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Effect of rearing systems on the production, reproduction and welfare of small ruminants in Lebanon

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To my children:

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Abstract

In Lebanon, small ruminants hold a key role in the economy of marginal regions and contribute to the income of the population involved in pastoral activities. The production does not meet the national growing demand for milk and meat, thus Lebanon depends on importation to satisfy the needs of the population. The aim of the thesis is to identify the principle rearing systems available in Lebanon and to optimize the small ruminant's production and reproduction according to those systems. The welfare notion will be studied in order to evaluate its impact on animal productivity and to aware farmers of welfare importance in their management strategy.

The experimental work started by the elaboration of a detailed questionnaire to be filled at the 517 farms representing the seven Lebanese districts. This survey was structured to collect informations related to the farm and the farmers, the production parameters, the reproduction parameters, the hygiene and the animal welfare. Results showed three different clusters representing the small ruminants systems in Lebanon and indicated on this thesis as "intensive system" 5 farms with a herd size of 740 ± 707 head, "semi-intensive system" 246 farms with a herd size of 145 ± 109 head and "extensive system" 266 farms with a herd size of 200 ± 152 head. Results concerning the effect of rearing systems on the reproduction of sheep and goats in Lebanon showed a weight at birth of kids and lambs varying from 3.9 Kg to 5.4kg between the different rearing systems. Prolificacy was 1.11 and 1.27 in the extensive system, 1.28 and 1.40 in the semi-intensive system and 1.79 and 1.77 in the intensive system for sheep and goats respectively. Fertility recorded 88%, 85 and 80% in the intensive, semi-intensive and extensive systems respectively. First lambing occurred at 12 months in the intensive system, 20 months in the semi-intensive and 21 months in the extensive for both sheep and goats. The average milk yield of ewes in intensive flock was 336.7 l/year, ewe in semi-intensive and extensive system produced 163.5l/year and 129.9l/year respectively ($p<0.005$). Flocks raised in the Bekaa district showed the lowest milk production compared to the other districts in the three rearing systems, significantly in the intensive and extensive systems. Goats raised in intensive system showed high annual milk yield 587.5 L/year. Annual milk production was significantly ($p<0.005$) affected by the rearing system with goats raised under semi-intensive system producing more milk (198.7 L/year) than those raised in the extensive system (133 L/year).

Animal welfare was studied in six semi-intensive and extensive farms to evaluate the effect of different stressors on the animals: environmental, physical, nutritional, management, pathological and psychogenic stressors. Cardinal physiological parameters were within the normal range for the small ruminants raised in semi–intensive systems during both winter and summer periods. The extensive system results, showed a high values of the pulse rate and the breathing score (107.55 ± 3.67 and 1.38 ± 0.49 respectively) during the summer period at noon when goats and sheep were exposed to high temperatures in direct sunlight. Sheep and goat houses were often inadequate in terms of design, materials and size. During May, small ruminants raised in both extensive and semi-intensive system, showed the higher body score condition (3.45 and 3.3 respectively). In extensive system, BCS declined during the summer period to reach a 2.4 score in September. While in semi-intensive system BCS maintained the same score during July and decreased to a score of 2.8 in September. BCS increased in November (around 3.15) for both systems and decreased again during January and March with a more expressive trend in the extensive system. Dehorning is practiced in a limited way in both semi-intensive and extensive system (7% and 10% respectively when needed).

The third experiment focused on the Bio molecular Study of the Melatonin receptors. 338 blood samples from 9 farms of local multiparous sheep (n=164) and goats (n=174) with a regular cycle, similar body condition score and similar average productivity, were collected using 2.5ml EDTA tubes in duplicate and directly refrigerated. Samples were frozen and transmitted with dry ice to the veterinary department in Sassari for DNA extraction and PCR analysis. Data concerning production and reproduction of the sampled animals were recorded. In all the analyzed sheep samples amplification products resulted in a single fragment of 824-bp in length that correspond to the entire MTNR1A exon II. Also in goat samples PCR evidenced a single band of 824-bp in length, corresponding to the MTNR1A exon II, according to the newest goat reference sequence ARS1 - *Capra hircus* melatonin receptor type 1A gene – GenBank assembly accession number: GCA_001704415.1. The allelic and genotypic frequency at the position g.17355458C>T found in the Awassi sheep showed a high frequency of the C allele and of the genotype C/C. The two most representative SNPs of the MTNR1A gene in the Awassi breed did not show any association with reproductive seasonality. The very limited variability found between the two breeds of goats analyzed in this research, does not make it possible to investigate the relationship between melatonin receptor polymorphism and reproductive seasonality.

To work in a sustainable perspective, it is highly suggested to keep the entity of each system with improving the zootechnical and welfare operations to valorize the natural rangelands and benefit from the native breeds characteristics and potentials.

Keywords: Baladi goats, Awassi sheep, welfare, rearing systems, production, reproduction.

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1 Introduction

1.1 Preface

In Lebanon, small ruminants, hold historically and traditionally a key role in the economy of marginal regions and contribute to the income of the population involved in pastoral activities (Hamadeh *et al*., 1996). The Lebanese goat herd counts around 436,000 head, 95% of which is from the local population "Baladi" and 5% from the Damasquine breed. The Lebanese sheep herd has around 350,000 head and is principally made up of the Awassi fat-tailed breed (FAO, 2001).

This high density of animals in a small country (superficie of 10452 km^2) does not meet the national growing demand for milk and meat, thus Lebanon depends on imports to satisfy the needs of the population.

Based on our research (Hosri and Nehme, 2006) and previous studies (Hamadeh *et al*., 1996; Hamadeh *et al*., 2001 and Chedid *et al.*, 2018;), the small ruminant production systems identified in the country range from transhumant to semi-nomadic, semi-sedentary and intensive systems and vary in the mobility of the herds, their use of rangelands, their size and composition.

Those identified systems have shown instabilities over the last fifteen years reflecting the effect of climatic constraints, depletion of natural pastures, increasing urbanization and lack of efficient awareness for the farmers (Hosri and Nehme, 2006; Darwish and Faour, 2008). In addition, as described by Chedid *et al.* (2018), all systems complained from the weak public veterinary services and a limited productivity due to the traditional methods of production (Abi Saab and Sleiman, 1995).

Alexander *et al*. (2012) mentioned that the future of livestock farming could be ameliorated by:

- Increasing the productivity through the intensification, the use of locally available resources and the improving of animal performance;
- Adopting techniques that guarantee the three pillars of sustainability (environmental, economic and social).

Thus, in order to improve the productivity of the herd, it appears important in the first step to understand the functioning of each system and to identify the weaknesses; then make benefit from the local populations potential reflecting their characteristics and adaptation. In addition it would be interesting to focus on the reproduction, as a key parameter of the herd productivity. Finally efforts should be done to adapt each system to the feed resources available as a part of the nutritional needs of the animals.

In this context, the aim of the thesis is to identify the principle rearing systems available in Lebanon and to optimize the small ruminant's production and reproduction according to those systems. The welfare notion will be studied in order to evaluate its impact on animal productivity and to aware farmers of welfare importance in their management strategy.

This document will serve as a tool to help breeders or decision-makers in a technical and political framework.

1.2 Small Ruminants breeds in Lebanon and productivity

1.2.1 Goat

The goat population in Lebanon is represented by the local population, known as "Baladi" (95% of the population) and the Damasquine breed (5% of the population). The dominant "Baladi" population is well adapted to climatic conditions and lives in continuous transhumance.

The goat herd is distributed in all Lebanese regions (Tab.1) with a high concentration in the Bekaa plain (45%) and low around the capital Beirut (FAO, 2001).

Table 1: Distribution of the goat population in Lebanon (FAO, 2001).

Area	Effective (head)	% of total
Mount Lebanon	46262	10.6
North of Lebanon	63278	14.5
Bekaa	206250	47.3
South	41549	9.5
Nabatiyé	78626	18.0
Total Lebanon	435965	100.0

1.2.1.1 Baladi goat (local breed)

The "Baladi" population, characterized by long hairs, mostly black or dark gray, is known for its hardiness and its adaptation to various environmental conditions (Abi Saab *et al.*, 1997). The weight of the adult female varies between 35 and 40 kg while that of the male varies between 65 and 70 kg. The first birth of the goats takes place between 20 and 24 months. They are raised for their production of milk and meat. The slaughter weight of the kids is 35-40 kg. This breed is well adapted to the mountainous regions where it is frequently found, and is of particular interest because of its walking ability, better thermal regulation and higher storage and mobilization capacity (Flamant and Cocks, 1989). The traditional farming method followed by Lebanese herders requires traveling long distances, which affects the production of goats. Since these consume only available vegetation, often poor on rangelands (Rahme, 1997). In addition, pastoralists do not plan their movements and their lack of training leads them to make some mistakes, such as accepting too much density per hectare. The result is an imbalance and a food deficit for goats. (Fig.1)

Figure 1. Baladi goat.

Some breeders say the Baladi breed is not productive enough and needs to be replaced by another, more productive breed that would cause less damage to nature. However, a current trend in ecology is the conservation of animal biodiversity, which leads to avoid the disappearance of this breed. To achieve this, it seems necessary to improve its production performance (Abi Antoun, 1998). Such an approach seems conceivable since no study has so far established the optimal conditions for breeding to enhance all its genetic potential for production and reproduction.

1.2.1.2 Damasquine breed

The Damascquine goat (Fig.2), also known as the Shami, is a native breed of Syria and other Near East countries (Mavrogenis *et al*., 2006). It is characterized by a reddish-brown coat with long hair and can be stained on the head, legs and abdomen. The black coat is extremely rare and may appear as a result of the presence of a recessive gene in the population. The ears are long and pendulous and the head is long with a Roman nose (Hancock and Louca, 1975).

Figure 2. Damasquine goat.

The weight of the adult female varies between 55 kg and 65 kg while that of the male varies between 70 and 90 kg (Constantinou, 1987).

This breed is considered as one of the best dual-purpose breeds of the Middle East under semi-intensive or intensive production systems, combining high prolificacy with high milk production (Mavrogenis *et al*., 2006). It was introduced in Lebanon for its milk production superior to that of the Baladi population. Total milk production, including milk produced until weaning, ranges between 350Kg and 650 Kg per goat per lactation (Louca *et al*., 1975). This breed has high prolificacy of 1.80 kids per doe per kidding the fertility is medium to high 80 to 90% (Constantinou, 1981). Birth at weigh in the semi-intensive system are high and range from 3.5 to 5.5 kg depending on the type of birth and sex (Mavrogenis *et al*., 2006).

1.2.2 Sheep

The Awassi is a predominant dual purpose, fat-tailed sheep breed of the Middle East (Gootwine *et al*., 1992). It is the main sheep breed in Iraq and Syria, the only native breed in Jordan (Hailat, 2005) and Lebanon (Sleiman and Abi Saab, 1995) and represents an important contribution to sheep breeds in Turkey (3.5% of total sheep population, Gursoy, 2005). The breed has spread from its place of origin in South West Asia to all continents including Australia and South America. It is the only sheep breed of non-European origin that acclaimed such wide distribution.

Awassi breed has been described earlier by Mason (1967), Epstein (1985) and more recently by Fahmy and Shrestha (2001), Hailat (2005), Alkass and Juma (2005), Khazaal (2005), Kassem (2005) and Gursoy (2005) in different countries. It is of a medium size, body covered with long coarse wool of creamy white color. The head is long and narrow with a convex forehead profile. It is bare and brown or black in color. Rams usually have horns that are twisted backwards and downwards with tips pointing outwards, while ewes are polled. Ears are of medium size and often pendulous. Neck is relatively long, strong in rams and fine in ewes. Body is relatively long and legs are medium in length and wide apart. Tail is characteristically fat, broad and medium in length ending above the hocks. The tail emerges from the rump in one stem that hangs down into two lobes that broaden out toward their lower portion which ends more or less abruptly in a short thick appendix. The lower part of the lobes is divided by a deep rift. Udder and teats vary greatly from one Awassi population to another. In dairy populations, i.e. Improved Awassi the udder is well developed and teats are regularly placed, while in other non-selected populations the udder is of moderate size and teats are extremely variable in size, shape and orientation. There are many variants or subpopulations of Awassi sheep. Some of these variants are Naiemi in Kuwait, Iraq and Syria, Shefali in Iraq and Herrik in Iraq (Alkass and Juma, 2005). (Fig.3)

Figure 3. Awassi sheep

Awassi sheep are well adapted to harsh environmental conditions, especially those related to the scarcity of feed availability and high environmental temperatures (Said *et al*., 1999). It also possesses very desirable characteristics such as endurance to nutritional fluctuations, resistance to diseases and parasites beside its high milk producing and growth abilities (Gursoy *et al*., 1992, 1993).

