long-term individual monitoring of animals, which was spread over the period of four production campaigns.

The content of our research presented in the following document consists of two main parts:

The first part, which concerns the bibliographical review, is made up of three chapters concerning respectively: the general context of the sheep sector in Algeria, the performances of reproduction and growth of the Ouled Djellal breed, as well as the dairy performances (colostrum) of the ewes. This part relates to the determination of the retained parameters, followed by a description of their variation factors and, finally, the effect of the climatic reheating on the ovine breeding, and to finish, to present the general problematic of this work

The second part reviews the results obtained and the discussion; it is organized in four chapters. The first one concerns the study of the birth weight of Ouled Djellal lambs and the influence of live weight and lipo-mobilization of their mothers. In this chapter, we sought to identify the relationships between weight and body condition of ewes and then examine the hypothesis that the relationship between ewe weight, lipo-mobilization and lamb birth weight can help us determine when technical control interventions should be located to improve growth performance.

The second chapter deals with the effect of body reserves mobilization on ewe breeding and lambs growth performances in the 'low input' system of the Algerian semi-arid region; this part aims at studying the factors affecting the mobilization of body reserves and their impact on production performances, in order to finally draw practical recommendations on the threshold scores to be respected at each phase of a production cycle in order to optimize the productivity of breeds.

The third chapter proposes a dynamic modeling approach that aims to present a method of calibration of the growth of Ouled Djellal lambs through the evaluation of some common growth models, proposing their validation by analyzing the results obtained in a commercial farm in a semi-arid zone.

The fourth chapter concerns the dairy performance of Ouled Djellal ewes, more precisely, the performance of colostrum, a product largely involved in the determination of the survival and growth of lambs. This chapter seeks to identify, for the first time, the biochemical, immunological and physico-chemical quality of colostrum of Ouled Djellal ewes; it has double objectives, first to study its variability according to some fixed factors, and second to study its effect on the growth and mortality of lambs. The development of this knowledge can be useful to improve the growth and minimize the mortality rates of lambs, with a better control of the productivity of the farms thereafter.

The work is finalized by a conclusion presenting a synthesis of all the results obtained and recommendations on the research and development plan.

REVIEW OF LITERATURE

Chapter1. Sheep production in Algeria

1.1. Current context of the sheep industry

Sheep in Algeria is the most responded livestock species, with a total of 28.4 million heads (**FAOSTAT, 2019**), endowed with a high genetic variability with nine identified native breeds (*Ouled-Djellal, D'man, Hamra, Rembi, Taâdmit, Sidaoun, Tazegzawt, Berber and Barbarine*) to which are added several other local populations that remain unknown (**Laoun *et al.*, 2015)**. This species shows a strong capacity to adapt to our harsh environmental conditions (**Gaouar, 2015**) based on resilience, prolificacy and high production potential (**Djaout *et al.*, 2017**). The main regions of sheep farming are: the steppe which hosts more than 80% of the sheep flock (**Yabrir *et al*., 2015**, **Habdaoui and Senoussi, 2016**) and the high cereal plains. Sheep is also installed in mountainous regions and even in oasis.

The "Ouled Djellal" is the most dominant sheep breed in Algeria, constituting 63% of the national flock according to **Boucif *et al*. (2007)**; **Lafri *et al*. (2014)**. The preference that farmers give to this breed is related to its conformation and its strong production performance (**Belabdi *et al*., 2019**), it has the reputation of being the most productive meat breed in Algeria (**Harkat *et al*., 2015**).

In addition to its socio-economic contribution and its ritual, cultural and religious place among the population, the most important role of sheep farming in Algeria remains its contribution to the development of food resources in poor and difficult areas to produce the meat most appreciated by consumers. Sheep is the major source of red meat, providing more than 50% of national production (**Kardjadj and Luka, 2016**), which represents 10 to 15% of the agricultural gross domestic product (**Moula, 2018**).

Sheep farms in Algeria are mostly extensive; the feed is based on pasture, fallow land and stubble with a supplementation often variable according to several parameters (region, flock size, orientation of the farm ...). According to **Chemmam *et al*** (**2009)**, the nutritional values of pastures are characterized by a great seasonal variation, linked in turn to the variability of the climate that characterizes the arid zone according to **Aidoud** (**1997)**, which affects the abundance and distribution of pastoral species.

1.2. Problems encountered by the sector

In Algeria, sheep farming is the first pillar of red meat production (**Mebirouk-Boudechiche *et al*., 2014**). However, the production does not meet the needs of the population in red meat and the authorities resort to imports to meet the needs of the market, especially in periods of high demand (Ramadhan and religious holidays). Algeria imports each year almost 40,000 tons of frozen meat (**Chikhi and Bencherif, 2016),** fresh meat, in addition to live animals mainly cattle **(ONS, 2014);** the imported frozen meat comes mainly from Brazil, India and Sudan. However, sheep meat remains an expensive food for about 70% of the population (**Chikhi and Benchrif, 2016**) with an average consumption of only 10.5 to 12 kg/year/inhabitant (**Alary and Boutonnet, 2006**).

The development of sheep production in Algeria does not find its full development, comparing it to the sheep sectors of neighboring countries and countries of the Mediterranean basin **(Zoubeidi *et al*., 2016).** This antithetical situation indicates that the sheep sector in Algeria is facing difficulties on several levels (health, genetic, logistical and organizational), according to **Moula (2018)**. The origin of the situation comes from a set of constraints including:

- Poor control of feeding and breeding practices due to the abundance of traditional livestock management.
- The close link between sheep production and climate: the dominant extensive management style is strongly linked to climatic conditions (rainfall), which affect sales prices and production costs and (periodically) influence investment decisions and management methods for feeding systems (**Alary and Boutonnet, 2006**).
- The instability of food and live animal prices (**Hadbaoui and Senoussi, 2016),** which undergo very remarkable variations with little intervention from the authorities.
- The lack of slaughter and meat marketing infrastructure (**Sadoud, 2017**)**.**
- The low level of supervision of the sector and the disengagement of the state, which gives more interest to the cattle-milk sector to the detriment of the sheep sector characterized by an inadequate professional organization (**Zoubeidi *et al.*, 2016**)**.**
- The structuring of the offer according to the socio-religious events, but also the emergence of the large surfaces with the development of a new type of retail sale (**Alary and Boutonnet, 2006**).

In spite of the multiplicity and the variability of the problems which led to the critical situation of the sheep sector in Algeria, we estimate that a deep work of analysis and diagnosis of this one is necessary.

In meat sheep farming, the profitability of livestock operations is essentially based on the efficiency of reproduction and the speed of growth of lambs, hence the interest of the following chapter.

Chapter2. Production performances of the Ouled Djellal breed and analysis of their variability

2.1. Reproductive performances

Reproduction is one of the main elements of productivity on sheep farms, and is assessed on three parameters. First, the ability of ewes to be pregnant and produce lambs, which is fertility, second the reproductive capacity of the ewes/flock or fecundity, and the ability to produce a high number of offspring, which is prolificacy.

The reproductive management of sheep flocks in Algeria is characterized by a no controlled breeding, an early age at breeding and a non-seasonal distribution of lambing (**Gani and Niar, 2020**) due to a continuous sexual activity almost throughout the year in Ouled Djellal ewes noted by **Niar *et al.*** (**2001**) in the West**, Benyounes and Lamarni** (**2013a**) in the North and **Adnane *et al.*** (**2018)** in the Center of the country. What is explained according to these authors by the low sensitivity of local breeds to photoperiod, they considered it as a useful ability for a better management of livestock. This is generalized even in very difficult climatic conditions according to the results of **Gani and Niar** (**2019**) who recorded in Ouled Djellal ewes raised in southern Algeria an ability to reproduce throughout the year.

Several studies have focused on the evaluation of reproductive performances and their variations in local sheep breeds, indicating an important potential of the latter. All studies agree that the Ouled Djellal breed has good reproductive performances in pastoral systems: **Dekhili** (**2002**) (fecundity 107% and prolificacy 108%), **Benyounes *et al.*** (**2013a**) (98.9% fertility, 102% fecundity, 108% prolificacy), **Gani and Niar** (**2020**) (91.69% fertility, 110.51% prolificacy and 14.35% mortality rate) and **Makhlouf et *al.*** (**2020)** (78% fertility, 92% fecundity and 117% prolificacy).

2.1.1. Factors affecting reproductive performances

Variability in reproductive performances can be caused by several factors.

A. The season

This is one of the factors that have the most impact, especially in the presence of extensive breeding conditions. Fertility is maximum during the breeding season and decreases during the short period of seasonal estrus (**Dekhili, 2010)**; the season also affects the fecundity rate (**Lamrani *et al*., 2008**; **Safsaf and Thlidjane, 2010)** and prolificity (**Beckers, 2003** and **Dekhilli, 2010**) in sheep. The best fecundity rates are obtained during spring breeding with a rate of 87% compared to autumn breeding 78.57% (**Belkasmi, 2012),** because in general, climatic changes affect the metabolism of animals (**Deghnouche *et al*., 2011)**, but also the food resources; **Skipor *et al*.** (**2012)** indicates that the concentrations of gonadotropic hormones (FSH, LH) are significantly higher during short days.

B. The physiological status

As well as seasonal anoestrus, postpartum anoestrus indicates the importance of considering the physiological state of the ewes for good reproductive performances. Postpartum anoestrus is due to the action of prolactin, which allows the maintenance of lactation and blocks the secretion of gonadal-pituitary hormones and thus the resumption of reproductive cycles (**Lucien *et al*., 2005)**, its intensity is closely related to the ewes' overweight status (**Benyounes *et al*., 2013a**).

C. The nutritional or body condition

The nutritional status or BC of ewes affects reproductive performances by influencing ovarian activity and the duration of seasonal anoestrus, which influences fertility (**Benyounes *and* Lamrani, 2013b**). As BCS at breeding increases, fertility and prolificacy improve according to **Taherti and Kaidi** (**2016**). The authors had shown that ewes with BCS at lambing greater or equal to 3 achieved fertility rates of 100% and prolificacy of 130%, compared to 76% and 100% respectively for those with BCS less than 3.

D. The race

Several authors (**Ricordeau *et al*., 1976**; **Rege *et al*., 2000**; **Gaskins *et al*., 2005**) have shown that breed has a significant effect on reproductive performances, with differences found between purebred and crossbred ewes.

E. The age of ewes

Theriez *et al* (**1971**); **Forrest and Bichard** (**1974**); **Fahmy** (**1990**); **Notter** (**2000**); **Zoukekang** (**2007**); **Gardner *et al*** (**2007**); **Webb *et al*** (**2010**); **Aliyari *et al*** (**2012**) have shown an improvement in reproductive performances with age to peak at 5-6 and at 7 years of age, and then decline beyond that.

Dekhili (2004) had shown the effect of age on the performances of the Ouled Djellal ewe, he explained that adult ewes take up the ovarian activity more easily than young ewes because of a better management of body conditions. **Belkasmi (2012**) indicated that in the Ouled Djellal breed, the fecundity rate increases progressively until the age of 4 years and then decreases slowly as the animals get older; a superiority was also recorded in multiparous (96.5%, 121%, 125%) compared to primiparous (86.6%, 85%, 100%) in relation to the rate of fertility, fecundity and prolificacy respectively.

2.2. Growth performances

2.2.1. Weight and average daily gain

Growth performances are usually established in observation devices or individual control protocols. Weights of animals are taken at different times (0, 10, 20 and 30 days, and then every month until weaning). The average daily gain (ADG) is calculated from the weight and indicates the average growth rate expressed in g/d for given periods. Growth performances allows, notably, the identification, control and optimization of herd performances, it allows, according to **Jean- Charles** (**2015**), to know the genetic values of the herds and to conduct selection programs thereafter.

The Ouled Djellal breed has very suitable performances according to **Zidane *et al*.** (**2015**). Several authors have contributed to study the growth performance of lambs in Algeria; the results, for the Ouled Djellal breed, are illustrated in the following table.

Table 1: Growth performance of male and female Ouled Djellal lambs from birth to weaning according to some authors (weight in kg ± standard deviation)

References	**Weight at birth (kg)**		**Weight at 30 days (kg)**		**Weight at 60 days (kg)**		**Weight at 90 days (kg)**	
	M	F	M	F	M	F	M	F
Bousbaa and Lachi (1992)	4.09	3.74	9.55	8.78	13.95	12.67	-	
Dekhili and Mahnane (2004)	3.73±0.73		9.70±0.77		13±0.45		17.80±0.42	
Daghnouche *et al* (2011)	4.19		6.04	8.44			18.30	
Bendiab and Dekhili (2012)	3.85	3.70	9.38	8.90	16.32	15.65	20.42	19.83
Belkasmi (2012)	3.68±0.98		8.24±1.72		12.76±3.71		16.91±4.69	
Boubekeur (2014)	2.72	2.63	7.6	6 .84	-	-	18.1	15.56
Chemmam *et al*.(2014)	4.6±0.83	4.4±0.8	11.01±2.4	10.31±1.9	-	-	20.5±4.8	18.6±3.4
Boussena *et al.(*2013)	4. 87±0.29		7.86±0.37		14.11±0.6		22.07±0.94	
Djellal *et al* (2015)	5.54±0.11		9.89±0.40		15.5±0.48		20.02±0.59	
Merghem *et al (*2018)	3.51		9.24		12.91		16.10	
Baa *et al* .(2020)	4.27	4.06	9.74	9.39	20.7	20.6	25.2	24.9

2.2.2. Lamb mortality rate

The mortality rate is considered as one of the determining factors of the productivity of flocks, it is equal to the number of dead lambs on the total number of born lambs. This rate must be less than 10% according to **Dudouet** (**2003**). For the Ouled Djellal breed it is 14.75% according to **Benyounes *et al*.** (**2013 b)** and 23.5% according to **Douh *et al*.** (**2019**)**.**

According to **Boubekeur et al (2019)**, mortality between birth and weaning was estimated at 10.3% with a high concentration of losses during the first 10 days of age. The effect of season was highlighted as mortality was significantly higher in summer (13.3%) compared to spring (9.4%), autumn (7.8%) and winter (8%).

2.2.3. Factors affecting lambs' growth

Several factors can cause variation in lambs' growth performances:

A. The season

The change of season creates variability in the availability and nutritional characteristics of pastures.

- ***Autumn lambing*** allows ewes to arrive in better condition at lambing despite losses during lactation. The period of reserve bill coincides with the high supply of pasture resources on spring pasture and grain harvest residues. Similarly, finishing lambs on grass can be beneficial for their growth after weaning.

- ***Spring lambing*** allows ewes to produce lambs with a higher weaning weight. However, the lambs are put to grass at the end of the grazing period, which can be restrictive for their growth (**Chemmam *et al*., 2009**).

Season significantly influences lambs' birth weight **(Boubekeur *et al*., 2019**). **Dekhili and Mahnane** (**2004)** noted that Ouled Djellal lambs born during the summer and autumn seasons are heavier than lambs born during other seasons. **Djellal *et al*.** (**2015)** added that lambs born in autumn tend to have higher birth weights than those born in spring**.** However, spring-born lambs show faster growth; this is due to the ability of Ouled Djellal' breed to compensate for stunted growth, if the animals are under favorable rearing conditions.

B. Body condition

The effect of ewes' BC on the growth performances of their lambs has been shown by **Aliyari *et al*.** (**2012**)**; Jalilain and Moeini** (**2013**). They report high birth weight of lambs from ewes with BCS equal to 3 at breeding period. According to **Zoukekang** (**2007**)**; Boudebza** (**2015**) ewes that are fatter in mid- and late-gestation give heavier lambs at birth.

Results of **Cholet** (**2017)** indicate that the leanest ewes had complications at parturition and gave birth to lambs that were significantly less heavy, less active at 5 minutes of life, and less independent at suckling. Very thin ewes at lambing produced significantly less milk than ewes in better condition.

C. The race

The breed influences the growth performances of lambs (**El Fadili, 2002**). In 2004 **El Fadili** shows, further, that the breed of the rams affects fattening performance and carcass characteristics and affects very significantly lambs growth up to 90 days of age. **Chikhi and**

Boujenane (**2005)** showed that the use of rams of pure breeds allows producing lambs with good quality of slaughter and improving sheep meat production.

These variations between breeds are mainly due to factors related to the genetic variability between them and the difference between the regions they occupy.

D. Age and parity

In Ouled Djellal breed, **Dekhili and Mahnane (2004)** showed the significant effect of age and parity of ewes on birth weight and weaning weight of lambs. According to the authors, lambs from adult and multiparous ewes are heavier (+0.8 kg and +3.2 kg respectively at birth and at weaning) than lambs from hogget and primiparous ewes. Similarly, **Karfel *et al*** (**2005)** found that birth weights at 30 days, 90 days and 135 days were influenced by the age; lambs from adult ewes are heavier than those from young ewes. According to **Chniter *et al.*** (**2014)** lambs born to 1-2 year old ewes had the poorest growth performances ($p<0.05$) compared to lambs born to older ewes (>2years), the best performances were observed in ewes aged of 6 years, after that a decrease was observed.

The low birth weight of lambs from young ewes is mainly due to the fact that the ewes are still growing during gestation and must share nutrients between their own needs and those of the fetus **(Inyangala *et al.*, 1992).**

E. Maternal behavior

According to the work of **Johnson and Everitt** (**2001)**, a massive release of hormones occurs in ewes at the end of gestation and during parturition, these hormones result in the establishment of maternal behavior (MB).

The MB develops from a mutual bond between mother and young under the influence of hormonal and peripheral somato-sensory stimulation (**Nowak and Poindron, 2016**) during late gestation and during distension of the cervix and vagina during parturition (**Xavier and Anthony, 2014**). However, the predominant sensory modalities vary between species. According to **Allouche *et al*.** (**2011)** the majority of Ouled Djellal ewes (75%) show a good or average MB overall, the risk of mortality related to maternal behavior is 4 times higher for lambs of primiparous females than for lambs of multiparous females (**Lecrivain and Ganeau, 1988**).

Madani *et al* (**2013)** also showed that MB has a significant effect on lamb mortality at 10 days ($p<0.05$), 30 days and weaning ($p<0.01$) and an increase in growth is observed at 10 days and 30 days in lambs from ewes with good and average MB compared to other lambs, the latter have less chance to suckle and a delayed ingestion of colostrum (**Xavier and Anthony, 2014),** which can sometimes be fatal.

F. Birth weight

This is an important parameter that has a considerable effect on subsequent lamb growth. Its variation is due to the genotype of the lamb, the quality of diet of the mothers in' late gestation or to the increase of prolificacy (**Khaldi, 1973**; **Villete and Thierez, 1981** and **Ben Kirane *et al.*, 1990**).

Several studies have evaluated the birth weights of Ouled Djellal lambs, (**Madani, 1987**; **Bousbaa and Lachi, 1992**; **Dekhili and Mahnane, 2004**; **Dehimi, 2005**; **Bendiab and Dekhili, 2012** and **Boussena *et al.*, 2013**), the average weight of lambs varies from 3 to 4.5 kg according to authors.

Heavy lambs at birth will have better growth, according to **Belaid** (**1986),** they have more strength and become less exhausted in search of suckling. These lambs have better weight and ADG development profiles compared to lean lambs at birth from birth to weaning (**Belkasmi, 2012**). **Dekhili (2003)** mentioned that birth weight has a highly significant effect ($p<0.001$) on weaning rate which increases proportionally with birth weight.

G. Litter size

Lamb growth varies considerably with litter size. Single born lambs have a higher birth weight compared to double born lambs, this difference is due to the competition phenomenon of doubles during fetal life and during the suckling period **(Fraysse and Guitard, 1992**). **Bendiab and Dekhili (2012)** reported that litter size has a significant effect on Ouled Djellal lambs' growth; single born lambs are heavier than doubles at different ages, the average weights of single lambs are 4.04 kg at birth, 10.02 kg at 30 days, 14.07 kg at 60 days, and 17.5 kg at 90 days, against, 3.5 kg at birth, 8.24 kg at 30 days, 11.7 kg at 60 days and 14.82 kg at 90 days for the doubles. According to **Merdef and Madani (2015**) single born lambs have a slight weight superiority (0.87 kg) compared to double born lambs; this is due to the compensatory growth effect. Ewes with multiple births produce more milk, but the surplus quantity is not sufficient to compensate for the increased needs. This lower growth rate of multiple lambs is reduced when the lambs approach 90 days of age, which is explained by compensatory growth during the post-weaning period (**Analla *et al.*, 1997**).

H. S ex

Lamb growth varies by sex (**Theriez *et al.*, 1991**), with the superiority of males over females explained by sex-linked genes, conformational differences (neck muscles, head bones, overall skeleton), and in particular the gradual advancement of the digestive organs of males (**Bendiab and Dekhili, 2012**).

The sex of newborns has a highly significant effect ($p<0.001$) on the recorded weights of Ouled Djellal lambs according to **Dekhili (2003). Boubekeur *et al* (2014)** had also noticed that males are heavier than females; they weigh on average 2.72 kg at birth, 7.6 kg at 30 days and 18.1 kg at 90 days, while females weigh respectively 2.63kg, 6.84 kg and 15.56 kg. For the ADG, the superiority was 27g between 10 and 30 days, 40g between 30 and 90 days and 190g in males compared to females.

2.3. Ewe's milk performance (Colostrum)

2.3.1. Definition and importance of colostrum

Colostrum is a thick, viscous, yellow, nutrient-rich fluid (**Uruakpa *et al.*, 2002**) on which newborns depend immediately after birth (**Ahmad *et al.*, 2000)**. Colostrum plays an important role in immunity, thermoregulation and stimulation of gastrointestinal tract function and development (**Davis and Drackley, 1998**; **Blum and Hammon, 2000**; **Rooke and Bland, 2002**; **Le Dividich *et al.*, 2005; Keskin *et al.*, 2007**). Some authors have even shown its influence on future lamb performance such as **Sawyer *et al.* (1977); McGuire *et al.* (1983); Bekele *et al.* (1992); Ahmad *et al.* (2000); Christley *et al.* (2003); Seo *et al.* (2018)**. In addition, colostrum has remarkable musculoskeletal repair and growth capabilities (**Uruakpa, 2002)**.

Colostrum is defined as milk produced within 36 hours postpartum by **Pakkanen and Aalto (1997)** or within 48 hours postpartum by **Playford *et al* (2000).** Extracted by suckling or milking, it must be provided in sufficient quantity and quality within the first few hours of life otherwise the newborn is at risk of failing passive immune transfer resulting in increased morbidity and mortality (**Jacques, 2012).** Inadequate intake affects the mortality rate even until weaning according to **Nuntapaitoon *et al.* (2020).** Because of this, several researchers have suggested standards to minimize these risks; for cattle, **McGuirk and Collins (2004)** recommended a minimum of 3 to 4 liters of colostrum consumption. **Chigerwe *et al* (2008)** added that a limit of 150g to 200g of IgG within 2 hours of birth is essential, but **Zwierzchowski *et al* (2020)** limited the minimum IgG level to 50g/l. For sheep, **Bentley (2018)** suggested that colostrum intake for lambs should be about 10% of their body weight.

Low colostrum intake results an insufficient level of immunity, which will increase susceptibility to digestive and respiratory tract infections according to **Donovan *et al.* (1998)**, and delayed colostrum feeding will result in lower plasma levels of total protein, globulin up to 30 days of age and growth factors up to 7 days of age (**Zanker, 2001**).

Mortality or poor growth causes significant economic losses to farms and significantly reduces profitability (**Raboisson *et al.*, 2016**).

2.3.2. Colostrum' composition

Colostrum is a very complex food, rich in nutrients (proteins, peptides, carbohydrates, lipids, vitamins and minerals) as well as many biologically active substances such as components with an immunological role (Leukocytes, Immunoglobulins A, D, E, G, M and Cytokines) growth factors (Growth Hormone GH, Insulin and Insulinlike Growth Factors IGF-I, Epidermalgrowth Factor EGF, Transforming Growth Factor TGF A, TGF B) and non-specific antimicrobial factors (Lysozyme, Lactoferrin and Lactoperoxidase) (**Foley and Otterby, 1978** ; **Lavoie *et al*., 1989**; **Kehoe *et al*., 2007**; **Główka *et al*., 2019)**.