Productivity of unimproved Awassi sheep under extensive management conditions tends to be low (Abdullah et *al*., 2002). The Awassi sheep mate primarily during the period of May–July (beginning of the summer), produce about 1.05 lambs per ewe and 40 - 60 kg of milk per 150-day lactation under extensive conditions (Epstein, 1985; Degen and Benjamin, 2003). Crossbreeding of sheep offers great opportunities for improving the efficiency, prolificacy and quality of market lamb production (Casas *et al*., 2004), growth, milk production and reproduction in less prolific breeds (Gootwine *et al*., 1992).

The Improved Awassi strain of the breed is known to have the highest milk production after the East Friesian.

1.3 Lebanese Small Ruminants Production Systems

The breeding system is the result of an interaction between ecological elements and socio-economic factors. It constitutes an important factor of variation of the shape of the lactation curves, integrating differences of genetic levels, level of technicality, buildings, feeding conditions and climatic conditions (Bouloc, 1992).

Small ruminants in Mediterranean regions have common points which can be analyzed and compared like:

- The importance of work for the management of farms generally with low mechanization.

- An important link to the territory and the tradition.

- A general good natural and environmental positive image.

- A low income compared to the average of other farm production sectors.

Dairy sheep and goats are per excellence the major farm animals of the Mediterranean basin. The two main traits of animal production that have been conditioned by the physical and human environment of the Mediterranean are as follows:

- animal factor is often associated with cereal (manure and grazing of fallow land);
- livestock management is linked to natural resources (forage) available. Thus, in the northern part of the basin, flocks of sheep and goats have traditionally transhumed from summer mountain grazing's to the plains in winter; in the south a unique way of life was born due to nomadic small ruminant grazing (Boyazoglu and Morand-Fehr, 2001).

1.3.1 Classification of the small ruminant production systems

According to Zervas and Tsiplakou (2011) dairy sheep and goat farming systems in the Mediterranean basin, could be grouped, according to the degree of intensification, breed characteristics, land dependency, flock size, stock feeding, origin, performance, volume of production, in the following simplified classes:

- indoor: often a gradual conversion from other systems as purchased feeds replace cultivated fodder;
- sedentary managed forage area: part of pastoral and indoor systems in which the holding provides part of the fodder needs;
- sedentary semi-natural grassland: semi-natural grassland on the farm holding, although some grazing to other pastures may occur;
- pastoral on stubble and fallows: use of traditional rights to graze on private arable land;
- pastoral on semi-natural vegetation: the most typical sheep and goat system in the Mediterranean, based primarily on poor, semi-natural forage resources (grassland, scrub and woodland, often mixed), especially common in uplands and mountains.

A study conducted by Hosri and Nehme (2006) in the northern area of Lebanon, distinguished two kinds of systems, according to the use of rangelands and cereal residues: traditional extensive systems (sedentary, semi-nomadic, transhumant) and improved systems (subsistence and intensive). The flocks studied showed seasonality of reproduction with a kidding period between January and March. Reproductive performance decreased drastically in the extensive systems with a mortality rate of weaned kids and lamb between 40 and 45%. In the extensive systems meat was the main source of revenue but in the intensive systems milk was the main source of revenue.

In the Bekaa Valley of Lebanon, Hamadeh *et al*. (1996), indicated three production systems depending on the estimated contribution of pasture in the animal's diet: low <20%; moderate 20 – 45% and heavy > 45%.

- sedentary where flocks remaining in and around villages are managed semi-intensively. Farmers are usually owners of small rain fed and irrigated farms (4ha), they manage medium size flocks with predominance of sheep (200 head) and apply a low use of rangelands;
- transhumant where flocks on integrated farms migrate to closed summer rangelands. Farmers are landless (< 1ha) with large sheep and goat mixed flocks (400 heads) and heavy use of rangelands;
- semi-nomadic large flocks, owned by landless farmers, migrating seasonally between cropping areas and distant rangelands. Farmers are owners of modest rained and irrigated farm (15ha), medium mixed sheep and goat flocks (200 head), moderate use of rangelands.

In West Bekaa area Chedid *et al*., (2018) found four semi-sedentary farming systems:

- landless shepherds, growing vegetables on rented agricultural land, with small herds that have access to crop residues;
- owners of small herds with no access to crop residues planting fruit trees and vegetables on the small lands they owned;
- farmers with medium sized herds having access to crop residues, planting fruit trees and vegetables on their own small lands;
- farmers with large herds that owned 0.15Ha and rented 0.8Ha in average, producing 40% of their need in hay in addition to vegetables destined for the market.

According to Abi Saab *et al*., (2008) the rearing system of goat in Lebanon is mainly traditional, with transhumance and pasturing as the main feeding resource.

In his study Srour (2006) identified five groups of production systems in Lebanon:

- The Zero-Pasture System: Farms in this group are conducted with small herds consisting exclusively of foreign goat breeds (Alpine, Saanen and Damasquine) raised for milk production, or the local Baladi breed for meat. Animals in this system do not have access to pasture, they are locked in a the farm and all the food is bought;
- The Sedentary System: characterized by the presence of medium-sized goat herds, which graze on rangelands or private forests. This system is not specific to a region, but it is mainly present in mountainous regions. The proximity of the villages allows the farmer to sell all his dairy products directly to the villagers;
- The Transhumance Vertical System: This system is characterized by a movement of herds between two fixed points (generally spaced from 30 to 100 km) in the mountain, in order to make the most of the seasonality of pastures. Transhumance for this group is between weak areas and average altitude in winter (some herds are even at the seaside) to the high mountains of 1500m altitude in summer, where the farmer has a house which hosts a part of the family during the whole year. During both seasons, the breeder try not to get too far from the villages (5-6 km) that make up the main market flow of dairy products. It should be noted that the characteristic of open fields (open field), reported by Flamant (1994) in the Mediterranean regions, giving farmers the opportunity to graze their herds on private or collective fallow land, is a common feature in Lebanon and especially for this system (67% of breeders do not have lands) (Fig.4).

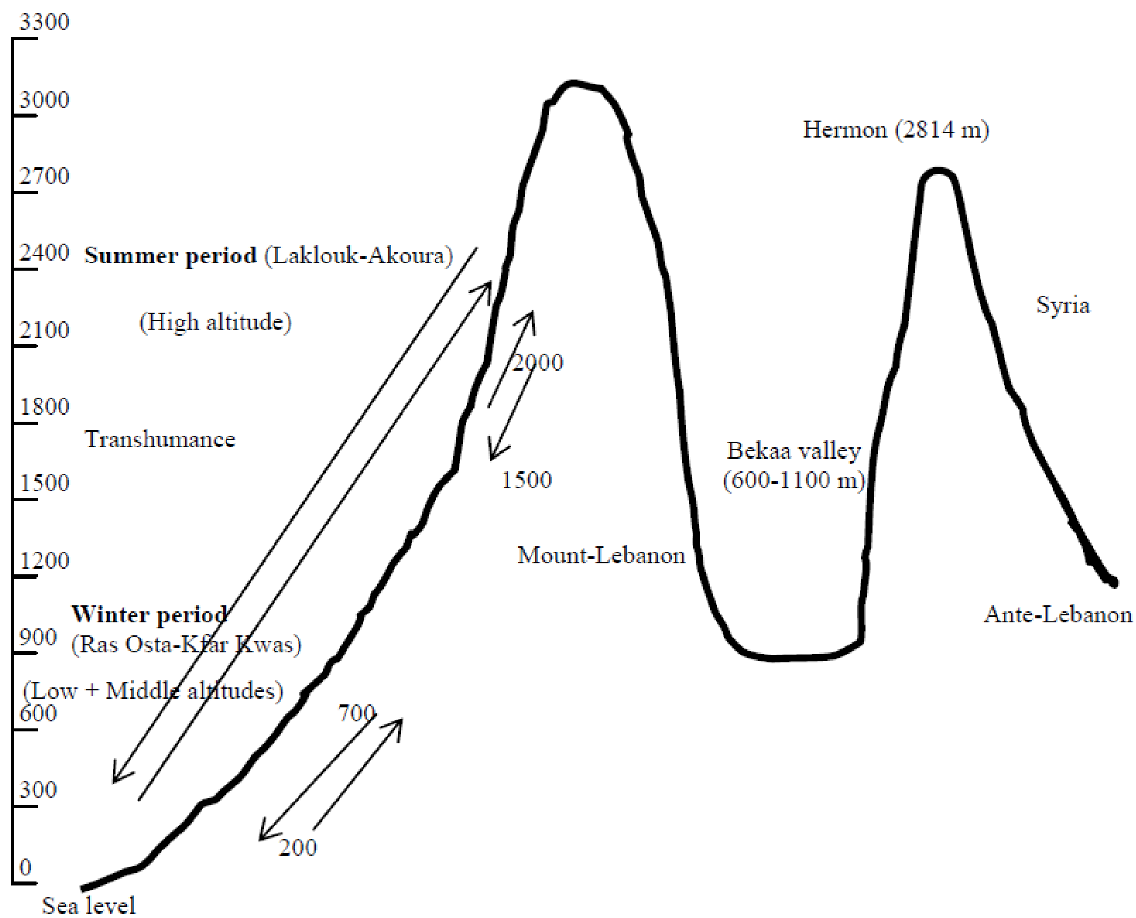

Figure 4. The Lebanese relief showing the two pasturing periods of goats through one year.

- The Transhumance Horizontal System: This system is specific to lowland areas, mainly Bekaa or North of Lebanon. Herds consist only of sheep or goat and sheep mixed together. The shepherd with some members of the family, or with the help of the workers, moves from May and October for a distance of 100 to 150 km looking for feed (stubble of wheat or residues of harvest);

- The Semi-Nomadic System: Most breeders of this type come from the Bekaa region. For this system, the movement of transhumance is of strong distance (200-300 km); it is done with almost all the family between Anti-Lebanon and Mount Lebanon while passing by the plain of the Bekaa.

The main features of this system are: the presence of flocks of large size, the dominance of mixed herds, the abundance of family labor and the great area of land rented for grazing herds, which varies from 1000 to 1500 ha in mountain and 400 to 600 ha in plain.

Shomo *et al*., (2010) classify sheep production systems in Syria into migratory, transhumance, semi-sedentary and sedentary, based on the duration of the migration period. In sedentary and semi-sedentary systems, animals are hand-fed for most of the year; although in the semi-sedentary system, owners migrate with their animals for at least three months. Flock size is usually the largest in the migratory system and smallest in the sedentary system.

1.3.2 Adaptation of small ruminants to different rearing systems

Small ruminants are the most efficient transformers of low quality forage into high quality animal products (Lombardi, 2005) with distinguished chemical composition and organoleptic characteristics, and with the least use of fossil fuel. Traditionally, they have been related to grazing, thus increasing the usefulness of farmland unsuitable for cultivation such as mountainous areas (Zervas *et al*., 1996) or semi-desert regions (Degen, 2007).

The goat adapts to very diverse breeding systems. It is known for its hardiness allowing it to survive in different climates: cold regions, humid tropical regions, high mountains and even sub-desert regions. It has the ability to survive, produce and reproduce under very adverse environmental conditions.

In dry areas extensive systems, the animal's capacity to mobilize and then reconstitute its body reserves to survive and maintain its milk production until food is available again is an advantage (Blanc *et al*., 2006; Sauvant *et al*., 2005). This physiological mechanism is however limited and when food supply is clearly insufficient, body condition degrades (Chesworth, 1996; Atti *et al*., 2004) and milk production is strongly reduced (Bocquier and Caja, 2001). This situation can affect directly the reproductive performances, compromising the next productive cycle (Atti *et al*., 2004; Blanc *et al*., 2006), as level of body reserves may be correlated to kids' birth weight and growth rate (Havrevoll *et al*., 1995; Abi Saab, 2005) which also depend on suckled milk production (Hary and Schwartz, 2002; Abi Saab, 2005). One of the possibilities is to supplement animals during lactation in order to maintain milk production (Bocquier *et al*., 2002) and replenish mobilized tissues (Goetsch *et al*., 2001; Atti *et al*., 2004).

1.4 Grazing areas

The morpho-geography of Lebanon is highly diversified which leads to different climates, vegetation, and nutritive value of the natural vegetation that varies with the seasons. (Abi Saab *et al*., 2008).

Lebanon, which is considered as a hotspot for biodiversity in the Mediterranean Basin (Médail and Quézel, 1997; Myers *et al*., 2000), is characterized by the coexistence of plants with diverse bio geographical origins and a large number of narrow endemic taxa. It is considered a key area of geological activity and climatic changes and recognized as a melting-pot of human cultures. The combination of geological variation and altitude, along with strong climatic variation among different slopes, created a marked heterogeneity in the ecological forces acting on the evolution of plant differentiation. Its floristic richness is estimated at 2612 vascular plant taxa, of which 108 are endemic to Lebanon (Tohmé and Tohmé, 2004, 2011, 2014).

Zahreddine *et al*. (2007) mentioned diverse climatic zones in Lebanon reflecting a large diversity of plant species:

- The Lower Mediterranean or thermomediterranean zone (0-500 m altitude) characterized by the presence of endemic genera such as *Ceratonia, Pistacia, Pinus*, and *Myrthus*;
- the Euremediterranean zone (500-1000 m altitude) characterized by *Quercus, Pinus*, and *Cupressus;*
- the Supramediterranean zone (1000-1600 m altitude) characterized by *Quercus, Ostrya, Fraxinus, Halimium,* and *Pinus*;
- the Mediterranean mountain zone (1500-1800 m altitude) characterized by *Cedrus*, *Abies, Juniperus, Quercus,* and *Berberis*;

- the harsh Oromediterranean zone (over 2000 m altitude) characterized by *Juniperus, Rhamnus, Berberis, Pyrus*, *Prunus, Daphne,* and *Cotoneaster*.
- the Pre-steppe Mediterranean zone (900-2400 m altitude), located at the east side of Mount Lebanon and north side of Anti-Lebanon in the Northern part of the country, were mainly *Quercus* and *Juniperus* species dominate.

1.4.1 Rangeland composition

Natural rangelands of the mountainous areas are the main source of feeds for small ruminants flocks (Srour, 2006). They consist of shrubby vegetation formed by “maquis” and garrigue” (Perevolotsky *et al*., 1998; Aharon *et al*., 2007; Rogosic *et al*., 2008), which are mainly exploited during spring because their nutritive value declines drastically in the dry season (Cabiddu *et al*., 1999). In the plain, goats graze crop residues, especially during summer time, that are of modest nutritive value, especially for cereal residues (Landau *et al.*, 2000).

In the summer period, herbaceous plants are predominant in pastures of high altitude; they constituted 95 to 100% of the pastures consumed (*Agropyron libanoticum, Astragalus echinus, Berberis libanotica…*). At the end of the summer period, proportions of herbaceous plants decrease to represent 70% of the plants consumed, while trees (*Prunus ursina*) and shrubs (*Rosa glutinosa*) increased from 5 to 30% between the beginning and end of the animals’ stay in the summer period. In the winter period, goats consume mainly trees (*Quercus calliprinos*) and shrubs (*Calycotome villosa, Poterium spinosum*) in proportions varying between 80 and 95%. However, at the end of this period, 70% of the plants consumed are herbaceous. (Abi Saab *et al.*, 2008).

The table below shows some of the herbaceous and ligneous plants found during the summer and winter periods in the natural pastures of Lebanon.

Table 2: Herbaceous and ligneous plants found during the summer and winter periods in the natural pastures of Lebanon.

Season	**Herbaceous Plants**	**Ligneous Plants**	**Reference**
SUMMER	*Agropyron libanoticum* *Artemesia judaica* *Bromus tomentellus* *Achillea odorata* *Notabasis syriaca* *Cirsium acarna* *Glaucium leioscarpum* *Cressa cretica* *Chrozophora tinctoria* *Astragalus coluteoides* *Astragalus angustifolius* *Berberis libanotica*	*Prunus ursine* *Rosa glutinosa*	Abi Saab *et al*. (2008)
	Salvia acetabulosa		Abi Saab *et al*. (2008) Bou Zeidan (2010) Aad (2018)
WINTER	*Convolvulus arvensis* *Hordeum hystrix* *Trifolium stellatum*	*Calycotome villosa* *Poterium spinosum* *Rubus sactus* *Quercus calliprinos* *Quercus infectoria* *Crataegus monogyna* *Prunus ursina* *Pistacia palaestina* *Ceratonia siliqua* *Pyrus syriaca* *Amygdalus orientalis* *Rosa glutinosa*	Abi Saab *et al*. (2008)
	Trifolium clypeatum		Abi Saab *et al*. (2008) Bou Zeidan (2010) Aad (2018)

1.4.2 Nutritive value

On natural rangelands the botanical diversity varies with the pasture, the season, and altitude, bushes increase as herbaceous species decrease. The nutritive values of herbaceous species degrade greatly from the first to the last rangeland as summer advances (Kharrat and Bocquier, 2010).

The analysis of plants consumed by goats in high altitude showed that dry matter increased from 48.9% to 61.2% between the beginning and the end of animal's stay in summer period, and remained high around 60% in winter period. The percentage of crude protein decreased from 15.2% to 8.5% between the beginning and the end of the animals' stay in the mountainous region and was around 10.4-11.5% for the winter period. The percentages of crude fiber showed fluctuations from 27 to 42% in the summer period and the lipids varied between 2.8 and 4.7 (Abi Saab *et al.*, 2008).

Similar results were observed by Aad (2018) in West Bekaa region of Lebanon who showed an increase of dry matter and crude fiber and a decrease in crude protein from spring to beginning of September.

1.4.3 Grazing behavior

Grazing is associated with daily activities considerably different than for confined animals, such as time spent eating and distances traveled (Lachica and Aguilera, 2003). These activities result in greater energy expenditure than in confinement, which can limit energy available for maintenance and production (Animut *et al.*, 2005).

Sheep and goats have different grazing behavior on the pasture, they spend different amount of energy and travel different distances while grazing (Animut and Goetsch, 2008).

Sheep are classified as grazers that consume grasses and roughage and goats as mixed or intermediate feeders that consume grasses and browses (NRC, 2007).

The mechanism of grazing behavior and forage selection of goats is quite complex (Morand-Fehr, 2003). It is mainly affected by the abundance and the quality of the forages (Baumont *et al*., 2000; Jouven *et al*., 2010) and their seasonal variation (Mphinyane *et al*., 2015), as well as several other animal, environmental and vegetation characteristics (Decandia *et al.*, 2008; Stuth, 1991). Goats are able to utilize the woody vegetation because of their particular metabolic efficiency (Silanikove, 2000) and anatomic characteristics, such as their small body size, the mobile upper lip and tongue and their ability to browse in a bipedal stance (Lebopa *et al*., 2011). These features enable goats to use a wide range of plant species to meet their nutritional requirements (Decandia *et al*., 2008).

Lynch *et al.* (1992) mentioned that the ingestive behavior of sheep on the pasture is seasonally affected by several factors including the animal's endocrine and metabolic state and the effects of climate on forage quality and quantity. Flock size may also influence grazing behavior and feed intake, because sheep are social animals (Rook and Penning, 1991; Penning *et al.,* 1993) and because they are selective grazers (Forbes, 1995). Selectivity is related to the number of grazing sheep and the amount of available herbage (Lynch *et al.*, 1992). Penning *et al.* (1993) found reduced grazing times in small flocks, assuming that sheep in larger groups may benefit from social facilitation and/or from the increased number of individuals that are vigilant.

The nutritive value of the diet depends on the quality of the ingested vegetation as well as supplementary feedstuffs (Morand-Fehr *et al*., 2007).

1.5 Animal Welfare

Animal welfare has become an important issue in recent years. There is an increasing interest in animal welfare in many countries and the European Union. Urbanization, media, influence of civil society organizations and increase in society's education and economic level are the reasons for an increased interest in animal welfare. People started to question how and under which conditions food came to the table from farm. Conditions under which animals are raised, transported and slaughtered started to draw attention of the public (Battini *et al*., 2014).

When considering animal welfare, addition to the physical health, psychological well-being of animals should be considered. Welfare as a word defines the state in which a person or an animal live healthy, happy and safely (Wehmeier, 2005). There are various definitions of animal welfare. Hughes (1976) defined it as: a state of complete mental and physical health, where the animal is in harmony with its environment. Carpenter (1980) defined it as: living or adaptation of animals without suffering to the environments provided by man.

Koknaroglu and Akunal (2013) mentioned that animal welfare can be defined as providing environmental conditions in which animals can display all their natural behaviors in nature. Importance of animal welfare changes from country to country as they differ in religion, economic development, education and perception. Animal welfare is not only the subject going on in the farm but also is the subject that interests the scientists and public. In general it may conflict with profitability and sustainability of animal production (Koknaroglu, 2008; Koknaroglu *et al.*, 2006). There is no animal welfare regulation that can be applied to all countries.

1.5.1 Importance and assessment of animal welfare

Scientific research has evidenced that protection of animal welfare can turn into profit, in terms of reducing veterinary costs, increasing animal performance, improving the quality of products and maintaining hygienic standards of food production. Welfare is strictly related to health and efficiency of production of farmed animals, and sustaining animal welfare can also increase the commercial value of animal products. The demand for high quality food has been rising and an increasing number of consumers expect animal products to be obtained and processed with greater respect for the welfare of animals.

Farmed ruminants might face many stressors of different origin, as follows:

- environmental stressors, such as climatic extremes, air pollution and poor drinking water quality;
- physical stressors, such as crowding and reduced air space;
- physiological and nutritional stressors, such as transition period, unbalanced diets, under-nutrition and fasting;
- management stressors, such as inappropriate milking, slaughter routine, transport, animal moving and handling, castration, and dehorning;
- pathological and traumatic stressors, such as lameness, diarrhea, and accidental trauma;
- psychogenic stressors, such as isolation and inappropriate human interaction.

The animal response to stressors, in turn, depends on a number of factors, which can be grouped as follows:

(a) breed differences, genetic selection, early influences and epigenetic factors, and individual life history, acting as endogenous factors; and

(b) the source and nature of stressors, the frequency of exposure to stressor, and the length and intensity of stress, acting as exogenous factors.

1.5.1.1 Environmental stressors

As a rule of thermodynamics the performance of farm animals depends on how much energy they consume and how much energy they spend for maintenance. Farm animals as homoeothermic animals live in a dynamic environment and interact with it (Hahn, 1999). The environment surrounding farm animals often dictates their maintenance energy requirement and their feed intake (Delfino and Mathison, 1991). Thus, controlling the factors affecting dry matter intake and energy expenditure is an important means to improve the performance and efficiency of the farm animal production. Ambient temperature is the most important factor affecting farm animal performance and welfare (Koknaroglu *et al.*, 2008). Ambient temperature may cause cold or heat stress on animals depending upon the severity of it and condition of animals.

Ruminants housed outdoor in cold weather require more energy for growth as they maintain body temperature and have higher feed intake. Thus more feed should be provided in cold weather. Providing a shelter in winter is proven to be helpful to the welfare of the cattle as displayed better performance.

Heat stress defined as the situation where livestock are not able to dissipate body heat effectively and their body temperature rises above normal is an important issue in animal production and causes poorer performance and sometimes death (Phillips, 2016).

Productivity of an animal is closely related to the quantity and quality of water ingested. In hot environments adequate amounts of drinking water, preferably no warmer than ground water temperature become essential (Hahn, 1986). Water intake seems to serve the most important role as heat receptor, diluting a potential rise in body temperature or decreasing body temperature during heat stress (Wagner, 1987).

As mentioned by Ogebe *et al*. (1996) and Darcan *et al*. (2007), ready access to fresh water is important to maintain full health and vigor; welfare can be compromised if animals cannot drink whenever they feel the need to, either because fresh water is not available or because of competition with other goats. Continuous and prolonged lack of access to fresh water may eventually lead to chronic dehydration, especially during hot periods.

1.5.1.2 Physical stressors

In small ruminant production, housing is one of the important factors affecting welfare of the animals. Housings should provide enough space, have good air circulation and prevent contamination of diseases. Koknaroglu *et al.* (2008) found that ruminants in open lot with access to an overhead shelter performed better than those in open lots or in confinement. Reviews clearly show that ruminant look for the cooler places to dissipate heat in hot summer days thus they should not be tied and be given chance to walk freely (Welfare quality, 2009). Regardless of the housing, ruminants should have enough space for resting, lying and feeding. Space allowance for sheep is given below (RSPCA, 2013) (Tab.3).

It is known that ruminants have a broad thermal comfort zone and a high degree of thermal tolerance (Sejian and Srivastava, 2010). Scarce information about the limits of thermal comfort, allowing goats to maintain a near-constant body temperature of approximately 39°C, is available in the literature. Toussaint (1997) suggested that adequate temperatures for goats kept indoors range from 6°C to 27°C (optimum from 10° to 18°C), with relative humidity from 60 to 80%. Beyond the limits of thermal comfort, behavioral and physiological changes may occur that reduce or increase the heat loss (Mount, 1979; McGregor, 2002; Darcan et al., 2007; Bøe and Ehrlenbruch, 2013). Inadequate temperatures, high humidity, and wind and rain are the main factors affecting thermal comfort in goats (McGregor, 2002; Bøe and Ehrlenbruch, 2013).

Table 3: Space allowance for sheep

	Straw bedded lying area (m^2/animal)	Total floor area (m^2/animal)
Ewes		
45-60 kg	1.1–1.2	1.65–1.8
60–90 kg	1.2–1.4	1.8–2.1
Lambing pens	1.5	2.25
Creep area		
2 weeks	0.15	0.15
4 weeks	0.4	0.4
Hoggets		
20–30 kg	0.7	1.05
30–40 kg	0.8	1.2
40–50 kg	1.0	1.5
Rams	1.5–2.0	2.25–3.0

1.5.1.3 Physiological and nutritional stressors

Changes in the nutritional status of the animals have a substantial effect on the animal's health and welfare and hence on production. Body condition score is a method for subjective assessment of the nutritional status of farm animals based on the estimation of their body fat. It is considered a valid welfare indicator in many species: sheep (Russel *et al*., 1969; Phythian *et al*., 2011), and goats (Santucci *et al*., 1991; McGregor and Butler, 2008; Anzuino *et al*., 2010).