Colostrum is essentially characterized by the rapid evolution of its composition, especially proteins, lipids, minerals and vitamins, which decrease in concentration over time and finally settle below the milk standards.

In general, **Kracmar *et al*. (2005)** found that colostrum contains large amounts of dry matter (DM). The DM level decreases from 20-25% to 18-20% during the first 24 hours (**Klobasa *et al*., 1987**) due to a drop in protein concentrations. However, this does not affect energy, which remains relatively constant on the first postpartum day (**Seerley *et al*., 1978**; **Coffey *et al.*, 1982**; **Noblet and Etienne, 1986**; **Migdal, 1991**; **Newcomb *et al.*, 1991**; **Le Dividich *et al.*, *1994b***).

A. Nutrients

1. Protein

The proteins in colostrum are mainly represented by immunoglobulins (45%), casein (34%) and albumin (6%) (**Foley and Otterby, 1978)**. This richness in proteins lowers the pH to 6.4 and gives colostrum a high buffering capacity (**Quigley *et al.*, 2000**)**.** Other proteins have been identified in colostrum, such as opioid peptides, which are believed to increase the bond between the newborn and the mother. Bombesin, which has a trophic effect on the intestine and stimulates gastrin secretion, and neurotensin, which also has a trophic effect on the intestine, are also found in colostrum. These proteins had a role in regulation of new born metabolism **(Maillard, 2006).**

According to the bibliography the protein content in colostrum is 6% to 20% (**Dubreuil *et al.*, 2005**; **Goran, 2010; Alves *et al.*, 2015; Kumar *et al.*, 2017; Kesseler *et al.*, 2019**). The large discrepancy is primarily related to the time of intake (**Le Dividich *et al.*, 1994a**). However, differences have been noted between races.

2. Fat

Fat provides the primary source of energy for the newborn. Fat concentration in colostrum is higher than that of milk according to **Kehoe *et al.*** (**2007**)**; Morrill *et al.*** (**2012)**. In sheep, several authors have determined the colostrum' fat content including **Alves *et al.*** (**2015**) (7.43%), **Ahmadi *et al.*** (**2016**) (8.21%), **Kumar *et al.*** (**2017**) (7.70% and 7.10% for Mapura and Marwari sheep breeds, respectively), and **Kesseler *et al.*** (**2019) (**7.44%, 6.93%, 6.47%, 8.05%, 4.04%, 4.74% 11.24%, 10.42% for Merino land, Valais black nose, grey horn moor, Swiss Charolais, Lacaune, Eastern Freissan milk, German black-headed sheep and Swiss Mortain black brown sheep breed respectively). The average triglyceride content is 0.50 g/l according to **Ndoutamia *and* Ganda** (**2005**). For cows **Abd El-fattah *et al* (2012)** had recorded a fat rate of 8.04% in Holstein which decreases to 3.9% after 5 days.

3. Carbohydrate

Carbohydrate is an important component of colostrum, primarily lactose **(Kehoe *et al.*, 2007).** It is the main component of colostrum and milk and plays an important role in thermoregulation **(Morell *et al.*, 1995)**. Lactose content in colostrum can serve as a good predictor of growth parameters in young according to **Szyndler-Nędza *et al.*** (**2020**)**.** Lactose content in ovine colostrum was found to be 2.7% according to **Mangin** (**2002**)**,** 4.11% according to **Alves *et al.*** (**2015)**, 3.23% according to **Ahmadi *et al.*** (**2016**)**,** 2% according to **Zarei *et al.*** (**2017)**, 4.30% according to **Kumar *et al.*** (**2017)**, and 2.79% according to **Belanche *et al.*** (**2019)** and this was found in 24-hour colostrum. A lower concentration was noticed in cattle and goats (**Kesseler *et al.*, 2019)**.

Concerning glucose, its dosage is less common than lactose; its concentration according to **Brugère *et al.*** (**2002**) has been estimated at 0.42 - 0.76 g/l.

B. Vitamins, minerals and oligo elements

In colostrum, vitamin levels, including β-carotene and fat-soluble vitamins (A, D, and E) are five to ten times higher than in milk (**Kincaid and Cronrath, 1992**). Work by **Foley and Otterby** (**1978)** and **Kehoe and colleagues** (**2007)** report high concentrations of some vitamins in colostrum, such as thiamine, riboflavin, and niacin as well as folic acid, and cyanocobalamin.

Minerals are divided into major elements (calcium, phosphorus, potassium, sodium, magnesium and sulfur) and oligo-elements, such as zinc, manganese, copper, selenium, cobalt and iodine. In colostrum, minerals are two to five times more concentrated than in milk (**Mathieu, 1985)**.

According to **Kráčmar** ***et al*****. (2005)** colostral concentrations of magnesium (Mg), calcium (Ca), and phosphorus (P) increase after parturition and then gradually decrease afterwards (**Goran** ***et al.*****, 2010**).

C. Components with immunological role

1. Immunoglobulins (Ig)

IgG represents the major part of colostral proteins and confers to neonates not only local immunity against gastrointestinal pathogens (**Serieys, 1993; Contrepois, 1996**) but also systemic immunity against septicemic and infectious agents **(Gartioux, 2003**). The IgG level represents 90% of colostral immunoglobulins (**Levieux, 1984**) but after 72 hours IgG decreases at the expense of IgA (**Klobasa** ***et al.*****, 1987**). Ovine colostrum is richer in IgG compared to bovine and goats' colostrum (**Caja** ***et al*****., 2006; Furman-Frątczak** ***et al*****., 2011; Zwierzchowski, 2020**), in addition, its concentration is known to vary even between sheep breeds (**Dwyer and Morgan, 2006; Alves** ***et al.*****, 2015; Hernandez- Castellano** ***et al*****., 2016),** they are between 40 and 120g/l according to **Al Sabagh** ***et al*****. (1995); Tabatabaei** ***et al. (*****2013); Alves** ***et al.*** **(2015); Kessler** ***et al.*** **(2019**).

2. Cells

Colostrum contains many living cells, mainly leukocytes including macrophages (40% to 50%), B and T lymphocytes (23%), neutrophils (38%) (**Reber** ***et al.*** **, 2008; Maillard and Guin, 2013**) and secretory epithelial cells. The role of colostral living cells in the immune defense of the newborn would likely be passive (**Rainard and Riollet, 2006**).

D. Other components of colostrum

1. Enzymes

Colostrum is more concentrated in enzymes than milk. The high concentrations of enzymes in colostrum may be related to higher liver activity in the face of high metabolic demands (**Hoedemaker** ***et al.*****, 2004**) of parturition and early lactation.

2. Hormones and cytokines

Colostrum is rich in prolactin (152 ng.mL-1), progesterone (2.6 ng.mL-1) and estrogens, cortisol (4.4 ng.mL-1) and thyroxine. It also contains insulin (4.02-34.4 ng.mL-1) and insulinlike growth factors (IGF-I: 100-2000 ng.mL-1), in concentrations 100 times higher than in serum (**Levieux, 1999; Gauthier *et al.*, 2006**). Other cytokines have been identified (e.g. Transforming Growth Factor: TGF: TGF A= 10-50 ng.mL-1 ; TGF B= 150-1150 ng.mL-1) (**Serieys *et al*., 1993 ; Maillard, 2006 ; Gauthier *et al.*, 2006**).

2.3.3. Factors of variation in colostrum quality

In ruminants, colostrum composition changes quite rapidly over time. The quality of colostrum is influenced by several factors such as the volume of colostrum produced, breed/species, age of the mother, number of parities, health status, weight and sex of the newborn, mode of birth, season...etc.

A number of factors that may affect colostrum quality have been identified and classified into intrinsic and extrinsic factors.

2.3.3.1. Intrinsic factors

A. Species and race

A large variability in colostrum composition between species has been found (**Hadji Panayiotou, 1995).** Ewe colostrum contains more total solids, crude protein, fat, and lactose than that of goat colostrum (**Keskin *et al.*, 2007). Ahmadi *et al*.** (**2016**) found different total lipid contents between sheep, cattle and goat colostrum, the highest content was found in ewes, less in cows, and the lowest content in goats. However, **Abdou *et al.*** (**2012)** found that cow colostrum is less rich in nutrients (lipid and lactose) than that of sow, ewe, and goat.

Kesseler (**2019)** showed the differences between the compositions in (fat, lactose, protein, IgG) between ovine and caprine colostrums marking the superiority of ovine colostrum quality. **Silim *et al*** (**1990**) linked these differences to the placental structure consisting of several layers, the number of which differs between species.

Differences in colostrum quality are found within the same species showing the important effect of breed on colostrum quality. Immunological quality differs between cattle breeds: 65.5g/l in Polish 'Holstein-Friesian' (**Furman-Frątczak *et al*., 2011)**, 35.8 g/l in 'prim' Holstein' (**Zarei *et al.*, 2017)** and 77.2 g/l in 'Swiss Holstein' (**Zwierzchowski *et al.*, 2020**).

According to **Gulliksen *et al*.** (**2008**); **Zhang *et al*. (2009**) **and Kumar *et al*.** (**2017**)**,** breed significantly affects the chemical and immunological composition of ovine colostrum. **Gilbert et *al*. (1988)** found a large influence of breed on the immunological quality of colostrum for 6 sheep breeds with IgG levels of 80, 64, 67, 72, and 69 g/l for Polypay, Rambouillet, Targhee, Columbia, Finnish Landrace, and Finn Crosses respectively.

The quality of colostrum also changes depending on the breed; **Patisson and Thomas** (**2004**) noted that lambs born to beef breeds may be at greater risk of hypothermia and infectious diseases than lambs born to dairy breeds, similarly in cattle**.** According to **Maillard** (**2006**) this appears to be related to the higher colostrum production in dairy breeds compared to suckler breeds**.** However, **Tyler *et al*** (**1990)** showed different colostrum qualities between dairy breeds.

Finally, rams are also a significant source of variation in colostrum, for colostral IgG concentrations. The heritability of total IgG mass produced by ewes is estimated to be 0.45 (**Halliday *et al*., 1978)**.

B. Age and parity of mothers

Age/parity affects colostrum in terms of quality and quantity. According to **Logan** (**1978)**, age had a significant influence on colostrum production. He found that heifers produced less colostrum than cows. **Levieux** (**1984)** added that primiparous cows produce 30% less colostrum than multiparous cows.

Colostrum quality in cattle improves with the number of parities according to **Turini *et al*.** (**2020**)**,** multiparous cows have better IgG concentrations than primiparous ones **(Kessler *et al*., 2020)**. In contrast, in ewes, **Gilbert *et al*. (1988)** showed that age affects colostrum quality, but higher concentrations were found in primiparous cows. The same was true for **Beyer *et al*** (**2007)** for the effect of parity on colostrum quality.

In studying the variability of colostrum quality with age, several authors have focused on immunological quality. **Halliday et al (1978)** had found that young (1 year old) and old (>6 years old) ewes produced significantly less colostral IgG than ewes aged 2-5 years, same for **Tabatabaei et *al (*2013), Higaki et *al (*2013); Chniter et *al (*2016); Torres-Rovira et *al (*2017)** who found a significant effect of age/parity on the immunological quality of colostrum. However, primiparous females showed the highest IgG values for Bakhtiyari, Lacaune, Awassi and D'man ewes respectively.

Higaki *et al*. (2013) had explained that the higher colostral IgG concentration in colostrum of primiparous ewes (Awassi) could be due to the production of lower colostrum volume. However **Vilette *et al*** (**1981)**, who had shown the independence between the immunological quality of colostrum and the age of the ewes, had added that the colostral IgG concentration decreases faster in the 12 hours postpartum in older ewes.

In relation to the other constituents of colostrum, **Zarei *et al*. (2017)**, observed the decrease of mineral concentrations with the increase of the number of parities. **Pesántez-Pacheco (2019)** had noted a decrease in glucose concentration in Lacaune sheep with age. For enzymes, **Belkasmi *et al*. (2019),** found that the highest levels of LDH and GGT were observed in ewes less than two years and more than six years of age, in contrast PAL content decreased with age. However, **Alves *et al*. (2015); Karakus and Atmac (2016)** found no effect of age on sheep and goat colostrum quality respectively. According to **Craig *et al*. (2019)** age also does not affect the change in colostrum quality of IgG, total protein, lactose, fat and net energy during lactation. However, their concentrations in colostrum decrease early in primiparous (after the first week) compared to multiparous (third week).

C. Body condition of the ewes

In pastoral livestock systems, feeding becomes a limiting factor of productivity, especially around parturition, and the nutritional status of the animals has a significant effect on colostrum production (**Bocquier and Caja, 2001; Devillers *et al.*, 2005**).

Underfeeding, according to **Mellor (1987)**; **Mahan (1990)** and **Vonnahme and Lemley. (2011)**, can alter udder development and therefore dairy performances. According to **Swanson *et al*. (2008)**, colostrum weight and volume are decreased in underfed (60%) or overfed (140%) ewes compared to ewes fed 100% of their requirements. Furthermore, **Aktas *et al* (2011)** noted that cows with a BCS of 2.81 ± 0.05 are less likely to develop metabolic disorders such as hypoglycemia, hypocalcemia and ketosis in the postpartum period than cows with a BCS of 2.29 ± 0.04.

According to **Banchero *et al* (2006),** underfed ewes during the last third of gestation accumulate less colostral IgG (168 ± 48 g/l) than properly fed ewes (451 ± 103g/l). However, for **Mellor (1987),** diet shows no effect on colostrum quantity, they add that correct re-feeding of ewes during the last 5 days of gestation restores mammary functions to the same level as for well-fed ewes throughout gestation. **Al Sabbagh *et al* (1995)** also noted no effect of ewes' BC at lambing on the concentration of IgG in colostrum.

Colostrum quality (total protein, albumin, lipids and enzymes) is affected by the nutritional status of the animal. For **Vihan and Rai (1983); Weaver *et al*. (2000); Lamraoui *et al*.**

(**2016**) **and Belkasmi *et al.*** (**2019**)**,** colostrum quality is better in lean compared to fat, the opposite results were observed by **Pires *et al.*** (**2013**)**.**

Busato *et al* (2002) noted that the higher is the BCS the better is the metabolite status. BCS had an impact on serum levels of glucose **(Đuričić *et al.*, 2017**), triglycerides, cholesterol, and low- density lipoprotein (LDL) (**Mouffok *et al.*, 2011; Jalilian *et al.*, 2013; Đuričić *et al.*, 2017** and **Pesántez-Pacheco *et al.*, 2019**). The increase in triglycerides, cholesterol and LDL in lean ewes is an indicator of high mobilization of body reserves (**Chillard *et al.*, 1998**). This confirms the better quality of colostrum in lean compared to fat.

D. Sanitary statue of ewes

Poor maternal health affects the quantity and quality of colostrum produced **(Stephan *et al.*, 1990, Veissier *et al.*, 1999)**. In case of mastitis, females produce significantly less colostrum **(Christley *et al.*, 2003)** and less IgG (**Dardillat *et al.*, 1978)**. **Zhao and Lacasse** (**2008**) showed that poor colostrum secretion in quantity and quality is a result of poor health conditions in the prepartum period.

E. Birth weight of lambs

Birth weight is the first parameter to be assessed in newborns, as it has great importance in evaluating growth performance and survival of lambs (**Hatcher *et al.*, 2009, Ptáˇcek *et al.*, 2017**). **Conneely *et al.*** (**2013**) reported higher colostrum yields as a function of newborn weight, also lambs that are too light have reduced growth performance and poor survival ability due to, according to **Theriez** (**1991**)**,** their high susceptibility to infections and low ingestion levels (**Cabello and Levieux, 1981**). On the other hand, **Morris *et al*** (**2000)** pointed out a negative influence of too high birth weight.

Birth weight had no detectable effect on colostral IgG according to **Cabrera *et al.*** (**2012)**, **Kassler *et al.*** (**2020**). Whereas **Campion *et al.*** (**2019**) found that colostrum volume and IgG yield in the first 18 hours postpartum were influenced by lamb birth weight.

The relationship between birth weight and colostrum intake was explained by **Ferrari *et al.*** (**2014)**, who showed that light piglets depended more on colostrum than heavy piglets, they consumed more to ensure the same performance as heavy ones.

F. Sex

For **Muggli *et al.* (1984) and Perino *et al.* (1995),** sex is not a significant source of variation in serum IgG concentration; but **Odde (1988)** found significantly higher serum IgG levels in female calves than in male calves and no significant difference in serum IgM levels between the two sexes. Similarly in sheep, male lambs have a poorer 24-hour survival rate (**Maxa *et al.*, 2009).**

G. Litter size

Litter size is also a significant factor of variation on colostrum produced. **Mellor *et al.* (1986); Gallo and Davies (1987)** reported the effect of litter size on the amount of colostrum produced; ewes giving birth to multiples produced a greater volume of colostrum than ewes giving birth to singles. **Gilbert *et al* (1988); Al Sabagh *et al* (1995); Higaki *et al* (2013); Kessler (2019)** observed the increase in IgG levels with litter size, thus colostrum quality increases with litter size. However, no significant difference in colostrum volume was observed between double and triple litters (**Shubber *et al.*, 1979; Villette and Levieux, 1981; Thomas *et al.*, 1988**). However, the number of parturition had no effect on colostral IgG concentration in ewes according to **Romero *et al.* (2013) and Alves *et al.* (2015).**

2.3.3.1. Extrinsic factors

H. Time of colostrum intake

The quality of colostrum changes considerably with time, at 72 hours the milk contains only 5% to 10% colostrum and 1% to 2% at day 7 **(Levieux, 1999)**. Drinking rapidity the colostrum after parturition is essential to guarantee the necessary elements for the newborns. IgG concentration decreases very rapidly after parturition, to very low values reached between 24 and 72 hours postpartum **(Górová *et al.*, 2011)**. Furthermore, IgG uptake by the newborn is maximal in the first 6 hours of life, and then decreases very quickly to almost zero after 36 hours of delivery (**Staley and Bush, 1985; Besser, 1993**).

I. The season

Climate has a direct effect on animal performance **West (2003)** including milk performance. **Kruse (1970)** (for cattle) and **Ruiz *et al.* (2015)** (for goats) observed a non-significant effect of season on colostrum quantity, concentration and total Ig mass produced. On the other hand**,** **Morin *et al* (2001)** had observed in cows a significant influence of month of birth on colostrum density; in **2010 Morin *et al*** had added that photoperiod has no effect on colostral IgG concentration and volume of colostrum produced.

It was found that the lower contents of total protein, albumin, fat, lactose (**Nardone *et al.*, 1997**) and IgG (**Zarei *et al.*, 2017)** in bovine colostrum were recorded in summer despite the low seasonality of cattle.

For sheep, **Torres-Rovira *et al.* (2017)** had noticed that lambing season did not have a significant effect on colostrum quality of dairy ewes. The intensive management of the flocks is probably the explanation for these results.

2.3.4. Effect of colostrum on growth performance

The first hours of postnatal life are the most critical moments for newborns (**Quesnel *et al.*, 2012**). Colostrum allows, because of its richness in energy, immunoglobulins, growth factors...etc, to ensure the functioning of the gastrointestinal tract, the reinforcement of the immune system and thermoregulation (**Serieys, 1993; Buhler*et al.*, 1998; Blum and Hammon, 2000; Xu *et al.*, 2002; Le Dividich *et al.*, 2005**) which leads to a good start of growth and a better viability

A. Effect of colostrum quality on growth (weight and ADG)

Morell *et al* (1995) and Blum *et al* (1997) have indicated that inadequate colostrum intake may contribute to higher incidences of newborns, particularly infectious diseases.

Mirand *et al* (1990) state that adequate colostrum intake stimulates intestinal activity for better retention of the energetic, protein and immunological composites of colostrum**.** According to **Morell *et al* (1995),** lipids and lactose in colostrum help maintain the body temperature of neonates during their first days of life. Otherwise, a high quality of IgG can be useful against various diseases that can partially reduce mortality**.**

Berge *et al* (2009) showed a positive correlation between colostrum intake and growth. As colostrum intake increased, weight increased with a long-term effect until weaning ($P<0.001$). Colostrum quality can be used as a marker of growth of animals (**Szyndler-Nędza *et al.*, 2020**).

B. Effect of colostrum quality on mortality rate

The first hours after birth are the most critical moments in the life of newborns (**Quesnel *et al.*, 2012**); their survivals depend on the amount of colostrum absorbed and its quality. A negative correlation (at $P <0.001$) was found between colostrum consumption and mortality by **Declerck (2016).**

Colostrum intake is important for the survival of newborns (**Ferrari *et al.*, 2014)**. Good IgG levels are necessary to resist common diseases, **Arsenopoulos *et al.* (2017)** had shown that colostrum limits the development of *Cryptosporidium spp*; a pathogen that cause neonatal diarrhea in calves. **Tabatabaei *et al.* (2013)**, had also found that mortality rate was lower in lambs born to ewes with higher IgG levels in their colostrum

Berge ***et al*** (**2009**) found no effect of colostrum on mortality rates, however, they did noticed that diarrhea in calves was associated with low serum IgG levels. Colostrum supplementation according to the same author can reduce diarrheal disease and the amount of antimicrobial treatment required.

Both colostrum intake and birth weight are essential for survival and growth.

Chapter3: Sheep production and climate change

3.1 General information

All developing countries depend on rainfall and natural factors in agriculture (**Tubiello, 2012**). Sheep production systems practiced in Algeria are globally extensive and their level of productivity is low compared to intensive systems (**Ameur *et al.*, 2020**).

Added to its conditions is global warming; a global phenomenon that leads to droughts, floods and depletion of natural resources (**Sejian, 2011**). According to **Feleke *et al.*** (**2016**) food scarcity, heat stress, and lack of water and rangeland lead to significant economic losses in crops and livestock, making climate one of the main factors limiting production efficiency.

3.2 Effects of global warming on livestock

The effects of global warming on livestock production are most closely related to changes in temperature and precipitation (**Hanson *et al.*, 1993).** Agro-ecosystems are becoming hotter and drier and the dry period has been steadily increasing over the past decades (**Solymosi *et al.*, 2010).** The greatest victims of these conditions would therefore be ruminants, given their dependence on pasture.

Temperature increase is one of the major effects of global warming; it seems to have the most impact on the production and reproductive potential of livestock and is one of the main recent concerns of researchers such as **Fournel *et al*.** (**2017**) who had found its non-negligible effect. According to their results, the increase in temperature reduces the performance of animals and increases morbidity and mortality rates. This is due according to **Allen *et al*** (**2013**)**; Habeeb *et al*** (**2018**) to its effect on food intake, hormonal concentration (cortisol, thyroid gland activity), body temperature and physiological thermoregulation (sweating, panting), maintenance requirements, reproductive efficiency and metabolic processes, animal behavior and finally on disease incidences. On the other hand, the lack of water/rainfall and rangeland causes nutritional deficiencies and can exacerbate the impact of high temperatures on the animals.

Climate change affects the reproductive performance of animals; it decreases fetal growth (**Collier *et al*., 1982**) and alters follicular dynamics (**Wolfenson *et al*., 1995**) and consequently reduced conception rates **(Morton, 2007)** and even causes abortions (**Vasconcelos *et al.*, 1997**).

Global warming, mainly heat stress, significantly affects animal growth, wool and meat production (**Janicot *et al.*, 2015)** due to decreased feed intake and milk yield of dams, hyperthermia also affects animal weight (**Padodara and Jacob, 2013)** and weakens digestibility due to plant lignification. In conclusion, climate change results in low herd productivity (**Gernand *et al.*, 2019).** In addition, climate change leads to several vector-borne diseases in sheep by compromising the immune status of the animals.

Cattle are more sensitive to climate change and water stress compared to sheep and goats (**Silanikove, 2000)**. Sheep have excellent insulating ability (**Degen and Shkolnik, 1978**) and the ability to maintain their appetite during harsh conditions (**Silanikove, 1992**).