Behavior and social interaction during feeding time can be good indicators to evaluate the absence of prolonged hunger. When given the opportunity (e.g., ad libitum feed distribution), goats may eat up to 7 to 10 h/d (Ferreira *et al*., 2013). On intensive dairy farms, goats usually receive restricted feed twice a day (Görgülü *et al*., 2008). This management procedure may alter nutritional condition (e.g., reduction in feed intake; Görgülü *et al.*, 2008) and behavioral patterns (e.g., coping strategy; Jørgensen *et al*., 2007; Görgülü *et al*., 2008).

Feed can be a limited resource because the amount of feed is restricted, or because the feed type and composition are not appropriate (e.g., the roughage: concentrate ratio is too low, therefore feed is consumed very quickly and competition is increased), or because feeding space is not accessible for all individuals in the group at the same time (Jørgensen *et al*., 2007; Görgülü *et al*., 2008). In a competitive environment, such as on intensive or semi-intensive dairy farms, these problems can be partly overcome by adopting a coping strategy that consists of consuming the feed at different times of the day to optimize access to the feed trough (Shinde *et al*., 2004; Jørgensen *et al*., 2007). However, under these competitive circumstances, low-ranking goats may have access to lower quality feed and may experience a negative emotional state similar to the frustration caused by the time spent queuing at the feed trough. Carbonaro *et al*. (1992) have documented frustration related to food thwarting in dairy goats, confirming that frustration may elicit physiological alterations (e.g., an increase of norepinephrine) and behavioral reactions (e.g., pawing, head movements, rearing).

1.5.1.4 Management stressors

Schwartzkopf-Genswein *et al*. (2012) indicated that management practices affect welfare of large and small ruminants and these practices are sometimes painful (dehorning, castration, branding) and not painful but stressful (weaning, cold stress, heat stress).

Horns in the animals pose risk of injuries to workers and other animals, thus they should be removed either by physical, chemical or genetics methods. This procedure is recognized as painful for animals. However, animals dehorned at younger ages heal more quickly than those dehorned at older ages thus age should be taken into consideration when dehorning. Since dehorning causes pain, genetic selection toward polled animals should be preferred (Schwartzkopf-Genswein *et al*., 2012).

Castration of male farm animals is done to prevent unwanted pregnancies, decrease the level of testosterone, to reduce aggression and improve ease of handling, and improve the palatability of the meat (Coetzee, 2011; González *et al.*, 2010). Regardless of the methods used castration causes acute and chronic pain (AVMA, 2010; CVMA, 2011). The trauma caused by castration increases as the testes grow bigger, so castration at a younger age results in quicker healing and causes less pain and distress overall (Schwartzkopf-Genswein *et al.*, 2012).

Branding is done to identify animals and to provide a permanent, visual means of establishing ownership. Research showed that both freeze branding and hot-iron branding cause pain and distress in animal but freeze branding causes less acute pain at the time of the procedure than hot-iron branding (Lay *et al.*, 1992a; Lay *et al.*, 1992b; Schwartzkopf-Genswein *et al*., 2012).

One common management practice that may have a negative effect on the welfare of adult dairy goats is ear tagging. If tags are not correctly placed through the center of the ear, inflammation or ear tear (Smith and Sherman, 2009; Anzuino *et al*., 2010) may occur, causing moderate pain.

Routine trimming is a required management procedure, essential to maintain normal hoof structure (Smith and Sherman, 2009). This procedure should be carried out at least twice a year due to the fact that on intensive farms, the limited movement of goats may alter the normal growth of the hoof, leading to claw overgrowth. If trimming is not correctly performed, it may cause pain or expose inner tissue to trauma and infection (Nagy and Pugh, 2012).

Weaning is a process involving withdrawal of milk from the calf's diet (Weary *et al.*, 2008).

1.5.1.5 Pathological and traumatic stressors

Animals should be free from physical problems that may affect their health; for example, skin damage and locomotion disorders (Welfare Quality, 2009). The presence of lesions (including skin damages, swelling, and hair loss) is an indicator of poor health.

Lameness is taken into consideration in several papers, as it is an important indicator of pain (O'Callaghan *et al.*, 2003) and may lower productivity in dairy goats by reducing milk yield (Hill *et al.*, 1997; Christodoulopoulos, 2009) and fertility (Hill *et al.*, 1997; Eze, 2002; Christodoulopoulos, 2009), as well as contributing to pregnancy toxemia (Lima *et al.*, 2012) and neonatal diseases (Eze, 2002), and hence premature culling (Hill *et al.*, 1997). The main causes of lameness in intensively kept dairy goats are claw overgrowth with or without deformation and diseases affecting the limb joints, such as caprine arthritis-encephalitis (CAE) and caprine contagious agalactia (Bergonier *et al.*, 1997; Hill *et al.*, 1997; Smith and Sherman, 2009; Winter, 2011).

In dairy animals, other possible animal-based indicators are lesions and abnormalities of teats and udders (Anzuino *et al.*, 2010). In the same set of goats on UK farms mentioned above (Anzuino *et al.*, 2010), teat and udder abnormalities in dairy goats were found with respective prevalences of 7.6 and 33.8%, including lesions, wounds, inflammations, and accessory teats. Teat and udder lesions can affect both welfare and production in dairy goats (Perrin *et al.*, 1997; Contreras *et al.*, 2007; Leitner *et al.*, 2008; Mavrogianni *et al.*, 2011), but little published information describes the welfare significance and etiology of different lesions (Menzies and Ramanoon, 2001). Certain aspects of dairy goat farming, such as rapid milking rates, large herd size, high milk production, number of stockpersons, and minimal hygiene routine at milking, as well as some specific goat behavior, such as teat biting or self-sucking, may contribute to the development of teat and udder lesions (Stelwagen and Knight, 1997; Anzuino *et al*., 2010; Martínez-de la Puente *et al*., 2011; Torres *et al*., 2013).

1.5.1.6 Psychogenic stressors:

Animal welfare is impaired when gregarious individuals such as small ruminants, are isolated from the group (Hashizume *et al.*, 1994; Siebert *et al.*, 2011) during processes and situations involving management (lambing, quarantine, etc) (Patt *et al.*, 2013). Isolation generally produces an emotional stress and fear (Carbonaro *et al.*, 1992). During isolation, general activity and vocalization increases in farm animals (Siebert *et al.*, 2011) indicating the social attachment with the group (Price and Thos, 1980). Separation from the group cause social disruption that leads to increased stress response and metabolic changes (Kannan *et al.*, 2002), which further play a role in activation of the neuroendocrine system (Carbonaro *et al.*, 1992) and changes in the level of circulating cortisol (Niezgoda *et al.*, 1987), thyroxine (T4), and triiodothyronine (T3) (Bobek et al., 1986). In the present context, animal welfare is not just important for ethical point of view but affects the economics of the animal production process (Tölü *et al.*, 2016). According to Kalyan *et al.* (2018) dry Matter intake, water intake, and body weight were reduced significantly due to isolation stress of sheep. Same results about the consequent reduction in food intake following separation in goats were observed by Patt *et al.* (2013).

In 2008, the EU Welfare Quality project re-elaborated the concept of the "Five Freedoms" of animals (Brambell Committee, 1965) and defined 4 main areas of animal needs ("Welfare Principles"), which were then split into 12 independent criteria (Blokhuis *et al.*, 2010; Rushen *et al.*, 2011), each of which corresponded to a key welfare question. Welfare principles and criteria are as follows:

1. Good feeding: absence of prolonged hunger, absence of prolonged thirst;

2. Good housing: comfort around resting, thermal comfort, ease of movement;

3. Good health: absence of injuries, absence of disease, absence of pain induced by management procedures;

4. Appropriate behavior: expression of social behaviors, expression of other behaviors, good human-animal relationship, positive emotional state.

1.6 Lebanese Small Ruminants Reproduction

Reproduction is a major contributing factor to efficiency of meat production. Even with animals kept primarily for milk or fiber production, reproduction makes an important contribution by:

- influencing the number of surplus animals which may be utilized for meat and;
- contributing to current and future production through influencing culling.

1.6.1 Seasonality

Sheep and goats have seasonal reproductive cycles. During each annual cycle, there is a season of low or absent reproductive activity (anestrous season) and a season of high reproductive activity (breeding season). Several factors are responsible for the regulation of this cyclical activity (Thiéry *et al.*, 2002). In high or medium latitudes, of >30◦ (Lincoln, 1992), >35◦ (Malpaux *et al.*, 1996) or >40◦ (Chemineau *et al.*, 1992) the photoperiod and the annual environmental temperature cycle are the main modulators of this seasonal reproduction.

In temperate latitudes small ruminants, are characterized by a seasonal trend with a period of sexual inactivity that can last for several months, usually from late winter to early spring (Chemineau *et al.*, 1995).

Todaro *et al*. (2015) mentioned that the breeding season in sheep and goats starts in the late summer/early autumn in all the breeds and at all the latitudes. During this period, the female animals ovulate spontaneously and become pregnant easily.

Reproductive functions in small ruminants are also regulated by other factors, such as social and sexual interactions and nutritional status (Álvarez and Zarco, 2001; Bearden *et al.*, 2004;

Zarazaga *et al.*, 2005). These functions are highly demanding in terms of quality and quantity of nutrients. Therefore, nutritional status is a very important modulator of reproduction in sheep and goats (Blache *et al.*, 2008).

Reproductive seasonality in ewes and goats is characterized by the succession of estrous behavior, ovulation and changes in hormonal endocrine levels during the breeding season, and the cessation of most of these events during the anestrous season. The transition from the anestrous state to the breeding season is gradual, with the occurrence of a short cycle not accompanied by estrus behavior (silent estrus and silent ovulation) in both species.

The length of the estrus cycle varied between 15 and 20 days, with an average of 18 days. The duration of heats ranged from 16 to 59 hours, with 29 hours on average. Nine percent of the heats were silent, as manifested by the occurrence of multiple cycles, accompanied by the absence of mating response (Barr, 1968). The Awassi ewe displays few outward signs of estrus. Pro-estrus is short and rather indefinite and the onset of estrus abrupt, while the cessation is gradual.

Many sheep breeds from Mediterranean area have seasonal patterns of estrous behavior and ovulation. Maximal reproductive activities occur from August to March (Martinez-Royo *et al.*, 2012).

In an experimental flock in Lebanon, estrus reached its peak with regular cycles in August and September but was still maintained on a fairly high level until December; from January to April the heats markedly decreased in number, and from May to July they ceased altogether.

According to Hamadeh *et al*. (1996) flocks of the Bequaa valley in Lebanon, showed great seasonality of reproduction with mating practiced from June to November and the highest rate of conception occurring in August and September. Galal *et al.* (2008), mentioned that Awassi rams are sexually active throughout the year, with a higher activity in summer and fall compared to spring (Kridli *et al.*, 2007). However Kridi *et al.* (2007) mentioned that the Awassi sheep can mate primarily during the period of May – July.

The mean gestation period in an Awassi flock in Lebanon has been reported to be 149.5 days for male lambs and 148.6 days for females (Choueiri, Barr and Khalil, 1966). In another Lebanese flock, the average gestation length for single-born lambs was 151.2 days (Fox *et al.*, 1971) while, at the American University Farm in Lebanon, it was found to be 152.6 days (McLeroy and Kurdian, 1958)

In the Middle East, Awassi ewes lamb mostly during December–January but are reported to lamb all year-round. In Iraq, the principal lambing season of Awassi ewes is in November, and in Lebanon, the Syrian Arab Republic in December-January.

1.6.2 Fertility and Litter size

Production traits such as ewe prolificacy and mature size are major sources of variation in overall efficiency (Large, 1970). Reports indicated that body weight has a significant effect on litter size in different breeds (Bunge *et al.*, 1993). An increase in the number of lambs marketed per ewe per year offers the greatest single opportunity for increasing the efficiency of lamb meat production (Shelton, 1971).

Fertility of the Awassi ewes in the Middle East area ranged from 76% in Irak (Hamdon, 1980) to more than 92% in Turkey (Gursoy, 1992) and it marked 87% in Jordan (ACSAD, 1983) and 82.5% in Syria (Kassem *et al.*, 1989). Same results were mentioned in Syria by Hatziminaoglou and Boyazoglu (2011) with fertility between 80 and 90%. Twining rate was low in Syria 1.02 (Kassem, 1998), 1 – 1.05 (Hatziminaoglou and Boyazoglu, 2011) and higher in Turkey 1.08 (Said *et al.*, 1999), 1.12 (Gursoy, 1992).