3.3. Strategies for adapting to climate change

The fragility of sheep production systems in the face of negative environmental impacts poses a major challenge for the development of the sector. Several researchers around the world have proposed strategies for adapting to climate change, including

- The provision of a shaded shelter, is suggested by **Silanikove** (**2000**),
- Detection of heat events in pasture with sensors on animals (**Shahriar *et al.*, 2016)**,
- An application of environmental control through controlled stall systems with the goal of providing an appropriate microclimate for optimal production (**Fournel *et al.*, 2017**),
- The development of thermo-tolerant breeds using biomarkers, and nutritional interventions to help the animal maintain production under adverse environmental conditions (**Sejian, 2017**).

With the extensive farming conditions that characterize our farms, and the low use of inputs, knowledge of the management of animal body reserves and their effect on the ability to adapt seems to be the ultimate strategy in the face of change. This is increasingly the essential lever for controlling and improving the productivity of livestock farms and the efficiency of production.

3.4. Possible solutions to the constraints of the sector

- Monitoring of body condition to select the most suitable animals
- Ewes can be selected and bred for body weight change to be more tolerant of uncertain feed supply
- Selection should be made for high production under anticipated climate change scenarios

The strong dependence of sheep on natural resources and rain-fed agriculture places them in the front line of climatic risks. The effect of the season on the Algerian semi-arid region adds an alternation of periods of food abundance and deficiency during the year, which leads the animal to build up body reserves in favorable periods (spring and early summer) to mobilize them in periods of scarcity (late summer, autumn and winter). In this context, the knowledge of the modalities of variability in the management of body reserves shows its importance.

Animals, in the face of harsh conditions, activate several adaptive mechanisms to maintain homeostasis through a range of behavioral, physiological (**MohanKumar *et al*., 2012**), neuroendocrine, cellular, and molecular responses (**Asarian *et al*., 2012; Tsigos *et al*., 2016**). Body reserve management is also linked to genetic factors (homeotic genes) (**Smith and McNamara, 1990**). The total amount of fat and its distribution within the body differs by breed according to **Ronchi and Nardone. (2003**); **Nürnberg *et al***. (**1998**).

The solution following harsh environmental conditions according to **Borg *et al***. (**2009**)**, Rauw *et al***. (**2010**); **Rosé *et al.*** (**2013**); **Macé *et al.*** (**2019a**) is to raise animals that are more resilient to feed variations with better abilities to manage their body reserves between periods of poor and good nutrients.

The results of **Fogarty *et al*. (2009)** suggest that the feed requirements of ewes could be reduced by selection. While maintaining good productivity levels **Hayes *et al.* (2009)**. **Rose *et al***. (**2013)** revealed that body reserve gain and loss are two genetically distinct traits and that loss is less heritable than reserve gain.

The evaluation of the capacity of females to mobilize and reconstitute their reserves is done by evaluating the BCS of these animals at different periods of the production cycle (**Dedieux *et al*., 1989)** according to the **Russel *et al***. scale (**1969**)**.** Its use will allow adjusting the nutritional status of the animals at key moments (reproduction, milk production, lamb survival and productivity) for optimal productivity.

3.5. Importance and reliability

There are several reasons for the high consideration of reserve mobilization in the study of sheep performance in low-input systems

Martin-Rosset (**2008**) indicates that the practice of BC makes it possible to adjust individual and herd feeding, particularly during key periods of the production cycle. The evaluation of BCS is a reliable, easy to use and inexpensive practice for the evaluation of an animal's energy and fat reserves, and it is particularly well adapted to the conditions of farm work (**Dedieux *et al.*, 1989).**

Compared to other methods, BCS is as credible as urea diffusion space and deuterated water, allowing for a very comparable estimation of body lipid **Schmidely *et al*. (1995).** It thus provides results consistent with the results of lumbar ultrasound, and morphometry (**Cellard, 2018).**

BCS is often associated with weighing **(Cam *et al.*, 2010; Aliyari *et al.*, 2012)**, they are the most commonly used methods to assess the feeding behavior of a herd **(Smaali and Boukazoula, 2019)**

3.6. Body condition monitoring for better sheep performance

According to **Bauman and Currie** (**1980**) changes in body reserves during a production cycle are characterized by a strong accumulation during the breeding period and gestation followed by a strong mobilization at lambing and at lactation. This is the origin of the energy deficit at the very beginning of lactation (**Froment, 2007**).

BC has a double effect on performance: a static effect at key moments of the production cycle and a dynamic effect resulting from the evolution of the nutritional status of the animals. Several studies have shown the importance of BC intake for better reproductive and growth performances:

3.6.1. Reproduction

Improving reproductive performances is the most effective way to optimize ewe productivity. BC affects reproductive efficiency in ewes according to **Suriyasathaporn *et al*.** (**1998**); **Madani *et al.*** (**2009**); **Aktaş *et al*. (2015)**. Fertility and prolificacy are sensitive to variations in feed availability before and after breeding **(Boukhliq, 2002; Dudouet, 2003; Scaramuzzi *et al*., 2006).** The better is the BC the better it improves reproductive performances (**Chaturverdi *et al.*, 2006; Vatankhan *et al.*, 2012**).

In the Ouled Djellal breed, **Abbas *et al*.** (**2004**) had shown a constraining effect of low BC scores of ewes on fertility and prolificacy rates. The link between the body conditions of ewes at the time of breeding and their reproductive performances was highlighted by **Taherti and Kaidi** (**2016)**, who noticed that the best fertility and prolificacy rates were obtained at a BCS greater than or equal to 3. Ewe' BC, moreover, shows an effect on the duration of sexual activity and seasonal anestrus (**Benyounes and Lamrani, 2013a**).

Improving nutritional status before or around breeding had increased the reproductive performances by improving ovulation rate (**Lassoued *et al*., 2004; Forcada *and* Abecia, 2006**; **Ghasemi- Panahi *et al.*, 2016**). Critical body weight and body fat influence the the hypothalamic-pituitary-gonadal axis activity via the leptin signaling pathway, and subsequent reproductive performances of animals (**Saleem *et al.*, 2015; Zarkawi and Al-Daker, 2018**).

3.6.2. Growth

According to **Madani *et al.*** (**2009**)**; Aktaş *et al.*** (**2015**) BCS affects lamb survival. **Chemmam *et al.*** (**2014**)**; Smaali and Boukazoula** (**2019**) showed the significant effect of BCS on lambs' growth at birth and weaning. They showed better growth in lambs from dams with better body conditions (BCS above 2.5). Good management of ewe' BC can result in better weight productivity given its significant impact on weaning weight (**Saul *et al.*, 2011)**. According to the author, lambs born from ewes with BCS=2.3 reached only 32% of mature live weight at weaning while lambs from ewes with BCS=3 reached 51% of mature weight at weaning.

Its effect on growth can be explained on the one hand by the relationship between the nutritional status of the ewes and milk production; in late gestation, undernourished ewes have low glucose and prolactin concentrations which induce lower colostrum and milk volumes, respectively **(Banchero *et al.*, 2006)**. On the other hand, underfeeding is correlated with a decrease in udder weight and performance **(Mellor, 1987*)*** and overfeeding also has adverse effects on mammary development **(Tucker, 1981).**

4. The problem

Sheep farming systems in Algeria are mostly of the traditional extensive type (**Dekhili, 2010),** they refer little to inputs despite the low resources. On the other hand, the animals are endowed with great qualities of adaptation to available food resources and the nature of the environment (**Moula, 2018**).

The adaptation of ewes to these constraints while remaining productive leads us to note the importance of investigating the variants that make them manage to mobilize their body reserves better at critical moments of the production cycle, as well as the mechanisms and sources of variability in the mobilization of the ewes' reserves, with the inclusion of BCS as a management tool and as a genetic selection parameter. BC is of great importance to optimize the performance of ewes.

From there, our work has its importance, it consists in the study of the zootechnical performances of the animals by testing models relating to the relation between the aptitudes of the mothers of local race to mobilize their body reserves and their impact on the performances of reproduction, growth and dairy performances in extensive sheep farming (low imput) to bring explanations and propose more tangible and practical solutions aiming the improvement of the productivity of sheep farms, to face the uncertain supplies and the fluctuations of the quality and the quantity of the food which characterize our breeding systems. The good management of reserves puts the ewe in the best food situation which will minimize reproductive disorders (infertility, mortality ...), improve the milk performance and subsequently the productivity of flocks.

The strong relationships between the BCS (static effect and its dynamics) along the cycle and the performance of sheep are highlighted, it is therefore necessary to acquire new knowledge on the modalities of management of body reserves of our ewes under the constraints of the environment and then identify the genetic traits affecting the efficiency of the use of body reserves of Ouled Djellal ewes.

Selection for robustness as described by (**Dumont *et al.*, 2014**) is an effective adaptation strategy for current and future challenges imposed by climate change.

PRACTICAL PART

Chapter 1: Live weight and lipomobilization dynamics: impact on lambs' birth weight of Ouled Djellal breed

Abstract

The major factor affecting productivity of ewes in low input systems is nutritional status, which can be evaluated by body condition score (BCS) in its static and dynamic effect, as well as live weight (LW) as an additional indicator. The objectives of the study were to identify relationships between LW and BCS in Ouled Djellal ewes and to investigate the hypothesis that the relationship between ewes' weight at breeding and lipomobilization and lambs birth weight (LBW) can determine when interventions should occur to improve lambs growth performances and ewes' productivity. 286 ewes and 299 lambs were used. ewes' weight was evaluated during breeding period while BCS was estimated at breeding, in early-gestation, mid-gestation, late-gestation and at lambing. We tested effects of season, age and parity of ewes and sex and litter size of lambs. Results showed relationship between ewes' LW during breeding and trends of BCS. Lipomobilization was not affected ($p>0.05$) by LW, however superiority of heavier ewes alongside the whole production cycle was noticed. BCS and LBW were affected by season ($p<0.05$), age ($p<0.001$) and litter size ($p<0.01$). The best regular BCS profiles were observed in spring, in young and multiparious ewes and for ewes giving birth to females and singleton lambs. The correlation analysis showed that the LBW was related to the mothers' weight ($p <0.01$) and their BCS recorded in early ($p <0.01$), mid ($p <0.001$), late gestation ($p <0.01$), and at a lesser degree to the BCS at lambing ($p <0.05$). Ewes' LW at breeding has significant consequences on their nutritional status until lambing**.** Our finding also demonstrate that ewes' LW and BCS in all the physiological phases can be considered as a reliable indicators of changes in LBW. Both indicators can be used as tools to improve prediction of lambs' birth weight and thus increase productivity in Ouled Djellal breed in low input production systems.

Key words: Body condition score (BCS), lambs birth weight, live weight**,** Ouled Djellal ewes

Résumé

Dans les systèmes agropastoraux Algériens, le principal facteur affectant la productivité des brebis est l'état nutritionnel qui peut être évalué par la note d'état corporel (BCS) dans son effet statique et dynamique ainsi que le poids vif (LW) des brebis comme indicateur supplémentaire. Les objectifs de l'étude étaient d'identifier les relations entre LW et le BCS chez les brebis Ouled Djellal et d'étudier l'hypothèse selon laquelle l'évaluation de la relation entre le poids des brebis au moment de la lutte, la lipomobilisation et le poids de naissance des agneaux (LBW) peut nous aider à déterminer quand les interventions doivent se produire pour améliorer les performances de croissance. 286 brebis et 299 agneaux ont été utilisés. le poids des brebis a été évalué pendant la période de reproduction tandis que le BCS a été estimé à la reproduction, au début de la gestation, à la mi-gestation, à la fin de la gestation et à l'agnelage. Nous avons testé les effets de la saison, de l'âge et de la parité des brebis, du sexe et de la taille de la portée des agneaux. Les résultats ont montré une relation entre le LW des brebis pendant la reproduction et le profil d'évolution du BCS. La lipomobilisation n'a pas été affectée ($p> 0,05$) par LW, cependant la supériorité des brebis plus lourdes tout au long du cycle de production a été notée. Le BCS et le LBW ont été affectés par la saison ($p <0,05$), l'âge ($p <0,001$) et la taille de la portée ($p <0,01$). Les meilleurs profils d'état corporel régulier ont été observés au printemps, chez les brebis jeunes et multipares et chez les brebis donnant naissance à des femelles et à des naissances simples. L'analyse de corrélation a montré que le LBW était lié au poids des mères ($p < 0,01$) et à leur BCS enregistré en début ($p < 0,01$), en milieu ($p < 0,001$), en fin de gestation ($p < 0,01$) et à un moindre degré au BCS à l'agnelage ($p < 0,05$). Le poids des brebis à la reproduction a des conséquences sur l'état nutritionnel des brebis jusqu'à l'agnelage. Nos résultats montrent aussi que le poids vif des brebis et le BCS des brebis à toutes les périodes physiologiques peuvent être considérés comme des indicateurs fiables des changements des poids des agneaux à la naissance. Cela incite à l'utilisation des deux indicateurs comme outils pour améliorer la prédiction du poids des agneaux à la naissance et augmenter la productivité de la race Ouled Djellal.

Mots clés: Note d'état corporel (BCS), poids à la naissance des agneaux, poids vif, brebis Ouled Djellal

1. INTRODUCTION

In semi arid region of Algeria, where rainfall did not exceed 400 mm/year, pastoral and agricultural resources are mostly valorised by sheep breeding, mainly indigenous sheep breed, as Ouled Djellal breed in Algeria (**Madani *et al.*, 2013**). Despite the use of low input breeding systems, flocks productivity is suitable (**Zidane *et al.*, 2015**) mostly because of ewes adaptation to feed resources scarcity and variability under harsh conditions of production (**Gaouar *et al.*, 2017**).

In order to manage commercial breeds, BCS (static or at a particular time, and dynamics or reflecting change) seems to be a reliable method to help manage flocks (**Sezenler *et al.*, 2011**). BCS and its association with weight can indicate nutritional status and adaptation of ewes (**Demirel *et al.*, 2004** and **Ptáček *et al.*, 2017(a)**). The relationship between LW and BCS of ewes in different physiological periods was studied by several authors, like **Staykova *et al.*, 2013** at mating, early pregnancy and early lactation and **Al- Sabbagh., 2009, Köycü *et al.*, 2008, Gaias., 2012, Karakus and Atmaca, 2016**, at lambing.

It is important to have information about BCS in all the physiological periods and its relationship with ewes' weight in order to determine the best feeding programs and supplement deficient diets to enhance production parameters (**Sezenler *et al.*, 2011**). Among basic production parameters, lambs' weights at birth have been shown to be related to ewes' BCS and LW (**Oldham *et al.*, 2011, karakus and Atmaca, 2016, Roca fraga 2018; De *et al.*, 2018).** It is also related to mortality (**Sušić *et al.*, 2005, Kanyon *et al.*, 2006; Steinheim *et al.*, 2008**), growth until weaning (**Kenyon *et al.*, 2004, Mathias-Davis *et al.*, 2013, Ptáček *et al.*, 2017a**) and it can even affect ewes' reproduction (**Mukasa-Mugerwa and Ezaz, 1992**), thus it can impact flock productivity. **Ptáček *et al.*, 2017(a)** have indicated that birth weight is the first indicator that can be used in early life selection, with heavier lambs being more viable and growing faster than light weight lambs.

The aim of this study was to evaluate the relationship between body weight of Ouled Djellal ewes and lipomobilization during the production cycle and investigate its effect on birth weight of lambs, in order to determine which changes could be carried out in management practices to increase birth weight of lambs for improved flock productivity in pastoral management system.

2. MATERIAL AND METHODS

2.1. Experimental design

Our study was carried out at a commercial farm in the semi arid region of Algeria. The farm is located at longitude 5.117°, latitude 36.033° and altitude 918m above sea level. The experiment involved 286 pregnant ewes aged from 1 to 7 years old. All animals were raised under the same conditions in low input management conditions; feeding system was mainly based on the grazing of pastoral resources in addition to a complement in sheepfold made of straw, hay and crushed barley during the breeding period. BCS was measured, based on the method of **Russel *et al.,* 1969** (a scoring is done on a scale of 0 to 5), by palpation of fat and muscles deposition over and around the vertebrae in the loin region during two lambing seasons (spring and autumn). A BCS of 0-1 is assigned to cachectic state animal and so on until a BCS of 5 assigned to overweight animals (too fat).

The data set consisted of 1446 records of BCS estimated at breeding, during gestation at early, mid and late gestation periods and at lambing. Because natural breeding was conducted, BCS was determined monthly and was assigned retroactively to lambing physiological state. Ewe' body weight was carried out during the breeding period. After lambing, sex, litter size and lamb birth weight were immediately recorded. Weights of lambs and ewes were evaluated with an electronic scale sensitive to100 g.

2.2. Statistical analysis

The SPSS (Statistical Package for Social Sciences) version 23 was used for statistical analysis and to produce graphs. All data are expressed as mean ± standard error (SE). The GLM repeated measures procedures was performed to evaluate the variability of BCS profiles according to season, ewes conditions (body weight at breeding, age and parity) and lambs variables (sex, litter size). Correlations of BCS and LW of ewes at mating with their lambs' birth weight were determined by the Pearson test. The independence test (Khi2) was used to investigate relationship between lambs birth weight and ewe's body live weight across fixed factors.

3. RESULTS AND DISCUSSION

3.1. Body condition dynamic and live weight of ewes

The analysis showed that during the production cycle whatever the ewes' LW range their BCS alter significantly, ($p<0.002$), although the weight showed no influence ($p> 0.05$) on the BCS trends. BCS dynamics during breeding, gestation and lambing according to weight of ewes is shown in figure1.1.

Our results agreed with **Benchohra and Amara, (2016**) findings for Rembi ewes and **Yilmaz *et al*., 2011** in Kivircik sheep. Furthermore, body condition was noticed as a good indicator of changes in body weight in Kivircik, Sakiz and Gokceada indigenous sheep breeds according to **Sezenler *et al*., 2011.**

Our findings confirmed that across different ewes' LW ranges, lipomobilization take almost similar profiles (**Benchohra and Amara, 2016**). Indeed, lightweight ewes registered reduced body condition at breeding (2.6 points) which increased after that in early gestation. The body condition decreased later during mid and late gestation and reached its minimum at lambing (2.0 points). However, moderate and moderately heavy ewes started with moderate BCS at breeding (2.8 points) and reached the maximum at early gestation with two different levels; two profiles have been noticed; moderate ewes registered a steady constant decrease and reached, at lambing, the same level as lightweight ewes. Heavy moderate ewes, however, recorded less fluctuation, maintaining a stable nutritional status around 3 points from mid-gestation to lambing.

The BCS increase from breeding to early gestation was the result of flushing. The constant decrease of body condition during mid and late pregnancy was a consequence of growing needs of gestation overlapping with a feed restriction period. The minimum BCS value was reached at lambing, consequence of the increasing level of nutritional demand of ewes (**Nicol and Brookes., 2007**). Also **Russel *et al.*, 1968** had mentioned that in late pregnancy lipomobilization increased considerably at lambing; they observed a contribution of the subcutaneous fat in the four first months, followed by scale bone fat in the last month.

We noticed that from breeding to lambing lightweight ewes revealed less decline in BCS as seen in moderate and moderate heavy ewes, which agreed with **Benchohra and Amara, 2016** findings; lightweight ewes probably overcome feed restriction by their light digestive tract (**Caldeira and Portugal, 2012**) and skeleton weight (**Vatankhah *et al*., 2012**) when compared to the heavier ewes.

Our results can be compared to **Köycü *et al*, (2008)** for Karacabey Merino, **Gaias (2012)** for Sarda ewes and **Staykova *et al*, (2013**) for Caucasian ewes, who reported correlation between BCS and ewes' LW in different periods of a production cycle. Unlike **Al- Sabbagh (2009)** who found a lower correlation in Border Leicester Merino ewes; also **Karakus and Atmaca (2016)** suggested that BCS is not a reliable estimator of live weight for Norduz ewes.

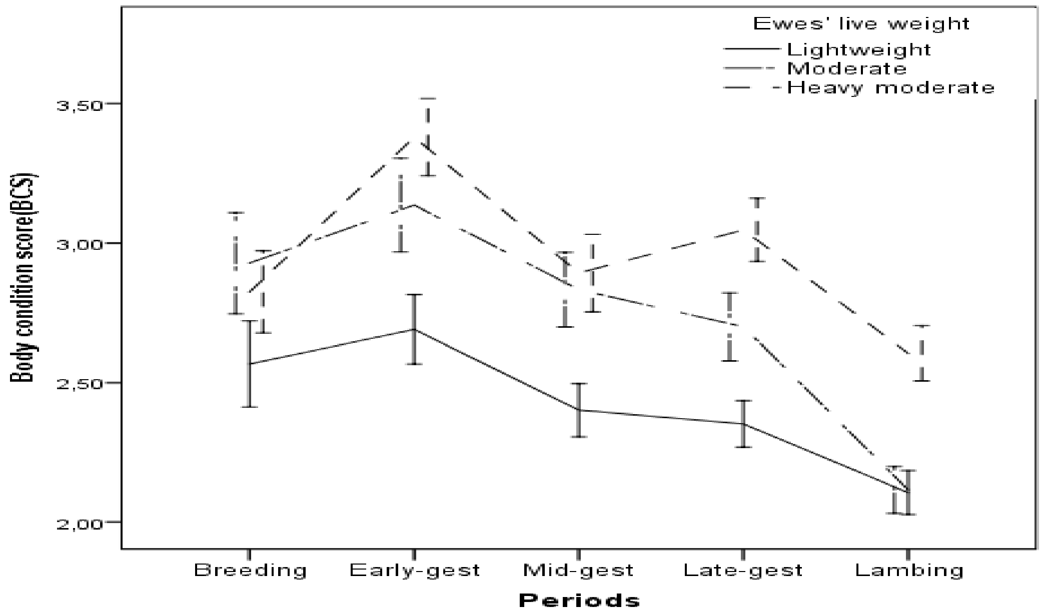

Figure 1.1: Trends of body condition score (BCS) according to Ouled Djellal ewes' live weight (ELW) from breeding period, early-gestation, mid-gestation, late-gestation to lambing. BCS (5 points scale; **Russel *et al*., 1969**) are presented as mean± SE.

3.2. Factors affecting body condition dynamic

Pattern of body reserves mobilization was significantly affected by breeding season ($p<0.05$), age of ewes ($p<0.01$) and number of lambs born ($p<0.01$).

3.2.1. Effect of Season on body condition dynamic

Effect of season on body condition dynamic was presented in figure 1.2. For spring breeding, the overall curve is maintained with two different levels, low, around 2.5 points for lightweight ewes, and relatively high (> 3 points) for the others. However, in the autumn breeding, lightweight and moderate weight ewes recorded a significant decrease of BCS from breeding to parturition, losing more than 1/3 of their body condition. However, heavy-moderate ewes showed a relatively fluctuating profile with peaks at early and late gestation (3 points) and a minimum BCS at mid-gestation and parturition (2.5 points).

Effect of season on BCS trends is more perceived for different LW ranges in autumn when feed resources were limited, and the effect was more pronounced in moderate weight ewes.