In Lebanon, Hamadeh *et al*. (1996) found a fertility average of 88% for the Awassi ewes with a litter size of 1.1 while Hosri and Nehme (2006) mentioned in their study that the Awassi sheep Litter size vary upon the Lebanese production system between 1.0 for the sedentary system to 1.2 for the subsistence system. Hajj (1999) mentioned that the kidding average of the Baladi goat is 1.3 kids per goat.

1.6.3 Weight at birth

The weights at birth of Awassi lambs vary between male and female. It ranges for the males between 4.2 kg in Jordan and 4.5Kg in Irak, while for the females it ranges between 3.8kg in Turkey to 4.2 kg in Syria. (Asker, 1964; Khori, 1965; Gursoy, 1980).

A study done In Lebanon by Hamadeh *et al*. (1996), reported a weight at birth average of 5.1 kg for the Awassi Lambs.

1.6.4 Insemination

Crossbreeding of sheep offers great opportunities for improving the efficiency, prolificacy and quality of market lamb production (Casas *et al.*, 2004), growth, milk production and reproduction in less prolific breeds (Gootwine *et al.*, 1992).

1.6.5 Melatonin receptors

Although the seasonal control by melatonin of various physiological activities of the animal has been clarified, the precise mechanism of action of this hormone remains to be explained. In fact, for some processes the precise sites of action of melatonin are not yet clarified and how this hormone exerts its action. However, it is common ground that the pineal hormone is the organic informer of the photoperiod trend and is therefore considered a regulator of all those seasonal activities such as reproduction. The Suprachiasmatic Nucleus of the hypothalamus, where the biological clock is located, is the site of integration of the light signal (Lincoln *et al.*, 2005). This hypothalamic nucleus shows its own oscillation that is synchronized to a circadian rhythm by the course of melatonin secretion.

Furthermore, melatonin has several action sites and each is linked to specific physiological functions. In fact this hormone at the level of the Pars Tuberalis of the pituitary influences the secretion of prolactin, instead its action at the level of the Premammillary and Suprachiasmatic nucleus of the hypothalamus influence the regulation of reproductive activity (Barrett *et al*., 2002; Malpaux *et al*., 1998).

To explain the mode of action of melatonin, various hypotheses have been formulated to identify which aspect of its secretory model is most important in regulating its activities. It is known that the nocturnal peak of melatonin secretion has duration inversely proportional to the length of the hours of darkness, however it is the duration in time of the peak that is perceived by the regulatory centers of reproductive activity (Foulkes *et al*., 1997; Bittman and Karsch, 1984).

Melatonin acts through specific receptors that are located both in the central nervous system and in various peripheral organs of the body (Cardinali *et al*., 1979). The typing of the different receptors has led to clarify different mechanisms of action of melatonin (Dubocovich, 1988)

Two types of receptors originally identified as ML1 and ML2 respectively with high and low affinity for pineal hormone have been identified (Dubocovich, 1995). Three subtypes have been identified from the ML1 receptor, Mnl1a, Mnl1b and Mnl1c (Reppert *et al*., 1994, 1996). Subsequently the nomenclature was changed and the Mnl1a, Mnl1b receptors were named MT1 and MT2 respectively while that Mnl1c maintained the same name. This last receptor until today has not been identified in mammals but only in amphibians. (Ebisawa *et al*., 1994; Dubocovich *et al*., 1999). The ML2 receptor was later named MT3.

The structure of the MT1 receptor is composed of 350 amino acids while that of the MT2 receptor is made of 362 amino acids, both have a molecular weight of 40kDa. These amino acid chains of the two receptors are equal for 60% and the gene that codes for these receptors resides in two different chromosomes (Reppert *et al*., 1996).

MT1 and MT2 receptors are present in the central nervous system and in various structures of the body in different mammals including the ovine. MT2 appears to be implicated in the mechanism of pressure regulation and inflammation response. (Reppert *et al*., 1996; Witt-Enderby *et al*., 2003).

The MT1 receptor, on the other hand, is implicated in the regulation of reproductive seasonality in different breeds of sheep as found by different authors (Messer *et al*., 1997; Pelletier, 2000; Notter and Cockett, 2005). Also in sheep of Sardinian breed the polymorphism of this receptor influences the reproductive seasonality (Carcangiu *et al*., 2009). However in some breeds of

French sheep this polymorphism does not determine any influence on the reproductive activity. (Hernandez *et al*., 2010). The lack of effect of polymorphism in this breed could be due to other environmental factors or to the breed itself. For this reason, investigating sheep breeds living on latitudes other than the Sardinian ones could be interesting to explain the effect of the receptor genotype.

1.7 Lebanese Small Ruminants milk production

Sheep and goat production contributes to the livelihoods of a large numbers of small scale resource-poor farmers in Middle Eastern countries, particularly Syria, Jordan and Lebanon, and accounts for 28–58% of agricultural output in the Middle East (Iniguez, 2005). They are considered the dairy animals of the poor because of the lower capital investment and production costs required the short pregnancies and the milk supply in quantities that is suitable for immediate household consumption.

According to Iniguez and Hilali (2009), Awassi sheep excel in milk and meat production. This breed is well adapted to the dry areas of western Asia (Kassem, 2005) and improved Awassi sheep exploited under intensive conditions is a high-yielding dairy breed (Epstein, 1985).

Gürsu and Aygün (2014) mentioned that lactation milk yields of Awassi sheep in the rural areas and in the amend flocks are from 100 to 150 kg and from 250 to 300 kg respectively. Milk production for the same breed ranged from 73 to 150 kg, however performance of Awassi ewe under extensive management conditions tended to be low: 40-60 kg of milk and 1.05 to 1.07 lambs par lambing (Epstein, 1985). In their survey on Awassi population in Lebanon, Srour *et al*. (2006) reported a milk yield per year per ewe of 112 kg, and varied between production systems from 30 to 170 kg.

Maiden ewes produce less milk than older ewes and maximum yields are generally achieved at the third or fourth lactation, after which total lactation yield tend to decrease (Giaccone *et al.*, 1992). Sheep suckling twin lambs produce more milk than those suckling single lambs and ewe rearing triplets produce more milk than those rearing twins (Bencini *et al*., 1992).

In a study done by El-Tarabany *et al.*, (2018) Baladi goats had a daily milk yield of 1.63 kg/day with a peak attained at the early stage of lactation, and then a steady decline observed until the end of lactation. Sleiman *et al.*, (1984) mentioned that the milk production of the Baladi goat is 120-140 L. for a lactation period of about 6 months. On the other hand Hamadeh *et al.*, (1996) mentioned that lactation duration in Baladi goat is of 140-180 days from April to September with an individual annual milk production yield that tops at 140 kg per year.

According to Aboul-Naga *et al.*, (1984) milk production of Damasquine goat is very variable from one region to another: it is 211 kg for a lactation period of 171 days in Tunisia (Najari *et al.*, 2000), 311 Kg for 230 days of lactation in Turkey (Özcan and Güney, 1988) and 533 kg during 7-8 months of lactation in Egypt (Aboul-Naga *et al.*, 1984).

Louca *et al.* (1975) reported that the lactation peak of Damascus goats were located between 5 and 6 weeks postpartum. Whereas Katanos *et al.* (2005) recorded no significant differences in Damascus goats between the average daily milk yield (1.26 ±0.06) at weaning (7–8th week) and that at mid stage of lactation.

Hamzaoui *et al.*, (2013) mentioned that heat stress decreases milk production of dairy animals, half of the reduction in milk yield is due to reduced dry matter intake (Rhoads *et al.*, 2009), the other half of milk yield losses could be explained by the increase in maintenance requirements (NRC, 2007), decreasing secretion of growth hormone (Mitra *et al.*, 1972) and lowering blood flow to the udder (Lough *et al.*, 1990).

In a temperate climate zone, sheep lambing during long days (summer) produce less milk and have shorter lactation than those naturally lambing during short days (winter). (Tomasz Misztal *et al.*, 2018).

2 Scope of the thesis

The small ruminant's productivity in Lebanon have shown instabilities over the last fifteen years reflecting the effect of climatic constraints, depletion of natural pastures, increasing urbanization and lack of efficient awareness for the farmers.

The thesis main target was to identify the principle rearing systems available in Lebanon and to optimize the small ruminant's production and reproduction. In this perspective, several experiments were conducted during three years in collaboration between the Department of Veterinary Medicine at the University of Sassari and the Department of Veterinary Medicine at the Lebanese University.

The first experiment focused on the identification, description and analysis of the small ruminant breeding systems available in Lebanon and their direct and indirect effects on the production and the reproduction parameters. For this purpose, a survey over 517 farms was done using a detailed questionnaire.

Adding to the survey results, advanced studies were performed within a second experiment on animal welfare in order to evaluate its impact on animal productivity and to aware farmers of welfare importance in their management strategy.

The third bio molecular experiment focused on the Study of the Melatonin receptors and the seasonality of the sheep and goats raised in Lebanon.

3 Materials and Methods

3.1 Study area

The study was conducted in the seven main districts (Mohafaza) of Lebanon: Akkar, North, Mount Lebanon, South, Nabatyeh, Bekaa, and Baalbeck El Hermel. The figure 5 shows the distribution of the seven districts in Lebanon.

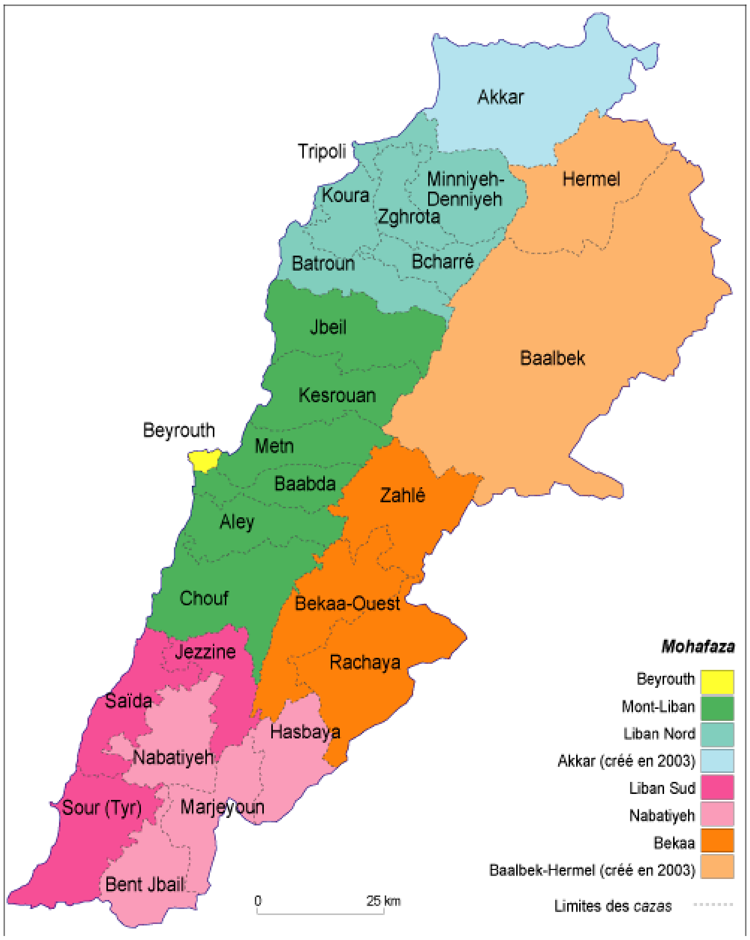

Figure 5. Seven districts of Lebanon.

The districts are divided into four geoclimatic regions:

(i) the coastal plain from Tyre in the south to Akkar in the north. The rainfall ranges between 700 and 1000 mm per year and the average temperature is around 19^{o}C;

(ii) Mount Lebanon, which rises from 500 m in the south to 3083 m in the north, is made up of softened peaks and steep slopes, with rainfall reaching 1500 mm. The average annual temperature varies from 10 to 18 ^{o}C;

(iii) The Bekaa Plain, stretching between Mount Lebanon and Anti-Lebanon; its altitude ranges from 600 to 1100 meters, it is divided into two climatic regions, the North with a sub-desert climate where the temperature average annual average is 17 ^{o}C with low rainfall of 200 to 400 mm and the South with a more rainfall (900 to 1000 mm) but a lower temperature of 15 ^{o}C;

(iv) Anti-Lebanon, which extends from 2814 m to 1000 m; Rainfall ranges between 350 mm in the northern and 900 mm in the south.

The rainfall in Lebanon is very high in winter and concentrated almost from November to February, while the summer is very dry, especially in the north of the Bekaa. The figure 6 shows the four geoclimatic regions in Lebanon.