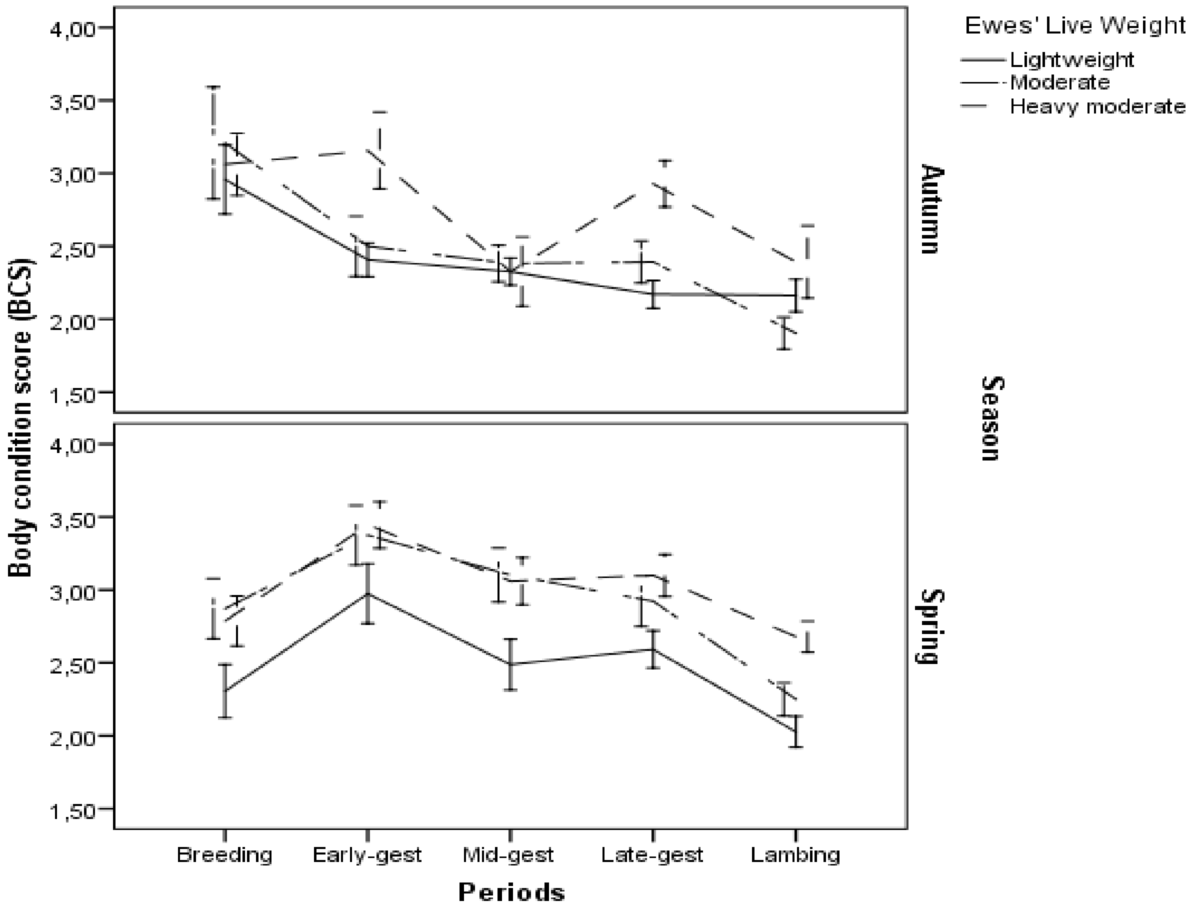

Figure 1.2: Seasonal patterns of body condition (mean± SE) according to ewes' live weight (LW) from breeding period, early-gestation, mid-gestation, late-gestation to lambing. BCS (5 points scale of **Russel *et al.*, 1969**).

3.2.2. Effect of Parity and age of ewes on body condition dynamic

Only age affected significantly BCS dynamic at $p<0.01$, however BCS pattern according to parity reveal similar concluding results. The trends profiles observed according to ewes' LW were illustrated in figure 1.3.

Indeed, the most regular trends regarding age and parity were observed in young and multiparous ewes respectively. For both factors, the maximum values of BCS were recorded in early gestation; they reached around 3.5 points, although the minimum values were observed at lambing (2 points).

According to age, young ewes expressed the less diverge profiles, adult ewes in otherwise had the most constant ones. For multiparous ewes, a significant difference between BCS profiles is observed, light weight ewes showed a BCS stability throughout the gestation period, which have been maintained around 2 points, however moderate and heavy moderate females presented similar profiles until mid-gestation; then, a marked reduction in BCS is observed in moderate ewes when compared to heavy moderate females. Heavier ewes, in yearling and primiparous, showed an inconsistent profile when compared to moderate and lightweight ewes, with a marked individual variability.

Our results can be compared to **Le Frileux *et al.*, 1995** findings, who revealed in goats that adipose tissues in lumbar region reduced with age. Unlike to **Aktas and Dogan, 2014** who found that LW of young ewes was significantly lower than older ones in Akkaraman sheep.

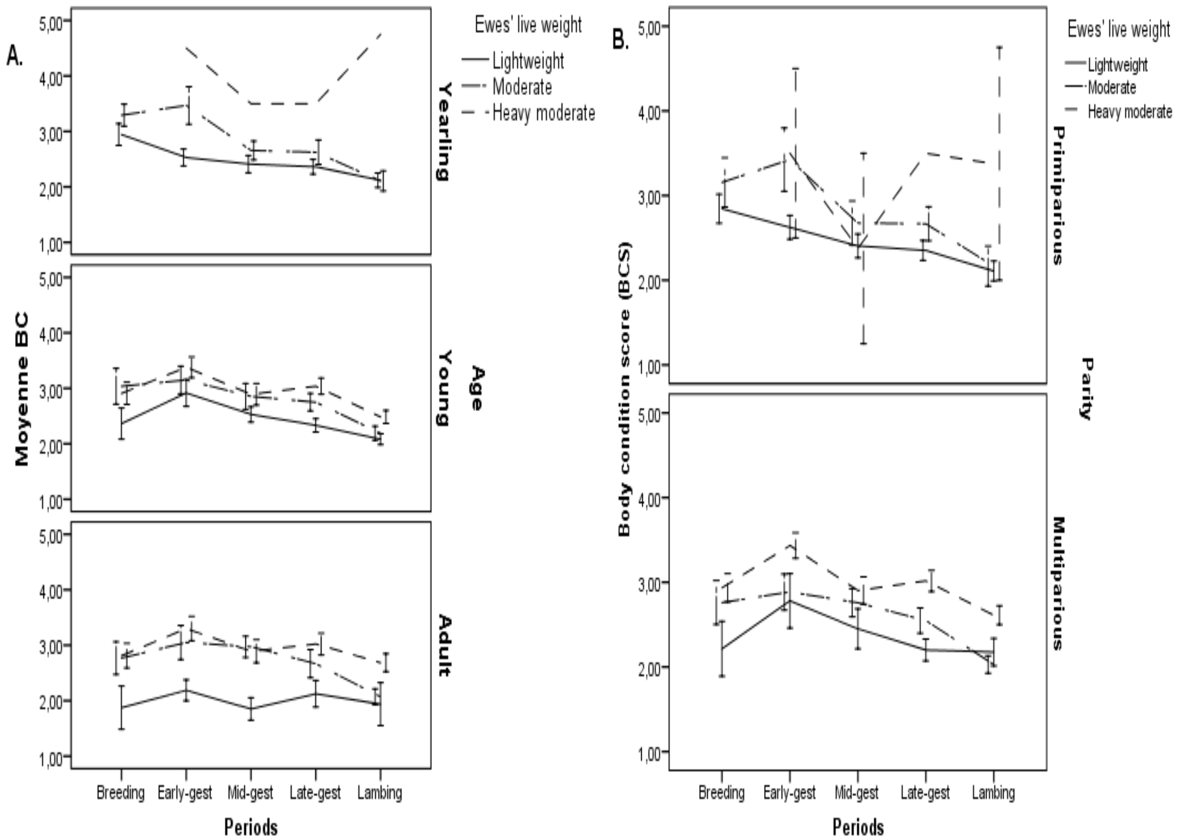

Figure 1.3: Effect of age (A) and parity (B) on Ouled Djellal ewes' body condition score (BCS) trends, according to ewes' live weight (LW) from breeding period, early-gestation, mid-gestation, late-gestation to lambing. Results are presented as mean± SE.

3.2.3. Effect of Sex and litter size of the offspring on body condition dynamic

Sex had no significant effect on BCS trending however; BCS maximum was always observed at the early gestation and the lowest at parturition whatever the litter sex. Pregnant ewes with male had relatively higher body condition at breeding time and had mobilized more reserves during gestation. Male lambing ewes' had a higher lipomobilization levels in moderate and heavy moderate versus lightweight ewes. This can be explained by the superiority of males' birth weight comparing to females, generating higher foetal growth needs and consequently more lipomobilization of mothers' body reserves (**Gardner *et al*., 2007**).

Different profiles of BCS related to litter size were observed ($p<0.01$); twins came only from females with moderate or heavy moderate weight. Thus, trends of BCS were more regular for ewes pregnant with single when compared to BCS of ewes with twins, which expressed higher variability of BCS between pregnancy periods and lambing. **Mollina, 1991**, also observed a superiority of BCS of ewes having single birth comparing to ewes with twin birth.

BCS pattern according to sex and litter size are showed in figure 1.4.

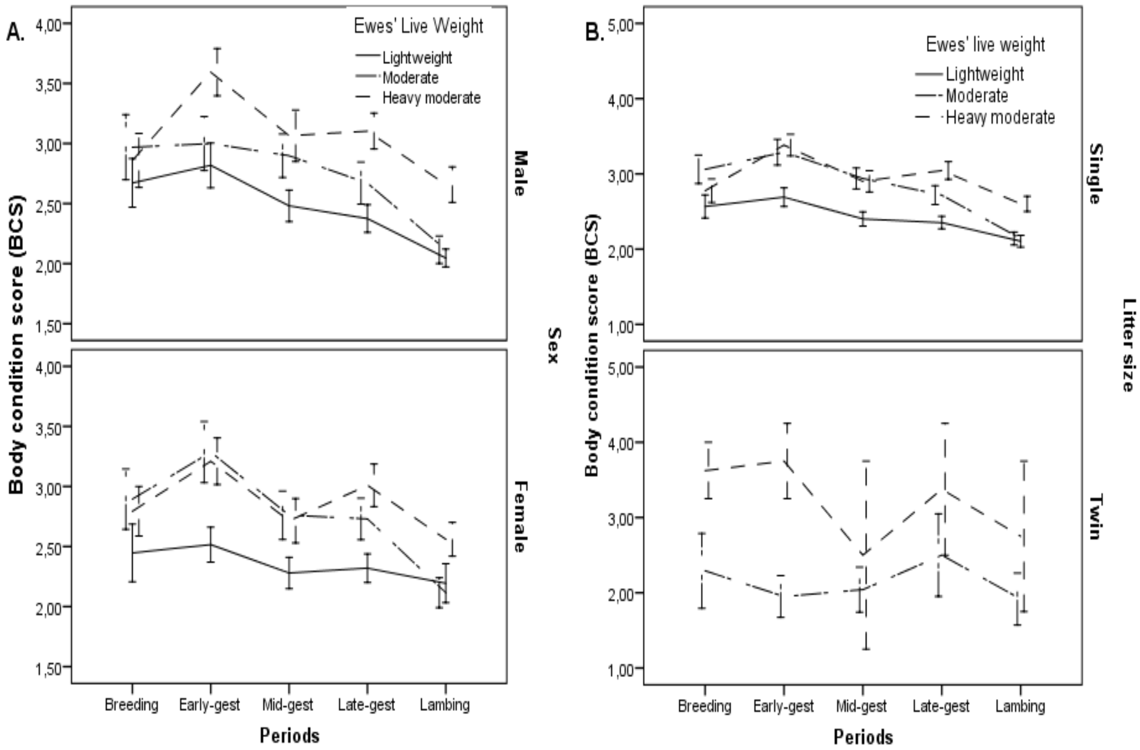

Figure 1.4: Effect of sex (A) and litter size (B) of lambs on ewes' body condition score (BCS) trends, according to ewes' live weight (LW) from breeding period, early-gestation, mid-gestation, late-gestation to lambing. Results are presented as mean± SE.

3.3. Relationship between body condition dynamic, live weight of ewe and their lambs born weight

Our results (table 1.2) revealed significant relationships between BCS, LW of ewes and their lambs' born weight, at the different takes, except for BCS at breeding period, which is comparable to results of **Corner-Thomas *et al.,* 2014**. Lambs birth weight was correlated to mother's weight ($p < 0.01$) and BCS recorded in early ($p < 0.01$), mid ($p < 0.001$), late gestation ($p < 0.01$) but to a lesser degree to the BCS at lambing ($p < 0.05$). This positive correlation indicated that the weight of the lambs increased with the increase of the mothers' weight and their BCS during the different pregnancy periods.

Ewes' LW at breeding characterizes their body condition scoring at breeding ($p<0.05$) and during the gestation period. This outcome is markedly greater from mid gestation to parturition ($p < 0.001$). **Ptáˇcek *et al.,* 2017(b)** also founded that live weight at mating improve the LBW in Suffolk ewes. In goats each kg of LW added 0.054 kg to litter weight at birth (**Constantinou, 1989**).

The strong relationship related ewes' BCS and LW to LBW have been explained by **Godfrey and Barker (2000**), and **Wu *et al.* (2006**) who found that foetal development during gestation is governed by nutritional status of their mother; **Neville *et al.*, 2010**, also stated that under nutrition throughout gestation can affect foetal growth and alter lambs' skeletal size.

Our findings confirm **Corner-Thomas *et al.*, 2014; Fraga Roca *et al.*, 2018** and **De *et al.*, 2018** results, with regard to the importance of late-pregnancy BCS to attain optimum lambs born weight; but, concerning the effect of early and mid gestation on lambs weight we found contrasting conclusions. According to **Mellor, 1983** and **Addah *et al.*, 2012**, most of foetal growth demands (70 to 85%) were occurred in the late gestation. So higher BCS in late gestation allow suitable fulfilling of foetal growth needs (**Kenyon *et al.*, 2014**), furthermore it induced high growth potential (**De *et al.*, 2018**)

Early and mid-gestation BCS had high impact on lambs birth weight at p< 0.01 and p<0.001 respectively. The highest correlation was observed between mid gestation BCS and LBW; our finding confirm **MacGovern *et al*, (2015**) results, who explained that mid-gestation is the most critical period within witch foetal organ growth can be affected. It can be related also to the ewes' placental development (**Gootwine *et al.*, 2007**), whish reach his maximum size at this period.

Kenyon *et al.*, 2007 also found that in mid to late pregnancy under-nutrition had reduced foetal growth and lambs birth weight. There was a positive and linear effect of body condition of the ewe on the body weight of their lambs (**Malik *et al.*, 2013**). Ewes with less lipomobilization during their gestation produced more efficient lambs (**Dwyer, 2003**).

Table 1.2:Pearson's correlation coefficients among ewes' Body condition score (BCS), ewes' live weight (LW) and lambs birth weight (LBW)

		LBW	ELW	BCS at mating	BCS at early-gestation	BCS at Mid-gestation	BCS at Late-gestation	BCS at lambing
LBW	r		**0,248**	**0,137**	**0,232**	**0,256**	**0,180**	**0,143**
	p		0,002	0,066	0,001	0,000	0,006	0,020
ELW	r	**0,248**		**0,217**	**0,258**	**0,273**	**0,355**	**0,333**
	p	0,002		0,016	0,001	0,000	0,000	0,000

The corrélation is significant at 0.05 level (bilatéral).

The χ^2 independence test showed, in table 1.3, a relationship between lambs birth weight and mothers weight at breeding (p <0.001). Lightweight ewes often gave light lambs (64%) and almost not heavy lambs (2%). However, moderate or heavy lambs are respectively more likely to be born from moderate (40% and 14%) and heavy moderate weight ewes (58% and 21%). This observation is not general; it is related to lambing season, sex of lamb, type of lambing, age and parity of mothers. Indeed, weight of ewes affected weight of lambs only in autumn (p <0.01), where the weight of the lamb at birth increased with the weight of the mothers. By contrast, lambs born in spring are rarely heavy (<5%) whatever the weight of their mothers. Males are often born with a moderate weight (43% to 52%) independently to the mothers' weight (p> 0.05). However, the weight of female lambs is highly dependent on the weight of their mothers (p<0.001). Lightweight ewes gave light female lambs (82%) and never heavy ones (0%). Thus, the percentage of light female lambs decreased with the increase of their mothers' weight (82% to 15%) and vice versa (0% to 19%). Because twin births are often small and weight-reduced, the weight of lambs and their mothers were not associated (p> 0.05). However, if birth type is singleton the mothers' weight affected significantly the weight of their lambs (p<0.001). Lightweight ewes gave birth to lambs that were fairly light (64%) and those with heavy moderate weight produced moderate (59%) or heavy (22%) lambs. According to the age of the mothers, the yearling ewes mostly gave light lambs and the adults provided moderate lambs. Nevertheless, young ewes often gave light lambs if they were lightweight or moderate weight (61% to 46%) or heavy lambs (15% to 23%) if they were moderate or heavy moderate respectively. Parity did not affect the relationship between the weights of the lambs and their mothers' (p> 0.05). Lambs are often light or moderate in primiparous (50% to 60%) and moderate in multiparous ewes (> 50%).

Table 1.3: Khi2 Independence test between lambs birth weight (LBW) and ewe's body weight (LW) for all data and across fixed factors

			Lambs Birth Weight (LBW)			p
			Lightweight	Moderate	Heavy	
	All	Lightweight	63,6%	34,1%	2,3%	
		moderate	45,5%	40,0%	14,5%	**0,001**
		Heavy moderate	21,1%	57,9%	21,1%	
Lambing season	Autumn	Lightweight	60,0%	35,0%	5,0%	
		moderate	41,2%	38,2%	20,6%	**0.002**
		Heavy moderate	11,9%	61,9%	26,2%	
	Spring	Lightweight	66,7%	33,3%	0,0%	
		moderate	52,4%	42,9%	4,8%	0.537
		Heavy moderate	42,9%	50,0%	7,1%	
Lambs Sex	Male	Lightweight	51,9%	44,4%	3,7%	
		moderate	39,3%	42,9%	17,9%	0.134
		Heavy moderate	24,1%	51,7%	24,1%	
	Female	Lightweight	82,4%	17,6%	0,0%	
		moderate	51,9%	37,0%	11,1%	**0.001**
		Heavy moderate	14,8%	66,7%	18,5%	
Litter size	One	Lightweight	63,6%	34,1%	2,3%	
		moderate	42,9%	42,9%	14,3%	**0.001**
		Heavy moderate	18,5%	59,3%	22,2%	
	Twin	Lightweight	0,0%	0,0%	0,0%	
		moderate	66,7%	16,7%	16,7%	0.587
		Heavy moderate	50,0%	50,0%	0,0%	
Ewes Age	Yearling	Lightweight	68,4%	31,6%	0,0%	
		moderate	85,7%	14,3%	0,0%	0.202
		Heavy moderate	0,0%	100,0%	0,0%	
	Young	Lightweight	61,1%	38,9%	0,0%	
		moderate	46,2%	38,5%	15,4%	**0.047**
		Heavy moderate	22,6%	54,8%	22,6%	
	adults	Lightweight	80,0%	20,0%	0,0%	
		moderate	33,3%	47,6%	19,0%	0.154
		Heavy moderate	22,7%	63,6%	13,6%	
Ewes parity	Primiparous	Lightweight	61,9%	33,3%	4,8%	
		moderate	66,7%	33,3%	0,0%	0.084
		Heavy moderate	0,0%	50,0%	50,0%	
	Multiparous	Lightweight	50,0%	50,0%	0,0%	
		moderate	40,0%	42,9%	17,1%	0.314
		Heavy moderate	25,6%	51,2%	23,3%	

Significant at 1%: $p<0.01$, significant at 5%: $p<0.05$, not significant: $p>0.05$.

The seasonal effect on lambs' birth weight can be linked to both direct seasonal effect on foetal growth, possibly mediated through variations in melatonin levels and indirect seasonal effect on gestation length (**Gootwine and Rozov, 2006**)

Female's birth weight is mostly affected by ewes' LW; this may be explained by the genetic background (**Gootwine *et al.*, 2007**). Lambs' birth weight born to yearling are often lower than those born to mature ewes, similarly to **Corner *et al*., 2013** and **Abd-allah, 2013** findings, who explained that mature ewes has larger placenta size which will reflect on lambs weight at birth. A positive relationship between ewes' LW and litter size was also observed by **Constantinou, 1989**; he revealed that each kg of body weight added 0.013 more litter size at birth. In addition of the studied factors, significant affect of LW on lambs' birth weight can be explained by placental size which increases with age, parity and with twins over singles (**Dwyer *et al*., 2016**).

4. CONCLUSION

Our findings revealed a strong relationship between LW and BCS in Ouled Djellal ewes; heavier ewes at breeding showed similar trend of BCS as the moderate heavy and the light ewes with higher BCS along the production cycle.

A general prediction of lambs' weight at birth can be made of the trade-off between BCS and LW. However, our study did not ignore the significant interference of season, age and parity of ewes, sex and litter size of lambs in the development of the lambs' birth weight. The highest birth weight comes from young, multiparious ewes and single litter size; furthermore seasonal increases of lambs' born weight in autumn coincide with seasonal decline of natural resources availability.

Results of the present study provide important and practical implications of ewes' measure of weight at breeding and body condition score dynamics till post lambing to improve management of ewes and increase lamb birth weight and consequently productive traits.

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Chapter 2: Effect of the mobilization of body reserves of ewes on their reproductive performances and on the growth of lambs in a low-input breeding system in the semi-arid region of Algeria

Abstract

Our study aims to investigate factors affecting body reserve mobilization and their impact on ewes' reproduction and lambs' growth performances, raised in low input production systems. We monitored eight measurements of body condition score (BCS) of 200 ewes during reproduction, lambing, lactating periods and lambs growth till weaning. The body condition score (BCS) of ewes increased after flushing and the best condition was found in the first third of gestation, the lowest coinciding with lambing. (BCS) of ewes changes very significantly with age, parity and litter size in favor of ewes aged from 2 to 4 years, multiparous and ewes with singleton. The BCS at breeding influences the reproduction parameters, it showed a significant effect on fertility (P <0.01) and fecundity (P <0.05). The best performance was observed in ewes with a BCS between 2 and 2.75, while at BCS <2 fertility and fecundity were moderate. Growth performances were also affected by the nutritional status of their mothers. BCS at lambing affected at p <0.000 lambs' birth weight. We also found that the more ewes are in good condition, the better is the weight of their offspring, until weaning. Understanding the effect of the factors that govern the variability of the performance of ewes reared in low input production systems will allow better control of their productivity and efficiency.

Keys worlds: Body condition score, ewes' reproduction, lambs' growth, low input system

Résumé

Notre étude vise à étudier les facteurs affectant la mobilisation des réserves corporelles et leur impact sur la reproduction des brebis et les performances de croissance des agneaux, élevés dans des systèmes de production à faibles intrants. Nous avons réalisé huit mesures du score de condition corporelle de 200 brebis pendant la reproduction, l'agnelage, les périodes de lactation et la croissance des agneaux jusqu'au sevrage. La note d'état corporel (NEC) des brebis augmente après flushing et le meilleur état était repéré au premier tiers de gestation, le plus bas coïncide avec le moment d'agnelage. La NEC des brebis évolue très significativement avec l'âge, la parité et la taille de la portée au profit des brebis âgées de 2 à 4 ans, les multipares et les brebis ayant des agneaux simples. La NEC au moment de la lutte avait influencé les paramètres de reproduction, elle a montré un effet significatif sur la fertilité (P <0,01) et la fécondité (P <0,05). Les meilleures performances ont été observées chez les brebis avec une NEC comprise entre 2 et 2,75, tandis qu'à NEC <2 la fertilité et la fécondité étaient modérées. Les performances de croissance également étaient affectés par le l'état nutritionnel de leurs mères, La NEC a l'agnelage agit à p<0.000 sur le poids à la naissance. On a constaté également que plus la brebis en meilleure état d'embonpoint plus les poids de leurs descendances est meilleure et cela jusqu'au sevrage. Comprendre l'effet des facteurs qui régissent la variabilité des performances des brebis élevées en systèmes de production à faibles intrants va permettre de mieux maitriser leur productivité et efficience.

Mots clés: Notes d'état corporel, reproduction des brebis, croissance des agneaux, système low input

1. INTRODUCTION

Sheep farming systems in semi-arid regions of Algeria are agro-pastoral systems exploiting the resources of the farm (low input), characterized by a seasonal, variable and poorly synchronized supply of fodder with the dynamics of sheep needs; the available pastoral resources are partly based on spontaneous annual vegetation of natural pastures (**Boudebza *et al.*, 2016)** generating low animal productivity (**Bencherif, 2011**). In this case, the modalities of accumulation and mobilization of reserves in ewes are a determining element of flock performance and consequently of the sustainability of production systems.

Body condition scoring (BCS) is an indirect method of measuring body condition and is used to study the evolution of body reserves along a production cycle. This measure, recommended by several authors such as **Gibon (1981), Frutos (1997)**, **Calavas *et al*. (1998)** and **Zoukekang (2007)**, appears to be a diagnostic tool for feeding systems and, according to **Bocquier et *al*.**

BCS is also a proxy for animal health according to **Berry *et al*.(2007)** and according to **Ollion *et al*.(2016)** assesses the ability to cope with external stressors and survive in restricted nutritional environments.

In this context, our study aims to determine the general evolution during the production cycle of the BC of ewes and the factors of its variation in the Ouled Djellal breed on the one hand, and on the other hand, to show its effect on the reproductive performance and the growth performance of lambs in a pastoral system of a farm located in the semi-arid region of Algeria.

2. MATERIALS AND METHODS

A group of 200 ewes was the subject of this study; all the animals received the same feed ration: pasture on the rangelands plus a supplementation in the sheepfold with straw, hay and crushed barley. The group was subjected to body condition scoring (BCS) according to **Russel *et al*. (1969)** scale, from 0 to 5, during one production cycle. Eight measurements of body condition were taken during breeding (2), at parturition (1) and then at each month until weaning, which was done at 5 months (5). Ewes were classified according to their BCS into three classes (<2, 2-2.75, ≥3) for the study of reproductive performance, and into different classes (<1.75, 1.75-2, >2) for the study of growth performance. Scores were assigned to the nearest 0.25 units, by the same technician.

The evolution body condition' profiles and lamb growth parameters, weight and average daily gain (ADG) were performed using the general linear model (GLM) with repeated measures. The study of the effect of BCS on fertility was performed by the « Khi2 » independence test, its effect on individual fertility, fecundity and prolificacy was performed with the GLM. The LSD (least significant difference) test was used to compare the means. The significance level was set at $p<0.05$.

The application of the analyses on the body condition required the classification of the data, for that an automatic classification method TWOSTEP was conducted and led to a better determination of homogeneous groups. The data from the experiment were processed using the Statistical Package for Social Sciences (SPSS) version 23.

3. RESULTS AND DISCUSSION

3.1. Profile of body condition evolution of ewes

The evolution of the average BCS of ewes during a production cycle is summarized in Table 2.1.

Table 2.1. Average body condition scores (BCS) of ewes by physiological stages during a production cycle (±standard deviation SD, standard error SE).

Physiological stage	N	Average	SD	SE
Before flushing (BCS1)	200	2,09	,58	,04
At breeding (BCS 2)	200	2,53	,73	,05
At parturition (BCS 3)	191	1,75	,50	,04
1st month of lactation (BCS 4)	191	1,87	,57	,04
2nd month of lactation (BCS 5)	191	1,82	,53	,04
3rd month of lactation (BCS 6)	187	1,80	,51	,04
4th month of lactation (BCS 7)	187	1,77	,50	,04
Weaning (BCS 8)	187	1,83	,57	,04

N : total number of ewes

The pattern of evolution of the ewes' BCS is characterized by an increase before and during breeding, between BCS1 and BCS2 (2.09±0.918 to 2.53±0.925), then a significant drop was identified at the time of parturition (1.75±0.797). This was followed by a slight increase (1.87±0.880) during the first month of lactation, followed by a slight relapse in BCS until weaning (1.83±0.851).

From our results, it can be seen that the evolution of BCS varies according to the physiological stage; in accordance with the results of **Le Frilleux *et al*. (1995),** who also observed that the best state of fatness takes place after flushing, while the lowest coincides with the time of lambing, which according to the author corresponds to the most critical moment of the production cycle **(Meredef and Madani, 2015)**.

3.2. Effect of body condition on reproductive performance

The effect of body condition at breeding on reproductive performance is shown in Table 2.2.

Table 2.2. Effect of body condition (BC) of ewes, at breeding, on herd' reproductive performances and individual fertility of Ouled Djellal ewes.

			BCS Classes	**Percentage**	**Signification**
Reproductive performances	Herd	Fertility	< 2 2-2,75 >2,75	85,70% 95% 100%	P <0.01
		Fecundity	< 2 2-2,75 >2,75	37% 52% 109%	P<0,001
		Prolificacy	< 2 2-2,75 >2,75	136% 125% 119%	NS
	Individual	Fertility	**Classes**	**BCS**	**Signification**
			Early fertile Average fertility Lately fertile	2,48 ±0,7 2,74± 0,68 2,28± 0,7	P <0.05

NS: not significant p<0.001: highly significant, p<0.01: highly significant, p<0.05:significant.

Our results show a significant effect of BCS at breeding on fertility and fecundity at P<0.01and P<0.001 respectively, however, it showed no significant effect on prolificacy; the best rates were observed in ewes with BCS greater than 2.75. A lesser effect of BCS was observed on individual fertility at P<0.05 in favor of ewes with a BCS mean of 2.48 ±0.7.

Our results are consistent with those of **Pryce and Coffey (2001)** who found a strong relationship between BCS and reproductive parameters in cows. In ewes also fertility increases with BCS increasing (**Bocquier *et al.*,1993 and Zoukekang, 2007** and **Yelmaz, 2011b).** Same for fertility; **Yelmaz et *al.*(2011a)** and **Yelmaz et *al.*(2011b)** noticed that better EC at the time of breeding leads to better fertility in goats and ewes respectively.

From our results, the best performance is obtained at BCS greater than 2.75, and then decreases sharply when it's less than 2. **Ducker and Boyd (1977); Forcada *et al.*(1992)** observed better fertility in females with BCS greater than 3 at mating than in those with BCS less than 2. **Castonguay (2006)** also showed that better fertility is obtained at BCS greater than or equal to 2.5, and it is lower in those with lesser body conditions.

Good body conditions at breeding results in better fertility and fecundity rates. This is explained by **Moeini *et al.* (2014)** who found the significant effect of BCS on FSH concentration in goats; **Webb *et al*.(2004)** also showed that good BCS is necessary to maintain cyclicity, optimize oocyte quality and embryo survival**.**

3.3. Effect of body condition on individual fertility

The effect of variation in body condition (dynamic effect) of ewes between physiological stages is as important as its static effect (**Le Frilleux *et al.*, 1995),** for this reason the evolutionary profiles of BCS according to individual fertility were studied and three profiles were obtained (figure 2.1).

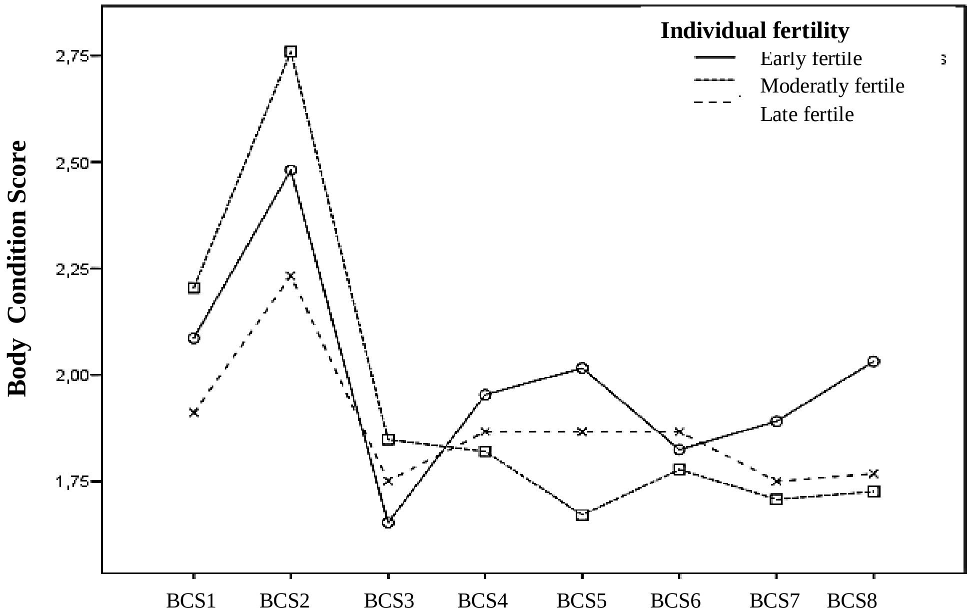

Figure 2.1. Patterns of body condition (B) of ewes according to their individual fertility

(i) The profile of early fertile ewes (64) includes ewes with average BCS at the time of breeding. Compared to the other groups, these ewes give more priority to reproduction and mobilize more body reserves until they reach a minimum BCS (1.5) at the time of parturition. However, they have the ability to reconstruct their reserves more quickly *'Best recovery'*.

(ii) The moderately fertile ewes (82) are those that are fat at the time of breeding (BCS above 2.75) and keep superiority until the first month postpartum. This group mobilizes more their body reserves for lactation than for reproduction, with however an average fertility although they keep a stable BCS (1.75) after lambing. In fact, they ensure an important accumulation of reserves from the 3rd month of lactation.

(iii) Ewes that are lean at the time of breeding (38) have late individual fertility. These ewes have the least fluctuating profile, reflecting a management characterized by maintaining body reserves in a more constant range, such as ewes in the first group '*same driven mecanism*', they accumulate rapidly after parturition but with a priority given to survival.

It can be seen that it is not the ewes with the best BCS that have the best individual fertility, but those that come up well during critical periods with an average overweight condition at breeding. This can be confirmed by **Lacerda *et al.* (2018)** who found a negative impact of the size increasing of Nelore ewes on their reproductive performances, and **De *et al*. (2019)** who showed that ewes with BCS more than 4 tend to be sterile. From our results, we also find that, body condition at breeding is a good indicator not only of fertility but also of the mechanism of mobilization of body reserves during the production cycle.

3.4. Effect of body condition on growth performance

The effect of BCS at parturition (BCS3) as well as the effect of total ewe score (from a global classification of different takes) was tested on lamb growth. The static effect of BCS 3 on lamb weights and ADG from birth to weaning is shown in Table 2.3.

BCS3 acts at $p<0.000$ on birth weight, however, its effect on ADG is limited to that of 10 days and 30 days ($p<0.05$). We also found that as the BCS of the ewes increases the weights and ADG of their offspring are better in accordance with the results of **Kenyon (2012),** however for his case, the effect of BCS did not show significance.

Table 2.3: Effect of body condition (BC) of ewes at parturition on lamb growth (weight/ADG). (± Standard deviation SD)

	BCS	Weight (kg) Avg ± SD	P	ADG (g) Avg ± SD	P
0 day	Very Lean	3.37±1.01	**<0.000**	–	–
	Lean	3.82±0.86			
	Moderate	4.10±0.78			
10 days	Very Lean	5.20±1.55	**<0.000**	173.37±93.15	**0.09**
	lean	5.81±1.49		199.23±101.34	
	Moderate	6.52±1.12		233.23±78.03	
30 days	Very Lean	7.40±2.34	**<0.000**	110.83±60.37	**<0.05**
	Lean	8.27±2.32		122.91±68.87	
	Moderate	9.73±2.21		160.16±77.03	
60 days	Very Lean	11.45±3.35	**<0.000**	134.03±55.46	**>0.05**
	Meager	12.77±3.58		149.93±69.11	
	Moderate	15.01±3.61		176.13±78.52	
90 days	Very Lean	15.39±4.37	**<0.000**	128.77±75.76	**>0.05**
	Lean	16.77±4.44		127.46±57.41	
	Moderate	19.49±4.35		149.46±58.58	
120 days	Very Lean	18.28±4.71	**<0.001**	89.79±63.02	**>0.05**
	Lean	19.58±5.00		89.58±56.34	
	Moderate	22.33±4.64		94.62±45.78	
Weaning	Very Lean	20.66±5.35	**<0.000**	79.37±43.78	**>0.05**
	Lean	21.82±5.44		74.67±71.63	
	Moderate	25.17±5.09		94.52±53.11	

p>0.05: not significant, p<0.001: highly significant, p<0.01: highly significant, p<0.05: significant.

The study of the effect of BCS3 as well as overall BCS on weight and ADG evolution profiles and results are shown in figures 2.2 and 2.3 respectively.

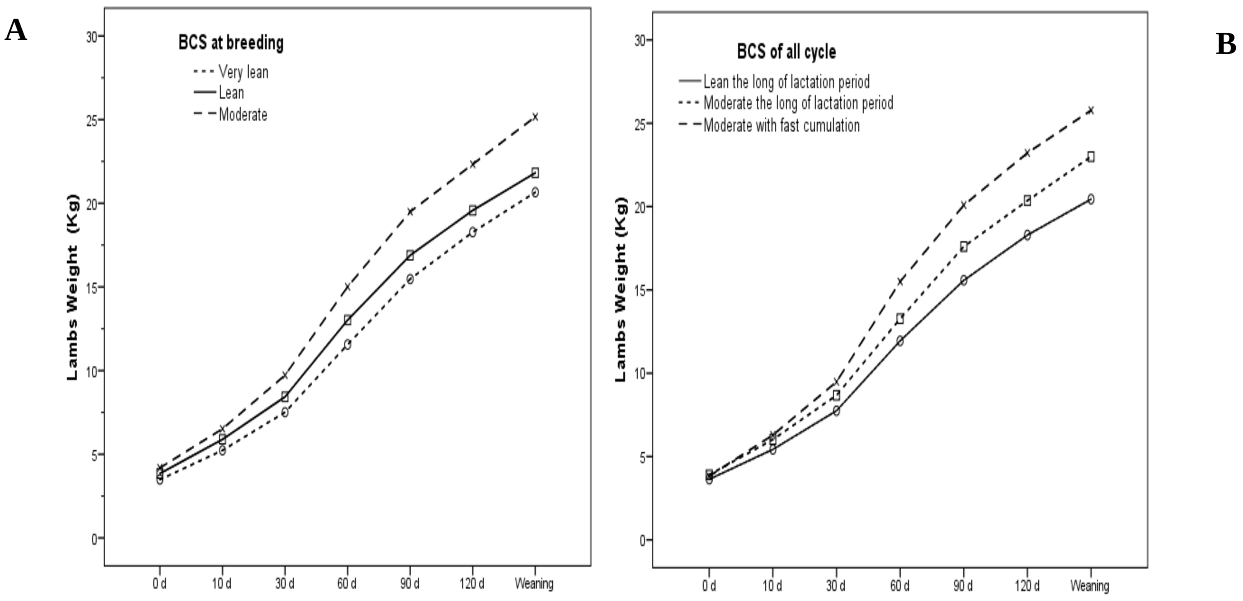

Figure 2.2.Evolution of weight according to body condition (BC) at lambing (A) and total body condition (BC) (B)

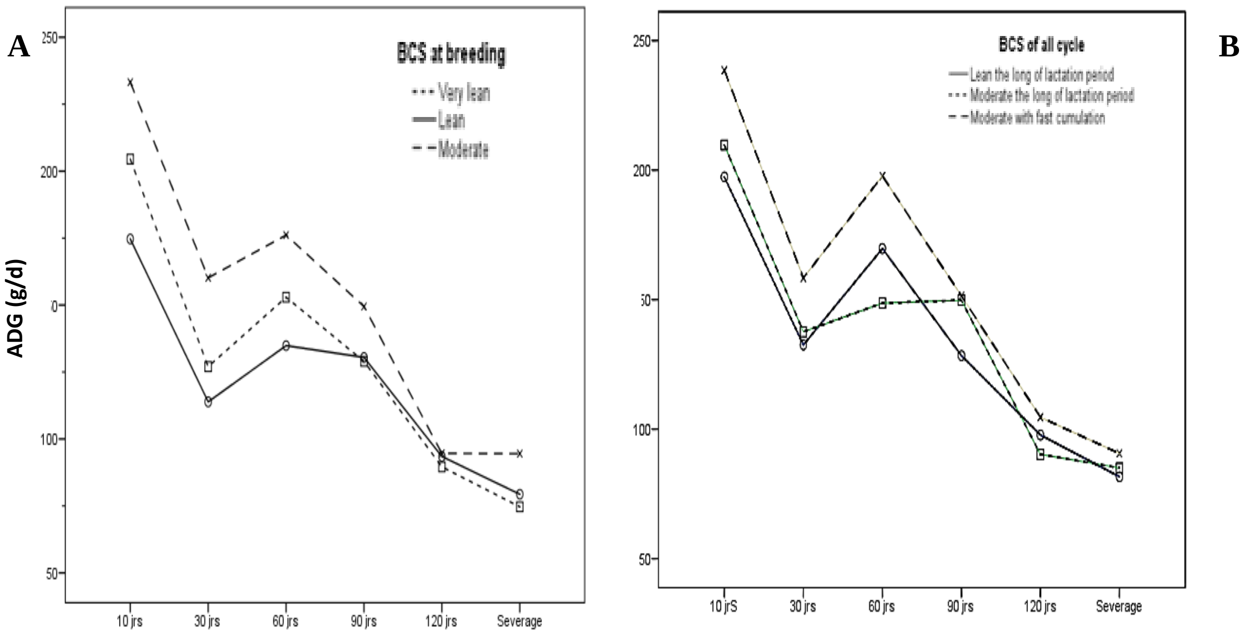

Figure 2.3: Evolution of average daily gain (ADG) by body condition (BC) at lambing (A) and total body condition (BC) (B)

Average weights and daily gain are related to body condition through milk production (**Molina *et al.*, 1991)**. In lambs from lean and very lean ewes, given the decrease in milk production of the dams, the weight and ADG curves are lower than those of lambs from ewes with average BC. This is confirmed by **Erdem *et al.* (2015)** who had found that BCS ≤3 is ideal for higher milk production. Good body condition at lambing was also recommended by **De *et al.* (2018)** to produce lambs with higher birth weight and growth potential. **Corner Thomas *et al.* (2014)** also found that ewes with a BCS greater than 2.0 resulted in higher live weight of lambs at weaning.

The growth trend profiles (weight/ADG) show that the better is the BCS of their mothers, the higher the trend in their evolution. It was also noticed that the BCS at the time of lambing affects growth in the same way as the average BCS which includes all the catches made during the whole production cycle. This shows the importance of body condition at lambing and its effect on growth that can be generalized over the whole period. Some authors had noted the positive effect of BCS of the ewe at the time of breeding on the birth and weaning weight of her offspring. **Atti *et al.* 1995; Malik *et al.* 2000). Moeini *et al*. (2014)** had recommended a BCS of 3.0 at the time of mating to optimize the profitability of Merghoz goats and their kids.

4. CONCLUSION

Our results show the importance of body condition and its significant effect on flock fecundity, fertility and individual ewe fertility. A BCS of 2.75 at breeding is recommended for better reproductive performances. Thus, BCS at parturition affects the weight of lambs at birth and at each intake until weaning.

Furthermore, our study shows that the mechanisms of body reserve management can be explained by the priorities of the three vital functions (reproduction, lactation and survival), which can vary from ewe to ewe. The general pattern of BCS evolution showed ewes that give more priority to reproduction and others to lactation and lamb survival

In order to control and improve the performance of ewe reproduction and lamb growth, the use of the BC tool will allow establishing feeding strategies and practical recommendations based on threshold scores related to each phase of the cycle. This leads to the usefulness of better understanding the strategies or mechanisms of body reserves management for a better management of flocks according to the objectives of the breeding farms. Knowing the sources of variability in the mobilization of ewe reserves will allow us to identify the most efficient ewes; those that adapt to the breeding conditions and give better reproductive and growth performances.

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Chapter 3 : Application of dynamic models for the growth modeling of Oueld Djellal lambs: analysis of some variation factors

Résumé

La présente étude a été réalisée pour comparer des modèles mathématiques afin de décrire la courbe de croissance chez les agneaux Ouled Djellal. À cette fin, cinq modèles connus (Gompertz, Logistique, Verhulst, Mitcherlich et Monomolecular) ont été testés pour évaluer et calibrer les courbes de croissance de 214 agneaux Ouled Djellal maintenus dans une ferme commerciale dans la région semi-aride Algérienne. Les enregistrements relatifs aux contrôles de poids ont été recueillis, à la naissance, à 10 jours puis tous les mois jusqu'à l'âge de 5 mois. Nos résultats montrent les même profils d'évolution du poids chez les mâles et les femelles avec un niveau de croissance relativement plus élevé chez les mâles expliquant la modélisation par sexe. Gompertz et Logistique, étaient les mieux adaptés pour décrire l'évolution de la croissance de tous les agneaux, ils ont présenté les meilleurs paramètres et ont été retenus pour la prédiction de la courbe de croissance des agneaux Ouled Djellal. Cependant, Verhulst, Mitcherlich et Monomoléculaire ont été exclus. En conclusion les modèles retenus peuvent être considéré comme outils de control et de prédiction du phénomène de croissance des agneaux Ouled Djellal permettant le suivi des taux de croissance et la planification des opérations de gestion.

Mots clés: Modélisation, courbe de croissance, Ouled Djellal, agneaux

Abstract

The present study was carried out to compare mathematical models in order to describe the growth curve of Ouled Djellal lambs. For this purpose, five commonly used models (Gompertz, Logistic, Verhulst, Mitcherlich and Monomolecular) were tested to evaluate and calibrate the growth curve of 214 Ouled Djellal lambs maintained at commercial farm in the semi aride region of Algeria. Records relating to weight controls were collected from birth to 10 days then every month until 5 months of age. Our results showed the same trend for males and females weight evolution curves with a relatively higher level of growth of males explaining the sex-wise modeling. Gompertz, and the Logistic models were the best fit growth models for to describe the evolution of growth all lambs, they provided the best parameters compared to other models and were retained for the prediction of the growth curve of Ouled Djellal lambs. However, Verhulst, Mitcherlich and Monomolecular were excluded. In conclusion, the selected models can be considered as tools for control and predicting of growth phenomenon of Ouled Djellal lambs, making possible monitoring growth rates and planning of management operations.

Key Words: Modeling, growth curves, Ouled Djellal, lambs

1. INTRODUCTION

In Algeria, sheep are the leading supplier of red meat **(Zouyed and Benmakhlouf, 2005)** however its production level is far to fit the population' requirements. Still, promoting the production and quality of meat comes through improving breeding conditions, animal welfare and performances monitoring. Monitoring is a management tool most necessary either way animals are intended to breeding or fattening. It begins at an early age, more often from birth, by rigorous control mainly of their growth performances. The use of prediction models serves to quickly identify deficiencies and promote corrections and improvements of sheep breeding strategies (**Akbas *et al.*, 1999; Bilgin *et al.*, 2004**), It helps to draw a convenient feeding schedule to achieve fixed goals (**Dominguez-Viveros *et al.*, 2019**).

Mathematical models nowadays occupy an important place in agricultural research. In animal production filed, notably animal growth, many models have been developed. **Brunner and Kühleitner, 2020** have identified approximately 32,000 papers related to the use for sheep growth modeling. Their degree of complexity and their level of integration of knowledge regarding physiological mechanisms vary according to their assigned objectives. However, taking biological processes at fines scales; hence at a low level of aggregation of the models; can constitute a source of uncertainty on used parameters values and affect consequently the operational trait of a model **(Hoch and Agabriel, 2004).** Simulation studies by **Goshu (2008)** indicate that the growth functions are flexible and match with data set, recommending that the choice of a model should be done in a prudent manner depending on the studied biological phenomenon.

Application of dynamic models to predict Oueld Djellal lambs' growth trends can give a theoretical support for decision makers for a best planning of feeding, vaccination, genetic selection or other interventions and help determine the optimum time for breeding, sale or slaughter lambs. It is in this perspective that this study was conducted, through a dynamic modeling approach, we aimed to propose and calibrate a set of models described in the literature by comparing them with the results obtained in a commercial farm in the semi arid region of Algeria.

2. MATERIAL AND METHODS

2.1. Animal Material

A total of 214 lambs, divided equally between males and females, were followed for 5 months of growth on farm. Weights at birth (P0), at 10days, at one, two, three, four and five months were taken and the growth rate was also calculated. Lambs monitored were classified according to three criteria; birth weight, body condition score (BCS) of their mothers at lambing and birth season. Indeed, the classification (table 3.1) showed that males were heavy at birth while females are light or medium. However, male lambs are often offsprings of lean mothers at parturition compared to females, which were born to ewes with medium BCS. According to the season, we noticed the dominance of autumn births, which represent more than 80% regardless of sex.

Tableau 3.1. Distribution of lambs monitored according to certain criteria linked to the lamb, ewes or environment.