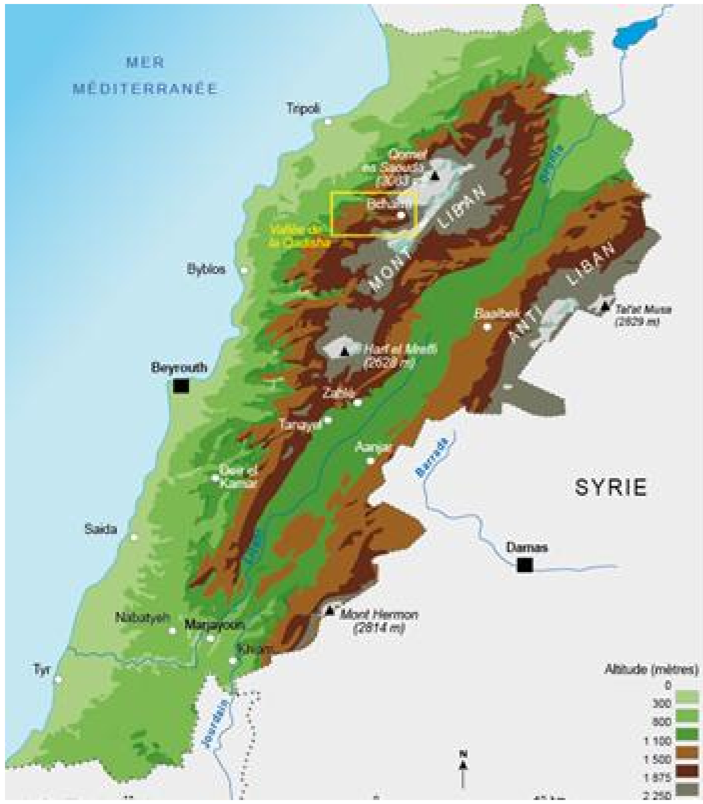

Figure 6. Geoclimatic regions in Lebanon.

3.2 Sampling and survey method:

A total of 512 farmers representing the seven districts were randomly selected for the survey. A formal single interview was conducted in 2017 and 2018 using a detailed questionnaire designed to collect data concerning the main aspects of small ruminant's rearing systems such as, husbandry practices, production, reproduction processing, marketing, consumption, products perception and welfare.

Table 4. Subjects discussed during the interview to fill the questionnaire

- Age of respondent	- Induction of cycle
- Herd size	- Weight at birth
- Herd composition	- Puberty age
- Breed	- Weaning age
- Rearing system and methods	- First lambing age
- Official registration	- Welfare
- Land use	- Dehorning
- Monthly income status	- Hoof trimming
- Other source of income	- Deworming
- Financial support	- Insect control
- Animal products	- Size of barn
- Insemination management	- Type of milking system
- Abortion rate	- Processing

3.3 Categorization of the small ruminant farming systems in Lebanon:

A typology of small ruminant farming in Lebanon was determined by the two cluster analysis method, using SPSS version 16, to classify the different rearing systems. Two qualitative variables relevant to the categorization were used: pasture rangeland and transhumance practices. The farm capital and the economic situation of the farm were excluded from the selected variables since interviewed farmers did not keep records of the financial statements.

3.4 Statistical Analysis

For the data entry and descriptive statistics, SPSS version 16 program was used. For the data analyses ANOVA test was used in the quantitative variable statistics while in all the other qualitative variables chi square test was used. Results was mentioned significantly different when $p<0.05$.

3.5 Welfare parameters evaluation

Welfare evaluation of small ruminants was done according to the 6 stressors (environmental, physical, nutritional, management, pathological and psychogenic) previously described and adapted following the below table (Tab. 5).

Table 5. Welfare stressors in small ruminants and their evaluation

Stressors	Criterion	Animal Indicators	Evaluation Production System
Environmental	Heat or cold stress	Heart rate	Measure on animals on the field
		Shivering score	Measure on animals on the field
		Breathing rate	Measure on animals on the field
	Water access	Drinker access	Evaluation of water access and availability
Physical	Housing conditions	Cleanness	Evaluation of the farm status
		Kneeling	Animals behavior on the feeders
		Allowed spaces	Farm area (m^2)
	Humidity	Dryness	Humidity of the floor and general humidity
		Air circulation	Windows availability and quantity
Nutritional	Prolonged hunger	Feeding queue	Behavior on the feeders
		Body conditions	BCS evaluation on the animals
	Hair coat	Rough or scurfy hair	Animals coat evaluation
	Water availability	Queuing at the drinker	Animals behavior at the drinking points
Management	Triming	Claw over growth	Animal Claws evaluation
	Tagging	Ear tears or inflammations	Evaluation of the animal ear injuries
	Weaning	Weaning age	Weaning age and methods for the flock
	Management Injury risk	Dehorning	Age and dehorning method when applicable
		Castration	Age and castration method when applicable
Pathological	Absence of Injuries	Lameness	Controlling the animals deplacement
		Lesions and swelling	Controlling the skin status
		Udder abnormalities	Controlling the udders status
	Absence of diseases	Abscesses	Controlling the presence of abscesses
		Vulvar, ocular and nasal discharges	Controlling the discharges on animals
		Vaccination	Controlling the farm vaccination protocol
Psychogenic	Isolation	Vocal response	Controlling animal behavior on separation and regrouping
		Locomotive activity	Controlling animal behavior
	Human – animal relationship	Avoidance distance test	Controlling animal behavior in front of humans
		Latency to first contact	Controlling animal behavior in first contact

Every stressor was evaluated by one or more than a criterion and the criterion was measured through different animal indicators.

Indicators were measured through the survey results. However for the parameters that needs measures on animals, like body condition or physiological parameters, further trials were held. For this experiment, three farms representing the semi-intensive system and another three from the extensive system were selected during the winter and summer season of 2019.

The flocks managed in extensive system were located in the regions of Hboub, Zgharta (coastal area) and the region of Kefraya (Bekaa plain). Small ruminants in these farms practiced vertical transhumance to the regions of Laklouk, Ehden and Kfardebian respectively.

The flocks raised in semi-intensive system were located in the regions of Jezzine and Nabatiye in Mount Lebanon geo-climatic area and the region of Bezaliye in the Bekaa plain. From each farm 20 subjects (sheep and goats) were selected and followed to assess the welfare status.

3.5.1 Determination of physiological variables

The physiological variables which include breathing Score (BS), pulse rate (PR), rectal temperature (RT) and shivering score (SC) were measured three time during the day in semi-intensive and extensive system: early in the morning before the flock leave the farm, at noon during the rest period near to the drinking point, in the evening when the flock returns at the farm.

The breathing score (BS) was assigned based on the visual observation of animal behavior, using a simplified 3-point scale (Fioni, 2014). The 3-point score system proved sufficient to highlight a condition of thermal discomfort, such as in presence of severe heat stress situations, where animal showed signs ranging from accelerated respiration with mouth closed (score 1) to panting with open mouth and excessive salivation (score 2). The pulse rate was obtained by counting the pulsations felt in the femoral artery per unit time, and pre scented as number of beats per minute. The body temperature of the animals was determined by measuring the rectal temperature using a digital thermometer and presented in ◦C.

The shivering score followed a 3-point scale scoring system which was developed and validated by Fioni (2014), who recorded signs of bristling hair on the back (score 1) and shivering with arched posture (score 2) related to severe cold stress.

3.5.2 Body Condition Score

The Body Condition Score (BCS) is rated on a scale of 0 to 5 with 1 being emaciated and 5 being extremely fat as described by Russel *et al.* (1969).

3.6 Blood sampling for DNA extraction

Five farms from the South district (2 for ovine and 3 for caprine) located between 500 and 1000 m of altitude and four farms from Baalbeck El Hermel (1 specialized in caprine and 3 in ovine) located between 1000 and 1200 m of altitude were used for this experiment.

During April 2018, 164 ewes and 174 goats multiparous (3-6 years), presenting similar milk production and body score condition 3 on the scale with a regular cycle were selected. From each subject a sample of 5 ml of blood from the jugular vein was collected using 2 vacuum tubes of 2.5 ml each with EDTA as an anticoagulant. Blood tube were maintained at -20^{o}C until DNA extraction.

3.7 Genomic DNA preparation and primers sequences

Ovine (n=164) and caprine (n=174) genomic DNA was extracted from whole blood using a genomic DNA extraction kit (NucleoSpin®Blood,

Macherey–Nagel, Düren, Germany) and then kept at −20 ◦C until use. Approximately 100–150 ng of genomic DNA was subjected to polymerase chain reaction (PCR) technique using specific primers synthesized by Sigma Genosys Ltd (Pampisford, Cambs, UK). Primers were the same by Messer et al. (1997) and correspond to positions 285–304 (sense primer 5'-TGT GTT TGT GGT GAG CCT GG-3') and 1108–1089 (antisense primer: 5'-ATG GAG AGG GTT TGC GTT TA-3') of the sequence by Reppert et al. (1994) (GenBank U14109). These primers allow amplification of the main part of exon II of the ovine MTNR1A gene. The newest MTNR1A gene sequence referred to from now on in the present research is the latest genome version Oar_rambouillet_v1.0 - GenBank assembly accession number: GCA_002742125.1.

3.8 DNA amplification and genotyping

PCR reaction was carried out in 50µl of total volume, containing 5 µl of 10X PCR Buffer Mg2+ free (0.8 M Tris-HCl, 0.2 M (NH4)2SO4, 0.2% w/v Tween-20), 3 µl of 25 mM MgCl2, 8 µl of dNTP mix 0.2 (mM of each dNTP), 1 µl of each primer (10 pM/l), 100–150 ng of ovine genomic DNA and 1.25U of Taq DNA polymerase (HOT FIREPol® Polymerase, Solis BioDyne, Tartu, Estonia). PCR conditions were as follows: initial activation of the Hot Start DNA Polymerase by a 15 min incubation step at 95°C, in order to prevent extension of non-specifically annealed primers and primers-dimer formed at low temperature during PCR setup, a further denaturation at 94 ◦C for 3 min followed by 10 cycles shared in denaturation 94 ◦C for 30 sec, annealing 68°C for 1 min, extension 72°C for 45 sec, finally additional 23 cycles shared in denaturation 94°C for 30 sec, annealing 58°C for 1 min, extension 72°C for 45 sec and a final extension at 72 ◦C for 5 min, on EuroClone® One Personal thermal cycler (Euroclone, Milan, Italy). PCR products were confirmed by electrophoresis on 1.5% agarose gel (w/v) (iNtrRon Biotechnology, Sangdaewon-Dong, South Korea) added with 7 µl of RedSafe stain (iNtrRon Biotechnology, Sangdaewon-Dong, South Korea), in parallel with 100 bp DNA marker (GeneRuler, Thermo Scientific™, Waltham, Massachusetts, US). An amount of 10 µl of the PCR amplification reaction were subjected to restriction enzymes analysis with the enzymes MnlI and RsaI (New England Biolabs, Beverly, MA, USA) for sheep samples and with RsaI alone for goat samples. In goats are no polymorphic sites detectable by MnlI enzyme (Carcangiu *et al*., 2009), so that only digestion with RsaI endonuclease has been carried out in these animals.

The recognition sequence cut is 5'-CCTC(n)7ˆ-3' and 3'-GGAG(n)6ˆ-5' for MnlI, and 5'-GTˆAC-3' for RsaI endonuclease. The digestion reaction was the same for sheep and goat, and it was carried out on 30 µl final volume, containing 17 µl of ultrapure water DNase/RNase free (Water PCR grade, Solis BioDyne, Tartu, Estonia) 2 µl of 10X CutSmart Buffer (50 mM Potassium Acetate, 20 mM Tris-Acetate, 10 mM Magensium Acetate, 100 µg/ml BSA, pH 7.9 at 25°C) and 1 µl of RsaI or MnlI endonuclease. The digestion mix were incubated in thermostatic bath at 37°C for 2 hours, followed by enzyme heat inactivation step at 65°C for 20 min. Products of digestion were resolved by electrophoresis on a 1.5% agarose gel (w/v) (iNtrRon Biotechnology, Sangdaewon-Dong, South Korea) added with 7 µl of RedSafe stain (iNtrRon Biotechnology, Sangdaewon-Dong, South Korea), in parallel with 50 bp DNA marker (GeneRuler, Thermo Scientific™, Waltham, Massachusetts, US).

4 Results

4.1 Identification of small ruminants systems in Lebanon

Data concerning the identification of small ruminants systems in Lebanon and the specifications related to every system are shown in table 6.

Table 6. Small ruminants rearing systems in Lebanon

System	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Significance**
Suggested system name	**Intensive**	**Semi - Intensive**	**Extensive**	
Number of farms	5	246	266	P<0.05
Herd size (Head)	740 ± 706.6	145 ± 109.3	200 ± 151.9	P<0.05
(Min – Max)	(350 – 2000)	(12 – 500)	(12 – 650)	
Mixed flock (%)	0	20.3	2.6	P<0.05
Access to grazing	No	Yes	Yes	P<0.001
Transhumance (%)	0	0	100	P<0.001
Family Business (%)	60	100	100	P<0.001
Level of Education (%)				P<0.001
None	20	74	83	
Primary	40	26	17	
University	40	0	0	
Farmer age (%)				0.004
Up to 40 years	20	4	8	
41 – 50 years	40	35	44	
51 – 60 years	20	37	29	
More than 61 years	20	23	19	

The analysis of the survey in the seven districts of Lebanon has identified three major production systems.