Factor	Modalities	Total		Male		Female	
		Number	%	Number	%	Number	%
Sex	**Male**	106	51.8	-	-	-	-
	Female	108	48.2	-	-	-	-
Lambs birth weight	**light**	73	32.9	36	31.6	37	34.3
	moderate	71	32.0	34	29.8	37	34.3
	heavy	78	35.1	44	38.6	34	31.5
Ewes' BCS	**lean**	98	44.1	55	48.2	43	39.8
	average	91	41.0	42	36.8	49	45.4
	Obese	33	14.9	17	14.9	16	14.8
Birth season	**Spring**	30	13.4	15	12.9	15	13.9
	Autumn	194	86.6	101	87.1	93	86.1

2.2. The tested growth models

In our study, five known models were selected to model and calibrate lambs' growth, their equations are shown below. "Nonlinear regression" procedure of SPSS software was used for the parameter estimation. The number of iterations was not initially set; the calculation stops after the stability of all the parameters. Each model is represented by the parameter estimators as well as the standard error of the estimate from which the confidence level of the estimator can be determined.

Gompertz : $Weight = a * e^{(-\mathrm{b}*\mathrm{e}^{(-\mathrm{k}*\mathrm{age})})}$

Logistic: $Weight = a * \left(1 + e^{(-k*Age)}\right)^{(-m)}$

Verhulst: $Weight = \frac{a}{\left(1+b*e^{(-k*Age)}\right)}$

Mitcherlich: $Weight = a - b * k^{Age}$

Monomolecular: $Weight = a * \left(1 - b * e^{(-k*Age)}\right)$

2.3. Evaluation of models' goodness of fit

The models established are subjected to an evaluation by the following parameters:

- Efficiency: it is the equivalent of the coefficient of determination in linear regression

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}\left(y_i - \overline{y}_i\right)^2} = 1 - \frac{MSE}{Var(y)(N-1)/N}$$

- MSE: is the SCE relating to the size of the sample; it's the average of the quadratic deviations from the predicted values

$$MSE = \frac{1}{N}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

- RMSE: it is the square root of the MSE; it has the same unit as the actual value of the parameter.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

- MAE : it's the absolute mean error; it is less used compared to RMSE

$$MAE = \frac{1}{N}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

- The bias : is the square of the difference between the actual and predicted means

$$Bias^2 = \left(\frac{1}{N}\sum y_i - \frac{1}{N}\sum \hat{y}_i\right)^2$$

- Akaïke information critaria

$$AIC = n * log(MSE) + 2 * p$$

3. RESULTS

3.1. General shape of the growth curve of Ouled Djellal lambs

Lambs of Ouled Djellal breed have a birth weight of 3.7±1.0 kg; with a significant difference of 100g observed between males and females. Similar results were reported in the same region by **Boukhalfa and Boukhames (2014**) and **Ben Hamouda (2012**) in Tunisia, for respectively, Oueld Djellal and Barbarine sheep breed. While **Boussena *et al.* (2013**) reported much higher birth weights (4.5 kg) for Ouled Djellal breed in Constantine region. At 3 months of age, lambs register 16.6±4.8kg and reach more than 21.9±5.5 kg at 5 months of age. Analysis of trend of growth shows that the same pattern is observed in males and females with a relatively higher level for males. This finding is also reported by several authors (**Boukhalfa and Boukhames, 2014**; **Boussena *et al.*, 2013**; **Laib and Yahi, 2008).**

The average daily gain during the follow-up period is approximately 128.4±79.3 g/day. The follow-up period can be divided into 3 phases; before 30 days, when growth was maximum with remarkable superiority of males. Between 30 and 90 days, a phase of stability and both sexes register average growth rates, while the difference within sex started after 60 days of age. After 90 days, the lambs reduce their growth to less than 100 g/day, the minimum is observed at weaning (figure 3.1). The same observations are noted in Constantine region by **Boussena *et al.* (2013).**

The effect of sex on lambs' weight pattern is remarkably observed for autumn births, lambs with moderate to heavy birth weight are generally coming from ewes with higher BCS (figure 3.2). The differences, in ultimate value, increased with age and represent less than 1 kg before the first month of age and 2 kg or more after the age of 3 months.

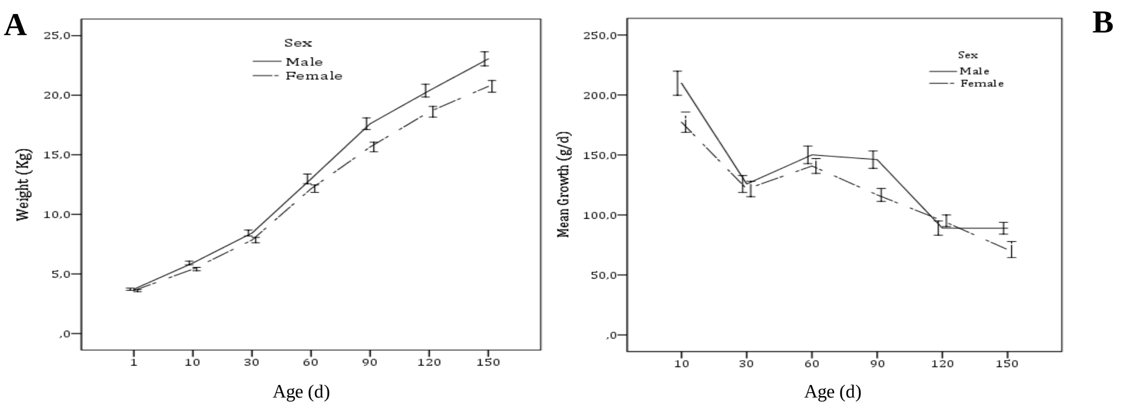

Figure 3.1. Evolution of weight (A) and average daily gain (B) of lambs by sex

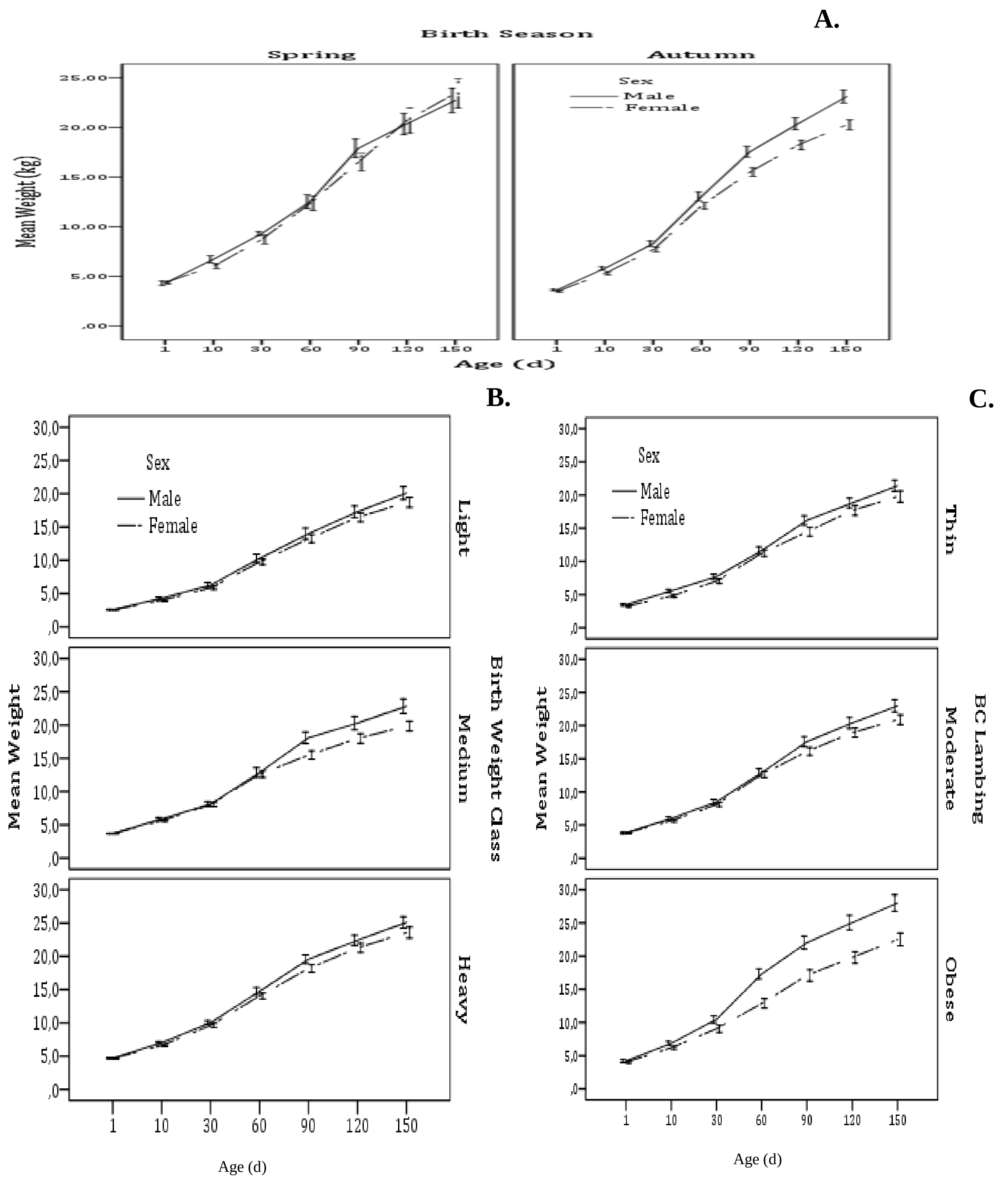

Figure 3.2. Lambs weight evolution according to their birth season (A), birth weight (B) and the body condition of their mothers (BCS) (C)

3.2. Estimated parameters of five growth models by sex of lambs

The parameters of the prediction of models according to lambs' sex are shown in table 3.2. Indeed, the asymptomatic values (a) are relatively greater for males for all different models. The gender-related weight differences vary from 2 to 3 kg. The estimation errors for the parameter also vary from 2% to 14% and are relatively small for females. However, the results showed that the Verhulst, Logistic and Gompertz models present the lowest error rates for this parameter. Compared with real data, the Mitcherlich and Monomolecular models overestimate weaning weight.

The parameter describing the growth shape (b/m) has lower error rates, except for Mitcherlich's model, where we found a high error rate, while the other models recorded error rates less than 3%. The relative growth (k) is comparable between males and females. The differences are almost nonexistent. The error rates vary between 7% (Gompertz, Logistic and Verhulst) and 20% (Monomolecular). The first inflection point of the growth curve occurs around the age of 17 days for males and 24 days for females corresponding to a weight of 9 and 13 kg respectively. Regardless of the model, inflection point takes place later and is relatively higher in males compared to females.

Table 3.2. Models' parameters according to the sex of lambs (SE)

	Sex	a ± SE	b/m ± SE	K ± SE
Gompertz	Male	27,22(1,22)	1,90(0,055)	0,016(0,001)
	Female	24,36(1,00)	1,84(0,05)	0,016(0,001)
Logistic	Male	25,79(0,94)	2,62(0,077)	0,020(0,001)
	Female	23,15(0,77)	2,57(0,07)	0,020(0,001)
Verhulst	Male	24,43(0,68)	4,56(0,26)	0,027(0,002)
	Female	22,02(0,57)	4,29(0,23)	0,027(0,002)
Mitcherlich	Male	36,16(4,14)	32,64(3,99)	0,994(0,001)
	Female	13,33(0,27)	33,47(17086)	0,290(148)
Monomoleculaire	Male	40,41(5,71)	0,91(0,011)	0,005(0,001)
	Female	34,76(4,19)	0,9(0,01)	0,005(0,001)

3.3. Variability of parameters according to factors relating to lambs, ewes and environment

3.3.1. Effect of lambs' birth weight

The estimated parameters vary greatly according to the lambs' birth weight (Table 3.3). Indeed, the parameter (a) increases with the increase of the birth weight while the parameter (b/m) inversely decreases. The differences are equivalent to 3-4 kg for the parameter (a) and

0.45 to 0.60 points for the parameter (b/m). However, the parameter (k) is comparable between P0 classes for the same sex and model. According to the results shown in the table, the error rates decrease with weight at birth for parameters (a) and (b/m) by the equivalent of 2 to 6% for males and 0.5 to 3% for females. The Mitcherlich and Monomolecular models showed different trends with a large value of the parameter (a) and (b) recorded in light lambs, whose estimation error rates are very high and can reach levels of 60%.

Tableau 3.3. Models' parameters according to lambs' birth weight of by sex (SE)

	Sex	Birth weight	a ± SE	b/m ± SE	k ± SE
Gompertz	Male	Light	25,79(2,78)	2,19(0,115)	0,014(0,002)
		Moderate	26,53(1,95)	1,92(0,101)	0,017(0,002)
		Heavy	29,16(1,59)	1,76(0,065)	0,016(0,002)
	Female	Light	23,75(1,94)	2,16(0,091)	0,015(0,002)
		Moderate	22,01(1,15)	1,72(0,077)	0,018(0,002)
		Heavy	27,59(1,56)	1,73(0,065)	0,016(0,002)
Logistic	Male	Light	23,98(2,05)	3,01(0,157)	0,018(0,002)
		Moderate	25,22(1,49)	2,65(0,141)	0,021(0,002)
		Heavy	27,76(1,22)	2,42(0,09)	0,020(0,002)
	Female	Light	22,16(1,44)	2,97(0,126)	0,019(0,002)
		Moderate	21,17(0,91)	2,38(0,107)	0,023(0,002)
		Heavy	26,25(1,20)	2,38(0,090)	0,020(0,002)
Verhulst	Male	Light	22,02(1,35)	5,94(0,648)	0,026(0,003)
		Moderate	23,95(1,09)	4,67(0,491)	0,029(0,003)
		Heavy	26,53(0,93)	3,93(0,275)	0,027(0,002)
	Female	Light	20,46(0,96)	5,80(0,513)	0,027(0,002)
		Moderate	20,44(0,72)	3,81(0,32)	0,029(0,003)
		Heavy	25,11(0,91)	3,80(0,266)	0,026(0,002
Mitcherlich	Male	Light	61,31(39,19)	58,78(38,96)	0,998(0,002)
		Moderate	38,36(8,65)	34,84(8,38)	0,995(0,002)
		Heavy	39,62(5,79)	35,00(5,59)	0,994(0,001)
	Female	Light	33,47(7,39)	31,32(7,21)	0,995(0,002)
		Moderate	27,48(3,32)	23,90(3,14)	0,992(0,002)
		Heavy	37,42(5,64)	32,90(5,42)	0,994(0,001)
Monomolecular	Male	Light	61,31(39,15)	0,959(0,023)	0,002(0,002)
		Moderate	38,36(8,65)	0,908(0,018)	0,005(0,002)
		Heavy	39,62(5,79)	0,884(0,015)	0,006(0,001)
	Female	Light	51,74(22,85)	0,954(0,018)	0,003(0,002)
		Moderate	27,48(3,32)	0,870(0,015)	0,008(0,002)
		Heavy	37,42(5,64)	0,879(0,016)	0,006(0,001)

3.3.2. Effect of body condition of ewes at parturition

The BCS of ewes at parturition is a determinant element of variability of the estimated parameters (Table 3.4). For Gompertz, Logistic and Verhulst models, the asymptomatic value (a) increases with the increase of BCS. Its highest values are observed in lambs coming from obese ewes (regardless of sex). However, lambs of lean or medium ewes register comparable values. Thus, estimation errors are higher in males from lean ewes (6-7%) and females from obese ewes (7-8%). For the Mitcherlich and Monomolecular models, the trend of parameter (a) is controversial for males, as value decreases with BCS trend. For females, the maximum values were observed in lambs coming from lean and obese ewes. Estimation errors are high and vary from 12 to 22%.

The values (b/m) are comparable between the ewes' BCS modalities and sex of lambs. The differences are small and ranged from 0.03 to 0.20 points. The estimation errors are also low for the Gompertz, Logistic, Verhulst and Monomolecular models (2-5%) and higher for the Mitcherlich model (15-30%). The parameter (k) showed relatively high values in males from fat ewes and in females with average fattening. The relative estimation errors vary between 8 and 16% for all models.

Tableau 3.4. Models' parameters according to ewes' body condition score (BCS) by sex (SE)

	Sex	BCS	a ± SE	b/m ± SE	k ± SE
Gompertz	Male	Thin	26,12(1,99)	1,92(0,083)	0,015(0,002)
		Moderate	27,36(1,98)	1,88(0,085)	0,016(0,002)
		Obese	30,47(1,58)	1,91(0,103)	0,020(0,002)
	Female	Thin	23,92(1,84)	1,95(0,089)	0,015(0,002)
		Moderate	24,01(1,33)	1,79(0,073)	0,017(0,002)
		Obese	26,76(2,30)	1,78(0,094)	0,015(0,002)
Logistic	Male	Thin	24,55(1,49)	2,64(0,113)	0,019(0,002)
		Moderate	25,89(1,51)	2,59(0,118)	0,020(0,002)
		Obese	29,40(1,28)	2,65(0,143)	0,024(0,002)
	Female	Thin	22,57(1,40)	2,68(0,122)	0,020(0,002)
		Moderate	22,92(1,03)	2,47(0,102)	0,021(0,002)
		Obese	25,36(1,77)	2,45(0,129)	0,019(0,003)
Verhulst	Male	Thin	23,05(1,06)	4,64(0,388)	0,026(0,002)
		Moderate	24,50(1,06)	4,64(0,393)	0,027(0,002)
		Obese	28,32(1,01)	4,68(0,498)	0,032(0,003)
	Female	Thin	21,26(1,00)	4,75(0,427)	0,027(0,002)
		Moderate	21,95(0,79)	4,07(0,319)	0,028(0,002)
		Obese	24,11(1,31)	3,99(0,394)	0,025(0,003)
Mitcherlich	Male	Thin	42,75(11,86)	39,27(11,65)	0,996(0,002)
		Moderate	40,97(9,39)	37,20(9,15)	0,995(0,002)
		Obese	38,57(4,85)	34,69(4,59)	0,992(0,002)
	Female	Thin	38,11(10,22)	35,04(10,02)	0,996(0,002)
		Moderate	32,22(4,74)	28,57(4,55)	0,994(0,002)
		Obese	38,05(9,31)	33,96(9,04)	0,995(0,002)
Monomolecular	Male	Thin	42,75(11,86)	0,919(0,019)	0,004(0,002)
		Moderate	40,97(9,39)	0,910(0,018)	0,005(0,002)
		Obese	38,57(4,85)	0,899(0,015)	0,008(0,002)
	Female	Thin	38,36(10,41)	0,920(0,019)	0,004(0,002)
		Moderate	32,22(4,74)	0,887(0,015)	0,006(0,002)
		Obese	38,05(9,31)	0,892(0,022)	0,005(0,002)

3.3.3. Effect of lambs' birth Season

The effect of lambs' birth season on asymptomatic value (a) is significant in females (Table 3.5). However In males, the values obtained per season are comparable, or even equal. Also estimation errors are significant for spring models. Thus, the error rates vary from less than 9% for males to over 13% for females. For models developed for autumn births, error rates are comparable between sexes and are around 5%. The parameter (b/m), on the other hand, shows a different trend, the high values are observed for autumn births in males, but also in spring births in females. The error rates thus established are important for models developed for spring births (5-10%), and more significant in females. The parameter (k) is relatively lower for spring births. Thus the differences observed are more noticed in females (5 to 6 points) than in males (1 to 3 points). The error rates are insignificant (<1%) for the Mitcherlich model, relatively low (5 to 10%) for the Gompertz, Logistic and Verhulst models and large (20 to 100%) for the Monomolecular model.

Tableau 3.5. Models' parameters according to season of birth by sex (SE)

	Sex	Season	a ± SE	b/m ± SE	k ± SE
Gompertz	Male	Spring	27,55(2,76)	1,75(0,103)	0,015(0,003)
		Autumn	27,17(1,34)	1,93(0,063)	0,016(0,001)
	Female	Spring	32,62(5,56)	1,95(0,143)	0,012(0,003)
		Autumn	23,28(0,95)	1,84(0,055)	0,017(0,001)
Logistic	Male	Spring	25,99(2,08)	2,41(0,140)	0,019(0,003)
		Autumn	25,77(1,03)	2,66(0,087)	0,021(0,002)
	Female	Spring	29,80(3,96)	2,65(0,178)	0,016(0,003)
		Autumn	22,22(0,74)	2,53(0,077)	0,021(0,001)
Verhulst	Male	Spring	24,67(1,52)	3,89(0,417)	0,025(0,003)
		Autumn	24,40(0,75)	4,68(0,303)	0,028(0,002)
	Female	Spring	27,24(2,58)	4,54(0,547)	0,022(0,003)
		Autumn	21,25(0,56)	4,28(0,249)	0,028(0,002)
Mitcherlich	Male	Spring	39,96(11,89)	35,52(11,59)	0,995(0,002)
		Autumn	40,53(6,34)	36,99(6,18)	0,995(0,001)
	Female	Spring	67,76(54,15)	63,52(53,77)	0,998(0,002)
		Autumn	31,72(3,52)	28,38(3,39)	0,994(0,001)
Monomolecular	Male	Spring	39,96(11,90)	0,889(0,028)	0,005(0,002)
		Autumn	40,53(6,35)	0,913(0,012)	0,005(0,001)
	Female	Spring	85,17(94,26)	0,949(0,052)	0,002(0,002)
		Autumn	31,72(3,52)	0,895(0,010)	0,006(0,001)

3.4. Evaluation of goodness of fit of used models

After calculating the parameters, the five models were subjected to several evaluation methods. Models thus established were evaluated using efficiency R^2, MSE, RMSE, MEA, $Bias^2$, and AIC. A model is said to be good fit if it has high efficiency and low error components. Indeed, the recorded efficiency for our models exceeds 75%, with a maximum of 89%. According to sex, the efficiency values reported for females are higher and indicate a better prediction. However, birth weight significantly affects the evaluation of the models' goodness fit. The best prediction characterizes heavy lambs rather than medium and light ones, for both sexes. Goodness fit vary according to the BCS of ewes at parturition shows the superiority of male lambs coming from obese ewes, which recorded an efficiency equivalent to 89% for all the models studied (table 3.6).

In the other hand, the components of the residual are inversely proportional to efficiency. They are important (MSE> 10) for relatively low efficiencies (<80%). The results mentioned in the figure 3.3, showing that the Gompertz and Logistic models record lower residuals (± 0.5 kg in average), mainly in females. In males, adjustment quality is affected and the residuals increase to more or less an average of 0.5kg in the case of medium birth weight lambs coming from lean or obese ewes, mainly in the spring season. In addition, null values of adjustment bias were observed for the heavy females at birth coming from obese ewes, or for those born in spring.

Table 3.6. Models' goodness of fit using coefficient of determination (R2), residual mean squares (MSE), the root of MSE (RMSE), absolute mean error (MAE) bias and information criterion (AIC) for nonlinear curves describing Ouled Djellal lambs' growth (male and female).