- Intensive system:

  Landless farmers, with either medium size herds (350-500 head) formed exclusively of the dual purpose Awassi sheep or large size herds (400-2000 head) formed exclusively of foreign goat breeds (Alpine and Saanen). Animals are kept confined in the farm all the year with no access to natural rangelands (zero grazing system) and no transhumance. (Fig 8, 9)

Figure 8. Alpine and Saanen raised in intensive system

This system is characterized by:

- The need for a large quantity of food. Animals are hand-fed on forages, concentrate (sometimes exceeding 500 kg/female) and agro-industrial products when available;
- The direct sale on farm of meat and milk to intermediate collectors. In goat farms milk is transformed into an array of traditional dairy products;

- The dominance of foreign goat breeds with high or medium dairy productivity ranging from 270 to 500 kg of milk per lactation.
- With regard to employment, 60% of the visited farms are family businesses, the remaining 40% are formed by corporate registered farms. Concerning the age of the farmers, 60% of the farmers were less than 50 years old, 20% were between 51 and 60 years, while only 20% were above than 61 years old. Farmers showed different level of education, 40% of the farmers had a university diploma, the other 40% a high school degree and the 20% left had no education.

Figure 9. Awassi sheep raised in intensive system.

- Semi-intensive system:

  Farmers manage rented or owned land, with medium size herds (12-500) formed either by goat (Baladi and Damasquine) or the dual purpose Awassi sheep or goat and sheep together. (Fig. 10,11 and 12).

Figure 10. Baladi and Damasquine goat raised in semi-intensive farm.

Animals remain in and around the farm with low to average use of rangelands. Pastures are usually located near to the farm and the flocks have short daily movement which allows them to return each evening to their initial location. They depend on crop residues. The negative effects induced by climatic conditions (summer drought from June to October and winter cold from December to January) are overcome by relying on the food supplement brought to the flocks. Milk and meat are sold to intermediate collectors and in some farms milk is processed into dairy products.

Figure 11. Awassi sheep raised in semi-intensive farm.

In these semi-intensive rearing systems 100% of the farms are family businesses. The use of labor is a part time operation that may be undertaken by unpaid family labor (children and farmer's wives) or by paid shepherds. In the case of small herds, it is not uncommon for the shepherd to herd the animals belonging to several farmers for grazing.

Concerning the level of education, the majority of the farmers 74% are uneducated while only 26% of the farmers have school diploma. 39% of the farmers were below 50 years old, 37 % between 51 and 60 years and 23% above 60 years old.

Figure 12. Mixed sheep and goat flock in semi-intensive farm.

- Extensive system:

  Flocks are usually of medium to large size consisted by Baladi goat or Awassi sheep and rarely goat and sheep together (only 7 flocks observed). (Fig. 13, 14).

Figure 13. Awassi sheep on extensive pasture.

Animals spend almost the entire year outside their home sites in search of grazing pastures. This system is divided into two kind of transhumance:

- Vertical transhumance: Herds follow a route between the coastal zone (200-700m of altitude) in winter and the high mountain (1500-2000m altitude) in summer from end of May till end of September.
- Horizontal transhumance: Herds shifting is carried out in the plain area mainly Bekaa or North of Lebanon.

In both transhumance farms are 100% family businesses. Some members of the family and their herds leave the territories in which the majority of the family is permanently settled (origin territory) to join different territories (of transit, host or destination) in order to access better resources of water and pasture.

Figure 14. Extensive goat flock in mountain rangelands

In extensive system 52% of the farmers are below 50 years old, 29% are between 51 and 60 years and only 19% of the farmers are above 61 years old. Concerning the level of education, none of the farmers has reached university, the majority 83 % has no diploma and only 17% of the farmers went to school.

The tables 7, 8 and 9 bellow show the distribution of goats and sheep herds in the different districts of Lebanon according to the three defined rearing systems.

Table 7. Sheep distribution in the different districts and rearing systems in Lebanon.

Production System / Region	Intensif		Semi-intensif		Extensif	
	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N
Mount Lebanon			169.43 ± 125.41	47	258.06 ± 162.02	25
Bekaa	350	1	103.16 ± 46.43	19	321.25 ± 147.98	8
Baalbek hermel			154.38 ± 95.28	16	345.71 ± 167.46	14
North Lebanon	450	1	71.64 ± 36.22	7	253.75 ± 168.52	8
Akkar			173 ± 156.77	11	317.72 ± 180.02	30
South Lebanon	500	1	124.07 ± 76.00	27		
Nabatiyeh			101.19 ± 75.64	18	113.33 ± 11.55	3
Total	433.33 ± 76.37	3	137.72 ± 103.65	145	292.76	88

The intensive sheep rearing system appears only in three farms distributed in three districts (Bekaa, North and South of Lebanon) over seven. The average herd size is 433 head/farm. The semi-intensive and extensive systems are found in the seven districts of Lebanon with an average herd size of 137head/farm and 292 head/farm respectively.

Goat raised under the intensive system are found only in one district (Mount Lebanon) of the seven districts with an average herd size of 1200 head/farm. The semi-intensive and extensive systems are distributed in all the seven districts with an average herd size of 129 head/farm and 151 head/farm respectively.

Table 8. Goat distribution in the different districts and rearing systems in Lebanon.

Production System / Region	Intensive		Semi-intensive		Extensive	
	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N
Mount Lebanon	1200 ± 1131.37	2	110.13 ± 101.12	12	197.53 ± 138.91	56
Bekaa			58.33 ± 23.17	6	113.48 ± 69.19	23
Baalbek hermel			160.45 ± 120.55	11	170.5 ± 127.50	20
North Lebanon			120 ± 54.16	4	149.09 ±105.87	11
Akkar			171.43 ± 81.51	14	166.92 ± 78.17	26
South Lebanon			86.67 ± 50.332	3	89.62 ± 64.28	26
Nabatiyeh			50	1	58.89 ± 38.87	9
Total	1200 ± 1131.37	2	129.93 ± 94.12	51	151.59 ± 113.70	171

Mixed flocks of sheep and goat are raised only under the semi-intensive and extensive systems in all the districts of Lebanon (excluding Nabatiyeh district in extensive system). The average herd size is 180 head/farm and 200 head/farm for semi-intensive and extensive system respectively.

Table .9 Sheep and goat distribution in the different districts and rearing systems in Lebanon.

Production System / Region	Semi-intensive		Extensive	
	Mean ± SD	N	Mean ± SD	N
Mount Lebanon	222.94 ± 132.04	17	100	1
Bekaa	96.67 ± 25.17	3	650	1
Baalbek hermel	85.79 ±70.05	7	225 ± 35.35	2
North Lebanon	226.67 ± 176.94	6	100	1
Akkar	220 ±153.54	9	60	1
South Lebanon	134 ± 61.48	5	40	1
Nabatiyeh	116.67 ± 98.15	3		
Total	180.81 ± 131.98	50	200 ± 212.21	7

4.2 Effect of rearing systems on the reproduction of small ruminants in Lebanon

4.2.1 Effect of rearing systems on the reproduction of Awassi sheep in Lebanon

Data concerning the effect of rearing systems on the reproduction of Awassi sheep in Lebanon are shown in table 10.

Weight of lambs at birth varied from 3.9 Kg to 5.4 kg between the different rearing systems. Prolificacy was 1.11 in the extensive system, 1.28 in the semi-intensive system and 1.79 in the intensive system. Fertility recorded 87.3%, 85 and 80.7% in the intensive, semi-intensive and extensive systems respectively. First lambing occurred at 12 months in the intensive system, 20 months in the semi-intensive and 21 months in the extensive.

Table 10. Reproduction data for Awassi sheep in Lebanon

	Intensive		Semi-intensive		extensive		Significance
	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	
Weight at birth	$3.9^{a} \pm 0.1$	3	$4.94^{ab} \pm 1.15$	145	$5.40^{b} \pm 0.97$	84	0.05
Prolificacy	$1.79^{a} \pm 0.05$	3	$1.28^{b} \pm 0.06$	145	$1.11^{c} \pm 0.03$	88	0.000
Fertility	$87.3^{a} \pm 0.57$	3	$85.0^{b} \pm 1.28$	145	$80.7^{c} \pm 1.66$	88	0.000
First lambing age (months)	$12^{a} \pm 0.00$	3	$20^{b} \pm 4.0$	145	$21^{b} \pm 4.5$	88	0.002
Abortion rate (%)	$5^{a} \pm 1$	3	$10.4^{b} \pm 2.8$	145	$14.7^{c} \pm 2.9$	88	0.000
Weaning age (months)	$2.8^{a} \pm 0.28$	3	$5.1^{b} \pm 1.23$	144	$4.47^{b} \pm 1.29$	88	0.000

Semi-intensive system did not affect the weight of lambs at birth. However Awassi lambs were significantly heavier ($p<0.05$) in extensive system comparing to the intensive system. Prolificacy was greater ($p=0.000$) in the intensive system than in the semi-intensive and the extensive system, respectively. Fertility was significantly higher ($p=0.000$) in the intensive system followed by the semi-intensive and extensive system. First lambing age was significantly affected ($p<0,002$) by the rearing system, lambs reached puberty earlier in the intensive system comparing to the semi-intensive and extensive system. Weaning age was earlier in the intensive system ($p=0.000$) followed by the extensive than the semi-intensive system. Abortion rate was affected significantly ($p=0.000$) by the rearing system being the highest in extensive system (14%) followed by the semi-intensive and extensive system (10% and 5% respectively).

Ewes raised in the intensive system tended to have better prolificacy and fertility than those raised in semi-intensive and extensive system. These results may be attributed to the feeding management that is controlled in the intensive system.

Lambs were separated from ewes earlier in the intensive system whereas weaning age was delayed in semi-intensive and extensive system. Such practices are explained by the fact that both milk (Hosri and Nehme, 2006) and meat productions (Shomo et al., 2010) are the main targets in the intensive system.

Concerning the weight at birth, ewes were heavier in the extensive system than the intensive, this is probably due to the fact that multiple births (twins and triplets) occur more in intensive system than in the extensive. These results are in accordance with (Thomson *et al.*, 2004) who found that lambs from larger litters sizes were significantly smaller, with on average a 1 kg disadvantage for every additional lamb. This was also similar to that found by Morris *et al*. (2003).

The high percentage of abortion in extensive system could be explained by the management practices such as pathological, traumatic, physiological and physical stressors.

4.2.2 Effect of rearing systems on the reproduction of goats in Lebanon

Results concerning the effect of rearing systems on the reproduction of goats in Lebanon are shown in table 11.

Table 11. Reproduction data for goats in Lebanon.

	Intensive		Semi-intensive		Extensive		Significance
	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	
Weight at birth	3.4± 0.14	2	4.14± 0.91	50	4.04± 1.02	170	0.54
Prolificacy	1.77^{a} ± 0.03	2	1.40^{b} ± 0.09	51	1.27^{c} ± 0.04	171	0.003
Fertility	88.5^{a} ± 0.7	2	84.9^{b} ± 1.1	51	80.6^{c} ± 1.4	171	0.03
First lambing age (months)	12^{a} ± 0.00	2	20^{b} ± 4.5	51	21^{b} ± 4.0	171	0.002
Abortion rate (%)	4.5^{a} ± 0.7	2	10.8^{b} ± 2.8	51	14.65^{b} ± 3.1	171	0.000
Weaning age (months)	2.0^{a} ± 0.00	2	4.6^{b} ± 1.16	51	5.0^{b} ± 1.26	171	0.001

Despite that the weight at birth was 3.4kg in the intensive system and more than 4 kg in the semi-intensive and the extensive system, the difference between rearing systems was not significant ($p>0.05$). Prolificacy was significantly affected ($p<0.05$) by rearing system, being greater for the intensive than the semi-intensive and extensive system. On the other hand fertility was higher ($p<0.05$) in the intensive system than the semi-intensive and extensive system respectively.

First lambing occurred earlier ($p<0.002$) in the intensive system compared to the semi-intensive and extensive system. No difference was recorded between the semi-intensive and extensive system concerning the first lambing age.

Weaning age was similar in the semi-intensive and extensive system, however it was significantly affected in the intensive system ($p<0.005$), kids being weaned earlier (2 months) in this system than the others (around 5 months).

The influence of rearing system on the weight at birth of kids in semi-intensive and extensive system could be referred to the nutritional conditions that vary between one system and another.

Prolificacy and pregnancy rate of goat kept in intensive system were greater than the others. This may be due to the breed effect, goat in intensive system being mainly foreign (Alpine and Saanen).

Concerning prolificacy and fertility in extensive system, results could be explained by the fact that in this system feeding management of goats relies on poor nutritive pastures, such as natural rangelands and crop residues. As a result Baladi goat shows poor reproductive performances (Hajj, 1999).