Factor	Modaliti-es	Model	Male						Female					
			R^2	MSE	RMSE	MAE	Biais	AIC	R^2	MSE	RMSE	MAE	Biais	AIC
Total	Total	Gomp	0,754	15,63	3,95	2,91	.096	975,49	0,776	10,98	3,31	2,49	.022	792,70
		Log	0,753	15,65	3,96	2,92	.096	975,95	0,775	11,02	3,32	2,49	.022	793,89
		Verh	0,752	15,71	3,96	2,94	.101	977,30	0,774	11,06	3,33	2,51	.025	795,08
		Mitch	0,753	15,66	3,96	2,90	.052	976,17	0,247	36,86	6,07	2,77	.006	1190,32
		MM	0,753	15,64	3,95	2,90	.093	975,72	0,776	10,98	3,31	2,48	.020	792,70
Birth weight	Light	Gomp	0,791	10,39	3,22	2,32	.227	262,19	0,827	7,06	2,66	1,95	.055	225,84
		Log	0,790	10,41	3,23	2,33	.227	262,40	0,827	7,07	2,66	1,95	.057	226,00
		Verh	0,789	10,49	3,24	2,37	.235	263,24	0,826	7,11	2,67	1,97	.061	226,63
		Mitch	0,791	10,37	3,22	2,31	.232	261,98	0,825	7,17	2,68	1,99	.020	227,58
		MM	0,791	10,37	3,22	2,31	.232	261,98	0,827	7,09	2,66	1,96	.055	226,32
	Moderate	Gomp	0,756	15,35	3,92	2,82	.080	288,29	0,796	8,68	2,95	2,04	.030	249,08
		Log	0,757	15,34	3,92	2,83	.082	288,23	0,795	8,72	2,95	2,06	.030	249,59
		Verh	0,756	15,36	3,92	2,86	.088	288,36	0,793	8,78	2,96	2,09	.034	250,37
		Mitch	0,755	15,45	3,93	2,79	.078	288,96	0,796	8,66	2,94	2,00	.028	248,82
		MM	0,755	15,45	3,93	2,79	.078	288,96	0,796	8,66	2,94	2,00	.028	248,82
	Heavy	Gomp	0,813	12,20	3,49	2,54	.030	340,60	0,840	8,79	2,97	2,12	.000	230,67
		Log	0,812	12,23	3,50	2,56	.032	340,93	0,839	8,82	2,97	2,14	.000	231,02
		Verh	0,811	12,30	3,51	2,58	.035	341,69	0,838	8,88	2,98	2,17	.000	231,72
		Mitch	0,813	12,19	3,49	2,51	.029	340,49	0,840	8,78	2,96	2,10	.000	230,55
		MM	0,813	12,19	3,49	2,51	.029	340,49	0,840	8,78	2,96	2,10	.000	230,55
Body condition score (BCS) at partutition	Thin	Gomp	0,756	13,26	3,64	2,73	.162	438,18	0,774	10,42	3,23	2,41	.090	312,38
		Log	0,755	13,27	3,64	2,73	.162	438,31	0,774	10,44	3,23	2,42	.091	312,63
		Verh	0,755	13,31	3,65	2,74	.167	438,81	0,773	10,49	3,24	2,43	.096	313,25
		Mitch	0,755	13,27	3,64	2,64	.163	438,31	0,774	10,42	3,23	2,40	.088	312,38
		MM	0,755	13,27	3,64	2,72	.163	438,31	0,774	10,42	3,23	2,40	.090	312,38
	Moderate	Gomp	0,758	14,79	3,85	2,83	.045	349,97	0,767	11,56	3,40	2,54	.004	370,59
		Log	0,758	14,81	3,85	2,83	.047	350,14	0,766	11,58	3,40	2,54	.004	370,85
		Verh	0,757	14,86	3,85	2,85	.052	350,57	0,765	11,63	3,41	2,55	.005	371,49
		Mitch	0,758	14,81	3,85	2,80	.043	350,14	0,766	11,58	3,40	2,53	.003	370,85
		MM	0,758	14,81	3,85	2,82	.043	350,14	0,766	11,58	3,40	2,53	.003	370,85
	Obese	Gomp	0,889	9,37	3,06	2,20	.051	121,64	0,774	7,21	2,69	2,09	.000	102,09
		Log	0,888	9,43	3,07	2,21	.053	121,97	0,853	7,25	2,69	2,11	.000	102,36
		Verh	0,886	9,60	3,10	2,24	.061	122,89	0,852	7,33	2,71	2,13	.000	102,89
		Mitch	0,889	9,37	3,06	2,61	.051	121,64	0,855	7,15	2,67	2,07	.000	101,68
		MM	0,889	9,37	3,06	2,21	.051	121,64	0,855	7,15	2,67	2,07	.000	101,68

Birth season	Spring	Gomp	0,841	8,11	2,85	1,91	.008	101,45	0,808	10,90	3,30	2,26	.000	114,93
		Log	0,841	8,12	2,85	1,93	.008	101,50	0,808	10,92	3,30	2,27	.000	115,01
		Verh	0,841	8,15	2,85	1,96	.009	101,67	0,807	10,95	3,31	2,28	.000	115,14
		Mitch	0,841	8,13	2,85	1,89	.008	101,56	0,808	10,91	3,30	2,24	.001	114,97
		MM	0,841	8,13	2,85	1,89	.008	101,56	0,808	10,90	3,30	2,24	.000	114,93
	Autumn	Gomp	0,743	16,78	4,10	3,06	.118	871,93	0,776	10,59	3,25	2,43	.028	673,21
		Log	0,743	16,81	4,10	3,07	.120	872,48	0,775	10,62	3,26	2,44	.029	674,01
		Verh	0,742	16,88	4,11	3,08	.127	873,75	0,774	10,68	3,27	2,45	.032	675,60
		Mitch	0,743	16,79	4,10	3,05	.117	872,11	0,776	10,59	3,25	2,42	.027	673,21
		MM	0,743	16,79	4,10	3,05	.117	872,11	0,776	10,59	3,25	2,42	.027	673,21

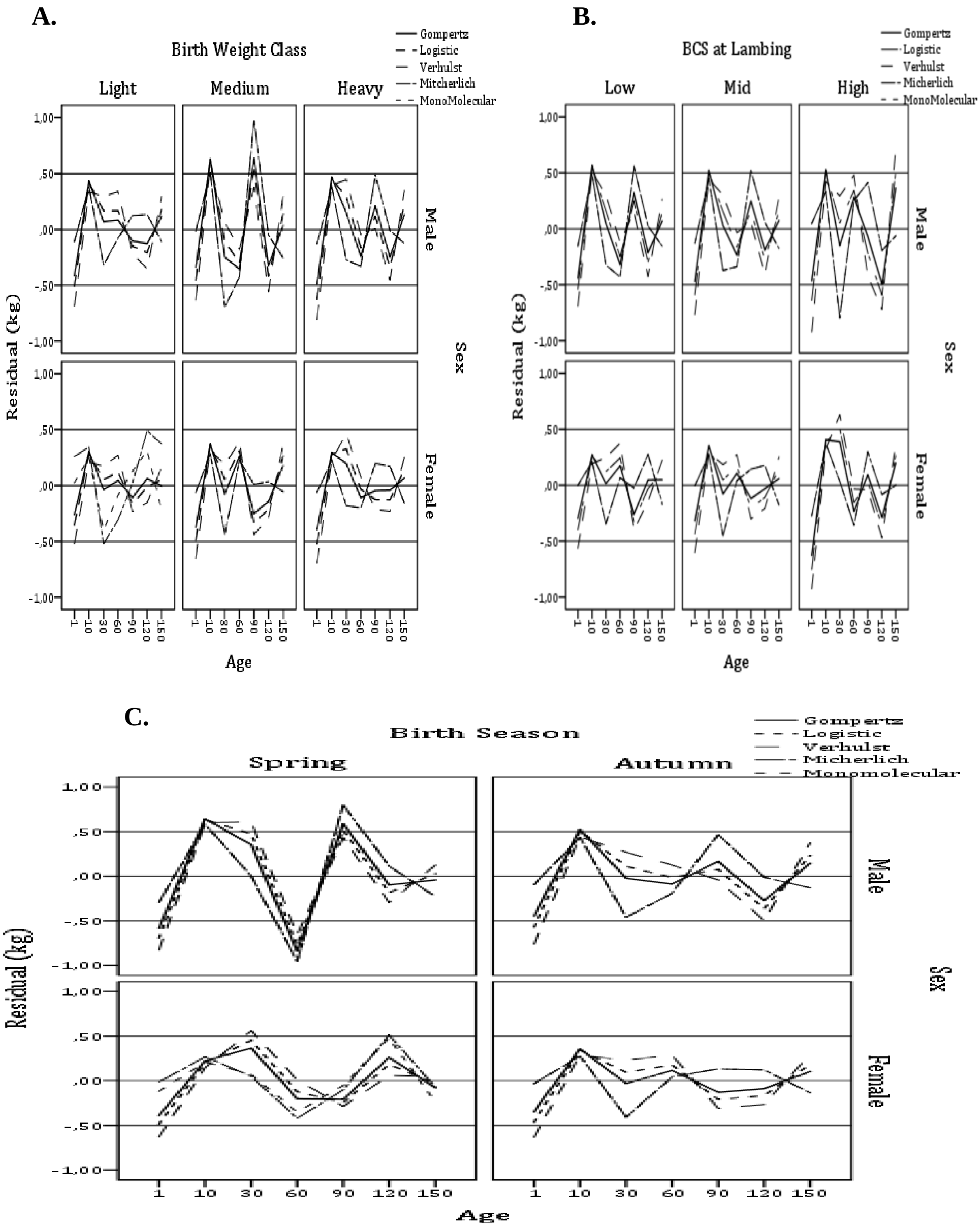

Figure 3.3: Models residuals by lambs' birth weight (A), body condition score of ewes at lambing BCS (B) and birth season (C)

3.5. Comparison of models

Three criteria were used to choose the most robust model. These are the efficiency, the components of the residual and the error recorded in the estimate of the model parameters. Results thus obtained showed that several prediction models, presenting high efficiencies and reduced residual components, but showed relatively higher estimation errors; this is the case with the Mitcherlich and Monomolecular models. The Verhulst model is characterized by lower efficiencies than other models but with the lowest estimation errors. Finally, the Gompertz and Logistic models represent the standard models to fit with the growth of Ouled Djellal lambs, for which the estimation and evaluation parameters were the best (figure 3.4).

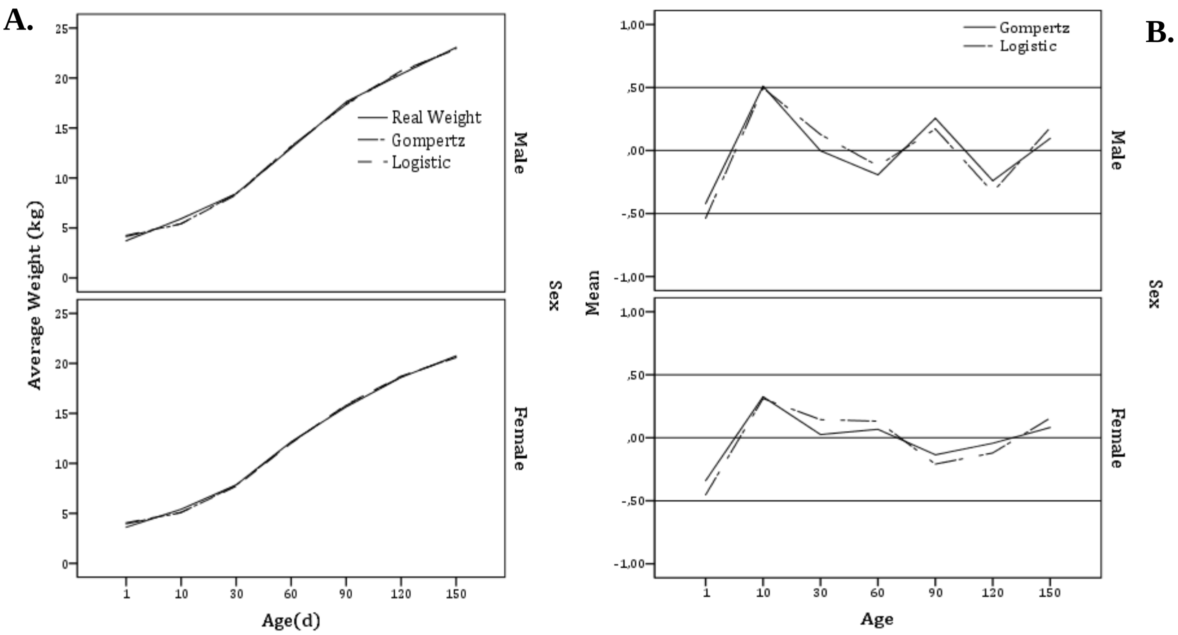

Figure 3.4: Comparison of growth curves (A) and residuals (B) as predicted by Gampertz and Logistic model for Ouled Djellal lambs

Discussion

The results obtained showed that the lambs' birth weight is 3.7 kg in average, with no significant difference observed by sex. Weight slowly progresses to reach 21 kg at the age of 5 months. This birth weight is relatively lower than that recorded in European breeds (4.5 kg on average) (**Makovichy *et al.*, 2017**). **Kurchtik and Dobes (2006),** reported, for the Wallachai breed in Turkey, similar birth weight average (3.6 kg) to that recorded by Ouled Djellal breed with no differences observed by sex, but the growth is faster, generating a weight at 100 days equivalent to more than 30 kg with a difference of 2kg in favor of males.

In Spain, **Lupi *et al*. (2015**) also reported that the sex effect is only detected from the 1st month of age.

Changes in weight vary according to the birth season with faster growth observed for spring births. This effect is linked to the sex of lambs; we observe that the differences between males and females are remarkably developed during autumn season, when they can exceed 3 kg in favor of males. This showed that males better manage best the difficult phases, expressing more adaptation to food restriction during the winter period. This same phenomenon is reported by **Kurchtik and Dobes (2006**) in Turkey where the seasonal effect does not affect birth weight but rather subsequent weights. For this author, winter births are more efficient and register differences of 3 kg at the age of 100 days.

The five models proposed have three parameters; asymptomatic value (a) which represents maximum value, maturity rate (b/m) and relative growth (k). Indeed, the value (a) is higher in males for all models. Thus, the Mitcherlich and Monomolecular models register high values with larger estimation errors. The same findings have been reported by several authors **(Raji *et al.*, 2015; Blan *et al.*, 2015**). **Hossein-Zadeh and Golshahin (2016**) in Iran, for the Guilan population, observed that the Gompertz and Logistic models presented lower values of (a) and acceptable estimation errors, evaluated at less than 1% of the estimated value. These authors report the superiority of males for the estimated values which also registered relatively high standard error rates. The values thus obtained vary depending on factors related to the birth weight, the nutritional status of mothers and the birth season. Indeed, the value of (a) increases with the increase of birth weight, which means that lambs born with a high birth weight retain their superiority thereafter at the final age of 150 days. Lambs from ewes that were obese at birth showed the highest values of (a), mainly in males, but with lower estimation errors. This showed that an aptitude for rapid lambs growth was coming from well fed mothers, they benefit from a more balanced diet during the milking period, promoting a good start and a more sustained development of the animals.

The variability of (b/m) and k parameters, between sex and the other factors, is relatively low, or even close to zero in some cases. The standard errors of the maturity parameter (b/m) are relatively higher for males, as well as in light lambs and lambs of lean ewes. Those of the parameter (k) are comparable and the differences are almost inexistent. Our results do not agree with the observations of **Raji *et al*. (2015**) in Nigeria, who reported that the parameter

(k) is more important in females than in males. However, **Hossein-Zadeh and Golshain (2016**) confirmed that the errors of (k) are comparable for all models.

The models were tested for their adjustment quality (prediction quality) using a test package namely the residual mean squares prediction error (MSE), the root of MSE (RMSE), expressed as a proportion of the observed mean, the mean of the absolute deviations, the bias and the efficiency (**Theil, 1966).**

A reference model is that having high efficiency with the low values of residual components with the lowest possible estimation error. Indeed, the efficiencies and the calculated residual components were comparable between models for a particular category of animal. The best adjustment quality was better in females than in males. The same results have been reported by **Raji *et al.* (2015**) in Nigeria and **Blan *et al.* (2017**) in India.

Therefore, we find from our results that the best models to retain under reserve of the review of estimation errors are Gompetz and Logistic. Our results are close to those reported by **Daskiran *et al.* (2010**) for the Northern breed in Turkey. However, **Tariq *et al.* (2013**) reported that, for the Bangali breed in Pakistan, efficiencies vary between 0.98 and 0.99 and RMSE between 0.35 and 1.65 on a number of 2377 lambs. The same findings were reported by **Ben Hamouda (2012)** for the Barbarine breed in Tunisia (r2 = 0.99). This shows the importance of the large samples in the calibration of a prediction model.

5. CONCLUSION

The present study is related to the application of dynamic models to the growth curves of Ouled Djellal breed. The weight data were collected through monitoring lambs in a commercial farm, located in the southern region of the Wilaya of Bordj Bou Arreridj. A total of 214 lambs and 1498 observations were analyzed. The results obtained showed that the lambs in the region are born with a weight of 3.7 kg and achieve a gain of 18.2 kg for 150 days; and an average daily gain equivalent to 121g /day. This is far from the standard of the Ouled Djellal breed which is characterized by faster growth. Analysis of weight trends showed similar trends observed in males and females with a relatively higher level of growth of males.

Mathematical modeling of growth curves using five common equations was carried out to describe the overall trends of weight trends in Ouled Djellal lambs. The estimation of the parameters of the models and their efficiencies shows that the R^2 vary according to the model

(0.75 to 0.85) with an MSE of 7 to17. Some models presented anomalies in the estimation of the parameters (error of important estimate) or incompatible parameters with the real values (very high asymptomatic value, high growth rate and very low relative growth). Indeed, these models (Mitcherlich, monomolecular and Verhulst) were excluded from the models retained although they present high efficiencies and almost zero biases.

At the end, on several selection criteria, we retained two models that we consider more relevant for the prediction of the growth curve of Ouled Djellal lambs: the Gompertz and the Logistic models.

Calibrating a growth model can help breeders plan for farm management practices such as feeding and drug administration (since these practices are generally focused on bodyweight) and also for breeders for taking decision regarding the selection of highly productive animals by monitoring their growth curve. More investigations are recommended to determine the characteristics of the growth curve of Ouled Djellal breed until mature age.

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GENERAL CONCLUSION

Conclusion

In the present study, we attempted to determine the reproductive, growth and dairy performances of a flock of Ouled Djellal ewes, managed in a low-input breeding system using pastures and cereal crop co-products in the semi-arid region of Algeria. The farm followed is quite representative of the sheep farming system existing in most of the Algerian high cereal plains, which occupy 9% of the total area of the country. First, we analyzed the effects of some factors related to the animals and the environment on the variation of the animal and flock performances. Then, we deepened the investigations on the implications of the factors having significant impacts on the performances of ewes, more particularly, the effect of the BC of the mothers, the quality of the colostrum and the season of reproduction on the elaboration of the productivity of the ewe, to determine finally knowledge and tools of help to the decision to improve the management of the breeding and its production performances.

The results of our study have shown that the modalities of accumulation and mobilization of reserves in ewes is an element that determines not only the individual performance of animals, but also that of the flock. Indeed, the level of BC of ewes varies significantly according to the season, age and litter size. Thus, the management of body reserves is better controlled for a breeding set in autumn and in spring lambing, but whatever the season, the ewes improves her capacity to manage their BC with age, but their capacity does not change significantly with the increase of the litter size. Special assistance may therefore be recommended in the fall for young and old ewes and for ewes with multiple births. We have identified that BC intake at key times in the ewe's productive cycle can be key to better control of the flock's feeding and productivity management.

Our results also showed a high correlation between live weight and BCS in Ouled Djellal ewes; better reserve management during a production cycle was noticed in heavy ewes. The live weight and BC of ewes together can inform us about the birth weight of lambs, which is also strongly correlated with BC scores throughout the gestation period; indeed, lamb weight depends significantly on the weight of the mother, but we also noticed the significant interference of season, age and parity of the ewes, sex and litter size of the lambs on the development of the lamb weight.

We conclude from our results that BC at breeding is a reliable indicator not only of fertility but also of the mechanism of body reserves mobilization during the rest of the production cycle. Thus, our results showed the significant effect of BC at breeding on fertility ($p<0.01$), fecundity ($p<0.001$) of the flock and individual ewe fertility ($p<0.05$). According to our results, at breeding, an average BC of 2.75 for the flock and 2.5 for the ewe is recommended for acceptable reproductive performances.

We also showed that the mechanisms of body reserve management by ewes vary between animals and express significant individual differences; this variability depends on the interactions between the three vital functions (reproduction, lactation and survival), and shows the usefulness of a better knowledge of the strategies of body reserve management of ewes to ensure a more efficient management of flocks according to the objective of livestock systems.

BC at lambing affects ($p<0.000$) lamb birth weight until weaning. A score of 2.5 at lambing is considered the threshold score for efficient lambs and acceptable productivity thereafter. The best performing lambs were born in the autumn and were born to multiparous ewes with a single litter.

The models selected for the prediction of the growth curve of Ouled Djellal lambs are the Gompertz and the Logistic models. That can help breeders to plan feeding and vaccination practices, and also presents an important tool for selection

Our study brought original results concerning the colostrum performance of the Ouled Djellal ewe. Our work allowed the evaluation of biochemical, enzymatic immunological and physicochemical properties of colostrum during the first 24 hours postpartum. The colostrum of Ouled Djellal ewes seems to have comparable concentrations to those of other meat sheep breeds, but it is particularly characterized by high fat (11.36%), protein (15.64%) and IgG (187.80 g / l) contents. The study of the evaluation of the potential influences of some factors on the quality of colostrum showed the significant effect of the age of the mothers; overall the concentrations of components are significantly higher in hoggets, except for lactose and Ca, in the lean mothers, except for triglycerides and Ca and in the ewes with single births.

Colostrum quality showed alteration with time; we identified that hogget and lean ewes produced colostrum of higher protein quality, while mature ewes and heavy ewes produced colostrum with higher energetic content. The main factor affecting variability in colostrum quality appeared to be season. Its effect revealed different individual behaviors in face of limited food availability and difficult rearing conditions, expressing different forms of physiological adaptation of ewes.

Colostrum quality had a significant effect on lamb weight at 10 days (P <0.05) and 30 days (P <0.01) and on ADG at 10 days in Ouled Djellal lambs in spring. Also, colostrum quality had a significant effect on growth pattern from birth to 30 days (P <0.01). This attribute could gain importance as a selection objective. However, colostrum quality had no effect on lamb mortality rate ($p> 0.05$).

This study has allowed to gain an in-depth understanding of the main factors of variation of animal performance; this allows the determination of not only threshold values of BCS for better reproductive and growth performances, but also the understanding of the mechanisms of mobilization of the ewes' reserves in an extensive agropastoral system. This will also allow us in the future to better organize and manage the load in the pastures for example, or the supplementary feeding, etc.

The study has scientific and economic relevance, and provides more concrete solutions, in the ultimate goal to improve the productivity of sheep farms in our rainfed and dry high plains agropastoral regions, while integrating the growing challenge of climate change. It aims to show that the selection of ewes adapted to changing environments with exceptional management modalities is as important as selection based on production performance.

It is recommended, for a more comprehensive study, that the ability of ewes to manage body reserves should be accompanied by the study of their feeding behavior on pasture for better feed management, higher efficiency gains and consequently improvements in food and economic security on a global scale.

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ARTICLE

Enzymatic quality of colostrum in Ouled Djellal ewes, Algeria

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ABSTRACT

Level of colostrums' enzymatic activity is a reliable indicator of ingestion and passive immunity and, thus, the viability of newborns. Our study evaluated the colostrums immunoglobulin-G (IgG) and enzymatic levels during the first 24 h after lambing in ewes and determined the effect of fixed factors on enzymatic quality. Colostrums were milked from 134 Ouled Djellal ewes aged from 1 to 8 years in a commercial farm of Algerian semi-arid region. Samples were taken at 3, 6, 9, 12 and 24 h after lambing and alkaline phosphatase (ALP), γ-glutamyl transferase (GGT) and lactate dehydrogenase (LDH) levels were determined in colostrums using the spectrophotometric analysis (Spin react). The IgG quality of each sample was measured using a digital brix refractometer (PAL colostrum–58%). Results showed significant differences related to milking period, lambing season and animal. Period of milking had significant effect on ALP ($p < 0.01$) and GGT ($p < 0.05$) activities, respectively. The highest enzymatic activity in ewe colostrums was observed in spring, in both lean and fat ewes. Enzymatic activity decreased with age until 5 years old and increased thereafter. GGT and LDH activities can thus be used alongside IgG in the determination of colostrums immunological quality, but ALP cannot.

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KEYWORDS
Colostrum; ewe; enzymatic activities; immunoglobulin-G

1. Introduction

Quality of colostrums is crucial for the profitability of livestock farms as it affects the viability of newborns. In this context, most researchers focus on immunological quality using immunoglobulin assays (e.g. Conneely et al. 2013; Ahmadi et al. 2016; Torres-Rovira et al. 2017; Zarei et al. 2017) since it is the main marker of passive immunity. Others choose enzymatic quality (Drikic et al. 2018), which can also be used as a sensitive, easy and inexpensive test for evaluating colostrums quality (Lombardi et al. 2001), mainly γ-glutamyl transferase (GGT), which contributes to colostrums ingestion (Braun et al. 1984) and has been identified as the first marker of colostrums quality in ewes (Zarrilli et al. 2003a) and in cows (Parich et al., 1997; Topal et al. 2018). On the other hand, according to (Zarrili et al., 2003a; Maden et al. 2004, alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) cannot detect passive immunity, as it cannot predict the transfer status of passive immunity, even though ALP is an essential enzyme in clinical chemistry regarding its activity in various tissues and biological fluids

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(Bjelakovic et al. 2009). Relationships between GGT and ALP with immunoglobulin-G (IgG) have already been extensively studied but so far LDH has never been observed as an indicator of passive immunity.

The objectives of this study were to investigate enzymes activity level in colostrums of Ouled Djellal ewe, evaluate the degree of association between enzymes and IgG, and assess the effect of several factors on the variability of enzymes activities.

2. Material and methods

2.1. Animal material

The experiment was conducted on a commercial farm in the semi-arid region of Algeria located at longitude 5.117°, latitude of 36.033° and at an altitude of 918 m above sea level. It involved 134 ewes aged from 1 to 8 years. Body condition score (BCS) was measured on the scale of Russel et al. (1969) during two lambing seasons (Table 1).

2.2. Experimental design

Colostrum was milked from 134 ewes at 3, 6, 9, 12 and 24 h after lambing. The flock receive similar feeding regimen grazing on cereals in addition to a supplement in sheepfold made of straw, hay and crushed barley (Steaming).

2.3. Biochemical analysis

Following (Zarrili et al., 2003a) protocol, the colostrums was centrifuged twice to extract serum. The colostrums was first centrifuged at 4000 × g for 15 min at 4°C in a refrigerated centrifuge to remove fat and sediment, and the supernatant was then centrifuged at 20,000 × g for 30 min. The final serum samples were stored at – 20°C pending analysis.

ALP, GGT and LDH were measured at 37°C using the commercial reagents Spinreact kit. The IgG quality of each colostrums sample was measured using a digital brix refractometer (PAL colostrums – 58%).

2.4. Statistical analysis

The SPSS (Statistical Package for Social Sciences) version 23 was used for statistical analysis. All data are expressed as mean ± standard error (SE). As the results of the Kolmogorov–Smirnov test for normality showed that the enzymatic activities did not

Table 1. Distribution of experimental flocks according to fixed factors.

	Modality	Number	Percentage (%)
Age range	Yearling	10	12.2
	Young ewe	33	40.2
	Adult ewe	39	47.6
BCS	≤ 2	46	38.7
	>2–3.25<	41	34.5
	≥3.5	32	26.9
Lambing season	Spring	33	24.6
	Autumn	101	75.4

follow a normal distribution, the non-parametric test of *Kruskal-Wallis* was performed to evaluate the variability of enzymatic activities among all fixed factors. The correlation between enzyme activities and IgG was determined by the correlation coefficient measured by the Spearman non-parametric correlation test.

3. Results

3.1. Enzymatic activities

Means and standard deviations of ALP, GGT and LDH activities in ewe's colostrums are shown in Figure 1. Comparing the three enzymes activities mean rates with each other, it can be observed that the most important activity was noticed in GGT (7821.15 IU/l) and the lowest values were observed in both ALP (655.97) and LDH (589.28) activities.

3.2. Factors affecting enzymatic activities

Many factors can affect the enzymatic activities in ewes' colostrums. Time of milking was the most determinant factor according to (Ahmadi et al. 2016) who noticed a decrease in enzymatic quality with time. Period of milking had significant effect on ALP ($p < 0.01$) and GGT ($p < 0.05$) activities, respectively. Indeed, different profiles of enzymatic activities of ALP, GGT and LDH related to the time of milking were observed (Figure 2). The profiles of enzymatic activities, according to milking period, were performed by season. Differences between enzymatic profiles were observed in time and amplitude of peaks.

Maximum level of ALP was observed in spring. It is noticed 3 h later and twice as important as its level in autumn and then decreased steadily with time. In spring, a significant regular decrease was observed in GGT activity from the first milking, although

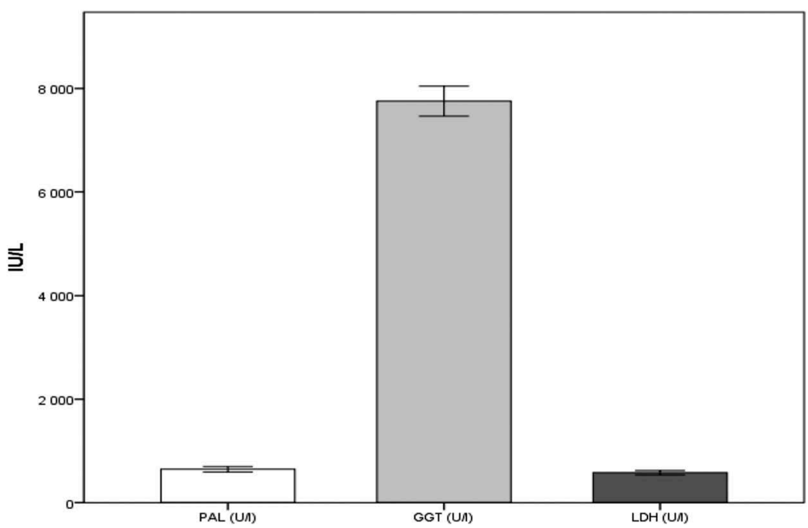

Figure 1. Enzyme activities of Alkaline Phosphatase (ALP), γ-Glutamyl Transferase (GGT) and Lactate Dehydrogenase (LDH) expressed as IU in ewes colostrums in the 24 h after lambing; results are presented as mean± SE.

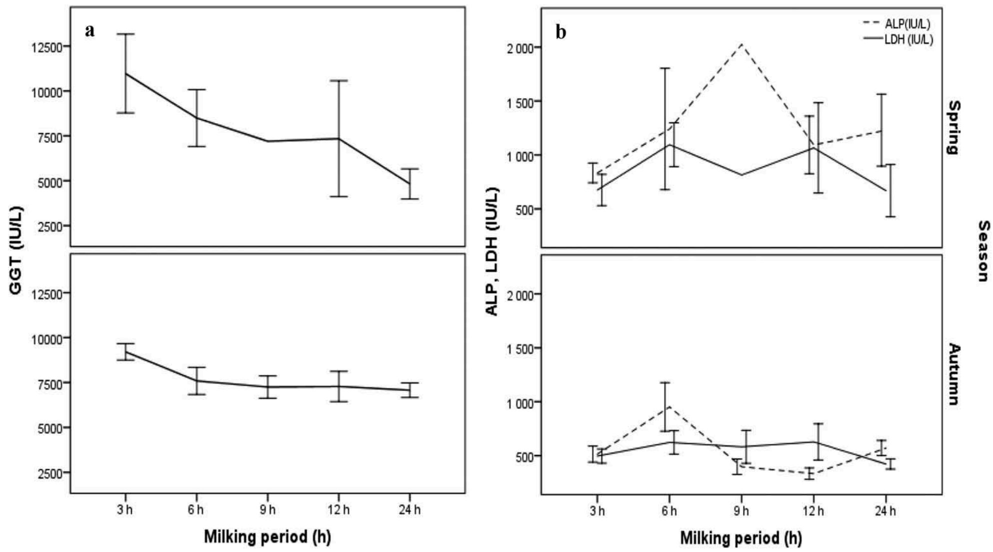

Figure 2. Evolution of enzymatic activities of γ-Glutamyl Transferase (GGT, A) and both Lactate Dehydrogenase (LDH, B) and Alkaline Phosphatase (ALP, B) in the colostrum of 134 ewes in different milking periods and per season (spring and autumn periods); results are presented as mean± SE.

we observed a high variability between ewes. While in autumn, we noticed more stability of GGT (close to 7500 IU) and LDH (close to 500 IU) during all the milking period when compared to spring activity. (Aydogdu and Guzelbektes., 2018) reported that decrease will be related to the increase of serum GGT activity observed in newborn serum.

Effects of Age, BCS, season and interactions on enzymatic activities were studied (Table 2).

Age, season, BCS, age-BCS and season-BCS interactions had significant effects on enzymatic activities. Our results revealed a significant ($p < 0.05$) decreasing tendency of ALP with age and when ewes gain weight. LDH and GGT showed contrasting trend; their highest levels were observed in yearlings and adults, and for lean ewes ($p < 0.05$). Highest levels of LDH ($p < 0.05$) and GGT were observed in spring.

3.3. Correlation between enzymes activities and IgG

Correlation test showed that IgG was significantly ($p < 0.01$) correlated with GGT and LDH; IgG was also correlated to GGT for lean ewes (0.58) and LDH for lean (0.42) and fat ewes (0.37); IgG was correlated to GGT in spring season and LDH for during the two seasons; milking period was significantly correlated only to LDH (Table 3).

4. Discussion

Our study reported, for the first time, significant correlation between LDH and passive immunity, and provided reference values of ALP, GGT and LDH activities in Ouled Djellal ewes' colostrum; our results also revealed factors affecting enzymatic variability.

Table 2. Variation of enzymatic activities (Alkaline Phosphatase (ALP), γ-Glutamyl Transferase (GGT) and Lactate Dehydrogenase (LDH)) in Ouled Djellal ewes' colostrums.

		ALP (U/l) Mean(ES)	GGT (U/l) Mean(ES)	LDH (U/l) Mean(ES)
Season				
Spring		1020.42 (142.62)	8092.50 (835.45)	776.08 (97.24)
Autumn		522.38 (44.27)	7682.19 (271.12)	520.38 (43.88)
p		***	**ns**	*
Age				
Yearling		814.39 (167.12)	8110.19 (985.78)	725.37 (124.14)
Young ewe		690.03 (124.48)	7441.63 (676.90)	482.29 (49.38)
Adult ewe		697.66 (87.56)	8187.46 (503.15)	682.51 (85.39)
P		*	**ns**	**ns**
BCS				677.56 (76.33)
≤ 2		864.97 (114.91)	8330.98 (597.06)	
[2–3.25]		558.42 (76.71)	6597.36 (441.69)	479.06 (79.43)
≥ 3.5		428.17 (45.00)	8304.13 (438.55)	573.38 (81.33)
P		*	*	*
Age * BCS				
Yearling	≤ 2	1314.06 (667.03)	7584.58 (2455.18)	993.22 (661.53)
	[2–3.25]	810.98 (513.39)	7192.36 (5964.11)	649.23 (331.94)
	≥3.5	297.00	8732.22	290.70
P		*	ns	ns
Young ewe	≤ 2	1051.56 (1061.82)	8795.75 (5341.42)	580.28 (352.48)
	3.25]	530.57 (359.20)	5792.65 (2574.54)	382.75 (194.92)
	≥ 3.5	454.58 (349.48)	7608.33 (2749.94)	401.17 (266.61)
P		**ns**	**ns**	**ns**
Adult ewe	≤ 2	870.27 (670.12)	8131.67 (4445.68)	877.91 (658.37)
	3.25]	618.40 (691.63)	6474.28 (2576.11)	407.67 (393.20)
	–≥3.5	396.92 (142.73)	10.104.95 (1362.59)	851.11 (753.78)
P		*	**	**
Season * BCS				
Spring	≤ 2	1174.53 (219.54)	8385.87 (1210.28)	949.36 (152.45)
	3.25]–	1009.14 (209.08)	6872.01 (2528.25)	609.50 (125.04)
	≥3.5	–	–	–
P		ns	ns	ns
Autumn	≤ 2	658.59 (110.17)	8292.36 (580.88)	486.29 (49.51)
	3.25]	495.82 (77.76)	6559.21 (390.03)	460.95 (88.81)
	–≥ 3.5	428.17 (45.00)	8304.13 (438.55)	573.38 (81.33)
P		ns	*	*

ns: not significant * Significant at 5%. ** Significant at 1%.

The proportions founded confirm (Zarrili et al., 2003a) findings. Similar results were also found in cows (Lombardi et al. 2001; Krsmanović et al. 2016; Aydogdu and Guzelbektes., 2018) and goats (Zarrili et al., 2003b). The enzymatic activities obtained in Ouled Djellal ewes were moderate when compared to findings of (Zarrili et al., 2003a) in ewes from Puglia region, Italy, and (Maden et al. 2004) in Akkaraman sheep in Turkey; the difference may be related to breed characteristics, diet and feeding plan (Ahamdi et al., 2016), or environmental conditions (Yang et al. 2014) .

Few researches had studied the trend of colostrum quality in time. (Oyeniyi and Hunter 1978) observed a significant constant decrease at $p < 0.01$ of dry matter, ash, total protein between the first, the second (12 h postpartum) and the third (24 h post-partum) milking. (Morin et al. 2010) had also reported a decrease in colostral IgG concentration of 3.7% per hour post-calving. These results could be extrapolated to the enzymatic quality since a strong relationship has been reported in the literature between protein, albumin, IgG and enzymes (Parish et al. 1997; Lombardi et al. 2001; Zarrili et al., 2003a; Alves et al. 2015).

Table 3. Correlation matrix between colostrums enzymes and total immunoglobulin-G (IgG).

Factor	Level	*n*	PAL (U/l)	GGT (U/l)	LDH (U/l)
Age	Yearling	10	−0.176	0.479	0.139
	Young ewe	33	0.247	0.171	0.213
	Adult ewe	39	0.030	0.146	0.267
BCS	≤2	46	0.339*	0.581**	0.425**
	[2–3.5]	41	0.036	0.127	0.103
	≥3.5	32	0.202	−0.285	0.371*
Season	Spring	33	0.190	0.630**	0.394*
	Autumn	101	0.164	0.039	0.235*
Milking period	3 h	29	−0.082	0.326	−0.022
	6 h	15	−0.463	−0.049	0.022
	9 h	14	0.209	0.020	0.216
	12 h	22	0.406	0.279	0.548**
	24 h	29	0.438*	0.233	0.480**
All data		134	0.153	0.227**	0.262**

Correlation signification: * Significant at 5%. ** Significant at 1%.
The correlation coefficient was measured by the non-parametric correlation of Spearman.

An inverse relationship was reported by (Conneely et al. 2013) between milking period and cows' colostrum weight, who explained that by a dilution effect. There are a few research examining the evolution of enzymatic quality of ewes' colostrums, which can be an area that needs further investigations.

The highest enzymatic activity was observed in spring; (Yang et al. 2014) found that the enzymatic activity increases with temperatures, and may also be related to diet characteristics.

Age does not affect the activity of the GGT and LDH as reported by (Alves et al. 2015). However, we observed a significant superiority ($p < 0.05$) of enzymatic activity in yearling for ALP. GGT and LDH showed lower enzyme activity in young ewes compared to yearlings and older ewes. Skripkin et al. (2018) confirm our results indicating that, with age, ALP serum concentrations decreased differently when compared to GGT and LDH trends. However, contrasting results were observed in cows by Aydogdu and Guzelbektes (2018) reporting that colostrums GGT activity in primiparous was higher than in multiparous.

BCS significantly affects enzymatic activities ($p < 0.05$) with similar trends to those related to age. Our results confirm Al-Sabbagh (2009) findings, reporting that ewes with moderate BCS (scored 2.5–3.5) produced more colostrums than both fat (>3.5) and lean ewes (<2.5) and explain low concentration of enzymatic activity by dilution; whereas, (Chapel et al. 2017) found that enzymatic activities increased in postpartum period and that the highest activities were observed in cows with BCS > 3.75 than cows with BCS from 3.25 to 3.75.

The interaction of age and BCS significantly impacted enzymes activities in similar way as individually. The interaction influenced ALP activity ($p < 0.05$) in yearlings and adults ewes and affected ($p < 0.01$) GGT and LDH only in adults. ALP decreased proportionally with age and BCS; this result was consistent with Yang et al. (2014) findings only for ALP activity; in cattle, they observed an increase in ALP activity with age. For GGT and LDH, the highest enzymatic activities (8330.98 and 8304.13 for GGT; 677.56 and 573.38 for LDH) were observed, respectively, in lean and fat ewes. Age–BCS interaction was studied in ewes by Alves et al. (2015) stating that age/parity had affected significantly colostrum production with BCS scored <2.75 and had no affect with BCS scored ≥2.75.

Roche et al. (2009) noticed similar findings for cow and related it to the interferences of growth and other physiological needs in yearlings; in contrast our findings, this may be due to limited by the number of yearlings.

Season–BCS interaction had an effect ($p < 0.05$) on GGT and LDH activities only in autumn; the highest activity was reported for lean and fat sheep. In spring, no effect of season–BCS interaction had been detected. We can conclude that BCS effect is more noticed in limited feed conditions as in autumn season.

Enzymatic activities of LDH and GGT were correlated with IgG levels in the Ouled Djellal ewes' colostrums at $p < 0.01$, while no correlation with ALP was observed.

GGT activity is an early indicator of failure of passive transfer; this result are consistent with those of (Braun et al. 1984; Lombardi et al. 2001; Zarrili et al., 2003a; Maden et al. 2004; Bender and Bostedt 2009; Pekcan et al. 2013; Topal et al. 2018; Aydogdu and Guzelbektes 2018) .

With regard to LDH, (Lombardi et al. 2001; Samarütel et al., 2016) did not detect any correlation between IgG and the activity of LDH in cows' colostrums; similar results were observed in ewes by (Zarrili et al 2003a). However, LDH and IgG correlation can be explained by (Chagunda et al.'s 2006) results, who considered that LDH activity is an indicator of the cows' udder health, and (Lehmann et al. 2013) who postulated that LDH activity was a suitable marker for the presence of IgG in milk. More recent publications (Hernandez-Castellano et al. 2017) founded positive correlation between LDH and IgG in milk of cows with mastitis.

Correlation between IgG and GGT was observed in spring in lean ewes, whereas correlation between IgG and LDH was observed in lean and fat ewes, in the two seasons and after 12 h of milking. In literature, correlation between GGT, LDH and IgG is not yet clear; for GGT activity, it was hypothesized that it is related to protein synthesis (Lombardi et al. 2001). This could explain its high activity in the udder, where large amounts of proteins are synthesized. Our results indicate that LDH and GGT can constitute suitable parameters to evaluate passive transfer state of immunity and could also be informative of passive transfer state in ewes, but further investigations are needed to confirm our findings.

5. Conclusion

Our findings reveal significant correlation between LDH and IgG, but needs more investigations to confirm its potential use as an indicator of passive immunity of lambs.

Our study also gives estimation of enzymatic quality (ALP, GGT and LDH) and variables affecting Ouled Djellal ewes' colostrums enzymes levels. We demonstrate that animal, season of lambing and time of milking had a significant effect on colostrums enzymatic-level variability; the highest enzymatic activities were observed in spring, in lean and fat ewes, and in yearling and adult ewes. Those results can help improve management and genetic selection to decrease lambs' neonatal mortalities. Most studies of enzymatic activities in ewes' colostrums have been carried out in humid areas, which probably can make our results a reference in semi arid regions.

Disclosure statement

No potential conflict of interest was reported by the authors.

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ملخص:

يعتبر التكيف مع الظروف الغذائية الصعبة في المناطق شبه الجافة من الجزائر ذو أهمية خاصة لتحسين أداء القطعان وإنتاجية المزارع الحيوانية. الأهداف من دراستنا هي : أولاً فهم و تقييم التباين في أداء سلالة أغنام أولاد جلال ، ثم تحديد الأنماط العامة و نماذج للتباين في حالة جسم النعاج لفهم العلاقات بين الآليات الفسيولوجية لإدارة احتياطيات الجسم وأداء الحيوان. أجريت دراستنا في مزرعة "يحيى بن عيشوش" وضمت 696 نعجة و 737 حمل من سلالة أولاد جلال.أتاحت لنا نتائجنا تقدير أداء إنتاج الحيوانات وأظهرت أن حالة الجسم تؤثر بشكل كبير على الخصوبة و القابلية للقاح النعاج ونمو الحملان مع تحديد قيم العتبة (2.75 عند التناسل و 2.5 عند الولادة) لتحسين القدرات. أظهرت نتائجنا أيضًا وجود صلة بين الوزن الحي للنعاج و احتياطيات الجسم ، تجعل من الممكن التنبؤ بوزن الحملان عند الولادة . النماذج Gompertz و Logistique تمثل بشكل أفضل منحنيات النمو لأغنام أولاد جلال .يمكن تحسين بقاء الحملان من خلال استهلاك اللبأ سلالة أغنام أولاد جلال الذي أظهر خصائص جيدة. تتطلب تقوية قطاع الأغنام في الجزائر حلولاً تتكيف مع أنظمة الإنتاج لدينا والتي تتمثل في اختيار المرونة التي طورتها الحيوانات لمساعدتنا على إدارة سلوك التغذية بشكل أفضل من ناحية، وبالتالي تعزيز هذا القطاع من خلال اختيار الحيوانات الأكثر كفاءة و التي تقدم أفضل أداء.

الكلمات المفتاحية: التكيف ، أولاد جلال ، النعاج ، الحملان ، الأداء، التكاثر ،النمو، اللبأ ،احتياطات الجسم.

Résumé :

L'adaptation des ovins aux conditions d'alimentation difficiles dans les régions semi-arides de l'Algérie revêt un intérêt particulier pour l'amélioration des performances des troupeaux et de la productivité des exploitations d'élevage. L'objectif de notre étude est de comprendre et d'évaluer la variabilité des performances de production des ovins de race Oued Djellal, et déterminer les schémas généraux et les modèles de variation de l'état corporel des brebis. Notre étude a été réalisée dans une ferme commerciale 'Yehia Ben Aichouche' en zone semi aride et a porté sur 696 brebis et 737 agneaux de race Ouled Djellal. Nos résultats ont permis d'estimer les performances de production des animaux avec la détermination de valeurs seuils (2.75 au moment de la lutte et 2.5 au moment de la mise bas) pour de meilleures performances. Nos résultats ont montré une liaison entre le poids vif des mères et leurs états corporels, et qui permet de prédire le poids à la naissance des agneaux. Les modèles Gompertz et Logistique représentent mieux les courbes de croissance des agneaux Ouled Djellal. La viabilité des agneaux peuvent être améliorée par la consommation du colostrum qui a montré de bonnes qualités chez la race Ouled Djellal. Le renforcement de la filière ovine en Algérie nécessite des solutions adaptés à nos systèmes de production et qui consiste à sélectionner les brebis résilientes pour nous aider à mieux gérer la conduite alimentaire et renforcer le secteur par les animaux les plus efficients qui donnent de meilleurs performances.

Mots clés : Adaptation, Ouled Djellal, brebis, agneaux, performances, reproduction, croissance, colostrum, état corporel.

Abstract:

Adapting to the difficult feed conditions in semi-arid regions of Algeria has particular interest for improving animal performances and livestock breeding productivity. The objectives of our study are to understand and assess the variability production performances of Ouled Djellal sheep, then set up the general patterns and models of variation of ewes' body condition. Our study was carried out in a commercial farm 'Yehia Ben Aichouche' in the semi-arid region, and involved 696 ewes and 737 lambs of Ouled Djellal sheep breeds. Our results allowed us to estimate the animals' production performances with the determination of limit values (2.75 at breeding and 2.5 at lambing) for enhanced performances. Achieved results also allowed us to find an association between ewes' live weight and theirs body condition score, and makes possible to predict lambs' birth weight. Our results showed that Gompertz and Logistics models represented the best the growth curves of Ouled Djellal lambs. The viability of lambs can be improved by consuming colostrum which has shown good quality in Ouled Djellal sheep breed. The strengthening of the sheep sector in Algeria requires adapted solutions to our production systems which consist in selecting the resilient ewes to better manage the feeding behavior and subsequently strengthen the sector by the most efficient animals that give the best performances.

Key words: Adaptation, Ouled Djellal, ewes, lambs, performance, reproduction, growth, colostrum, body condition.