4.2.3 Effect of rearing systems on the reproduction of goats and sheep in Lebanon

Results concerning the effect of rearing systems on the reproduction of goats and sheep in Lebanon are shown in table 12 below

Table 12. Reproduction data for goats and sheep in Lebanon

	Semi-intensive		extensive		Significance
	Mean ± SD	N	Mean ± SD	N	
Weight at birth	$4.81^{a}\pm 1.11$	48	$3.29^{b}\pm 1.18$	7	0.001
Prolificacy	$1.32^{a}\pm 0.06$	50	$1.19^{b}\pm 0.07$	7	0.000
Fertility	$84.9^{a}\pm 1.05$	50	$80.7^{b}\pm 1.11$	7	0.000
First lambing age (months)	20± 4.3	50	21± 3.0	7	0.54
Weaning age (months)	4.8± 1.37	50	5.4± 1.27	7	0.26
Abortion rate (%)	$10.4^{a}\pm 3.00$	50	$13.4^{b}\pm 3.2$	7	0.02

Rearing system did not affect the weaning age; kids were separated from their mothers at 5 months approximately. Weight and birth, prolificacy and fertility were higher ($p<0.05$) in the semi-intensive system comparing to the extensive system. Finally first lambing occurred at a similar age in both systems around 20 months.

4.3 Effect of rearing systems on the milk production of small ruminants in Lebanon

4.3.1 Effect of rearing systems on the milk production of Awassi sheep in Lebanon

The figure 15 illustrates milk production of Awassi ewe per year in the different districts and rearing systems in Lebanon.

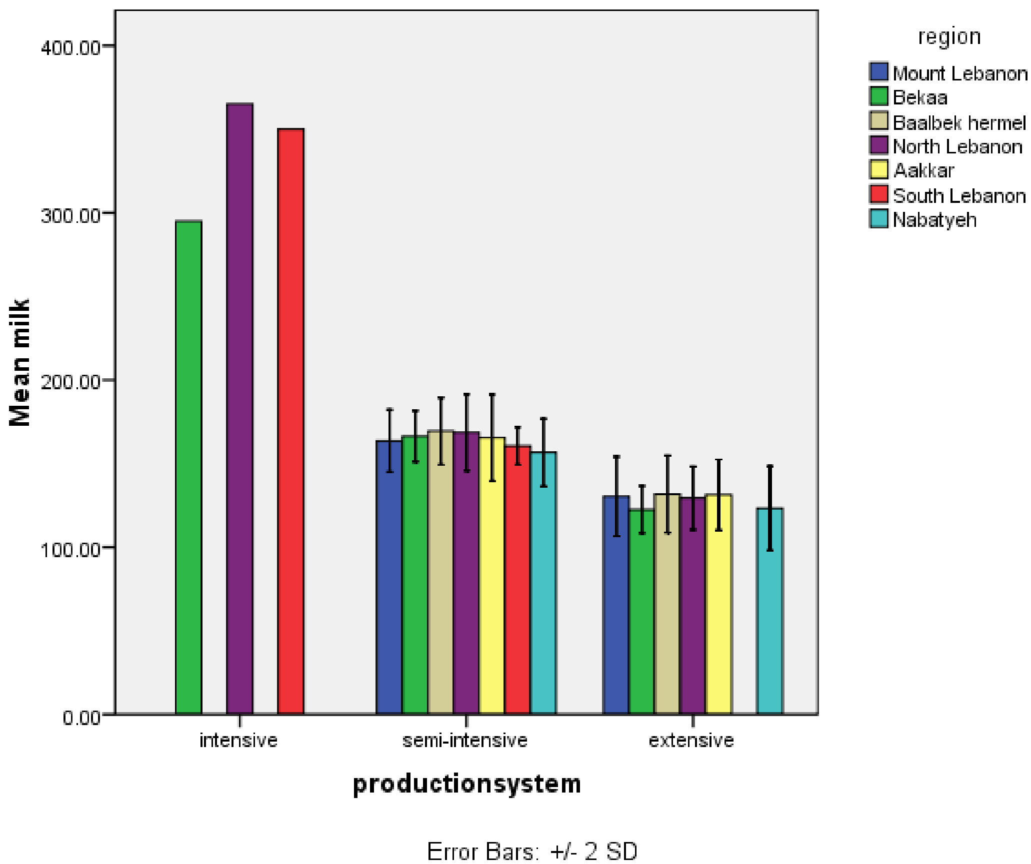

Figure 15. Average milk yield (L/year) of Awassi sheep in the different Lebanese districts according to the production systems

Ewe raised under the intensive system produced the highest amount of milk ($p<0.05$). The average milk yield of ewes in intensive flock was 336.7 l/year, ewe in semi-intensive and extensive system produced 163.5 l/year and 129.9 l/year respectively ($p<0.005$).

Flocks raised in the Bekaa district showed the lowest milk production compared to the other districts in the three rearing systems, significantly in the intensive and extensive systems.

Results concerning the average milk yield/year are similar to those found for the same breed by Alkass and Juma (2005), ACSAD (1996), Fadel *et al*. (1989), Kassem (2005), Hosri and Nehme (2006) and Gürsoy *et al*. (1992) who reported an annual milk production from 60 to 327 kg/year.

On the other hand, the average milk production of ewes in semi-intensive system was higher ($p<0.005$) than the extensive system. This could be due to the fact that Mediterranean pastures are subject to important dietary decline as the summer season advances Cabiddu *et al*. (1999), Ben Salem *et al*. (2004). In the same time energy requirements for the extensive flocks on the nature lands increase with walking elevation and distance Lachica and Aguilera (2003).

4.3.2 Effect of rearing systems on the milk production of goats in Lebanon

Results concerning annual milk production of goat in the different districts and rearing systems in Lebanon are shown in the figure bellow (Fig.16).

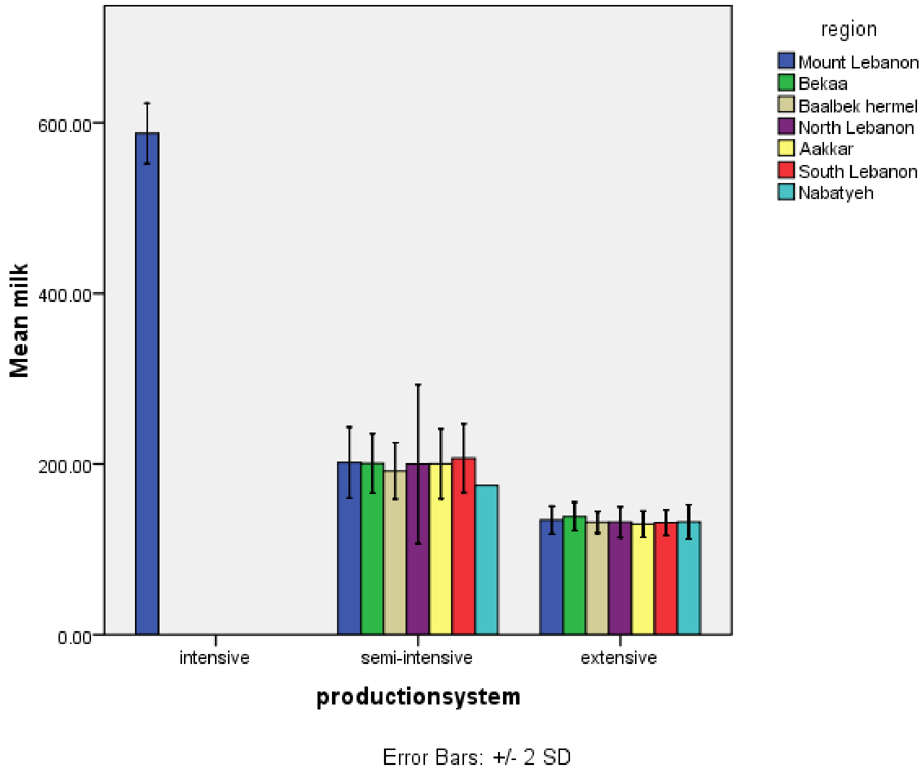

Figure 16. Average milk yield (L/year) in the different Lebanese districts according to the production systems

Goats raised in intensive system showed high annual milk yield 587.5 L/year, this could be due to the breed effect Saanen and Alpine goats, being the highest performant milk producers, are imported to Lebanon and raised exclusively under intensive systems.

Annual milk production per year was significantly ($p<0.005$) affected by the rearing system with goats raised under semi-intensive system producing more milk (198.7 L/year) than those raised in the extensive system (133 L/year).

The significant difference ($p<0.005$) between the two systems can be related to following reasons.

- Feeding management in extensive system that relies on poor nutritive pastures wich affects the goat that shows poor dairy production. This finding was described by Lefrileux *et al.* (2008) who mentioned that milk potential during lactation can be improved when supplemented with concentrates on poor rangelands.
- Flocks in semi-intensive systems are mixed between Baladi, Damasquine and their hybrids. Damasquine goat, originated from the area and well adapted to semi-intensive systems, is a medium to high milk producer 311 L/year-to 530 L/year depending on the region (Aboul-Naga,(1984) and Özcan and Güney, (1988)). This high productivity will leads to an increase of the overall average of the semi-intensive flock.

4.3.3 Effect of rearing systems on the milk production of sheep and goats in Lebanon

Results concerning annual milk production of sheep and goats in the different districts and rearing systems in Lebanon are shown in the figure bellow (Fig.17).

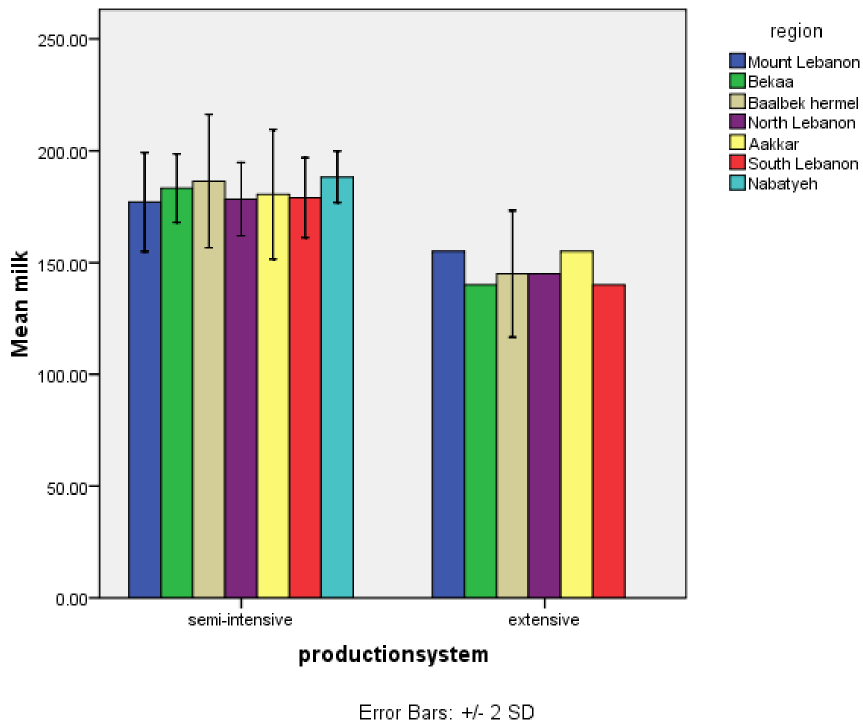

Figure 17. Average milk yield (L/year) of sheep and goat in the different Lebanese districts according to the production systems

Annual milk production of sheep and goat was significantly ($p<0.005$) affected by rearing systems. Mixed flocks raised in semi-intensive system produced more milk (180.4L/year) than those reared in extensive system (146.4L/year).

4.4 Effect of rearing system on welfare of small ruminants in Lebanon

Welfare evaluation of small ruminants was done according to the 6 stressors (environmental, physical, nutritional, management, pathological and psychogenic) previously described.

4.4.1 Environmental stressors

The bellow table 13 shows the results of the environmental stressors evaluated upon the heat and cold stress criterion measured according to cardinal physiological indicators (Pulse Rate, Breathing Score, Rectal Temperature and Shivering Score.

Table 13. Mean (±SD) values of Pulse Rate (PR), Breathing Score (BS), Rectal Temperature (RT) and Shivering Score (SC) in different Lebanese small ruminant's production systems during summer and winter seasons.

		Semi-intensive system			Extensive system		
		Morning	Noon	Evening	Morning	Noon	Evening
Winter	PR	73.63 ± 5.07	79.43 ± 8.42	75.6 ± 7.27	84.38 ± 5.29	76.07 ± 6.72	70.4 ± 4.93
	BS	0.16 ± 0.37	0.18 ± 0.39	0.13 ± 0.34	0.10 ± 0.30	0.21 ± 0.41	0.16 ± 0.37
	RT	38.6 ± 0.25	38.5 ± 0.22	38.8 ± 0.33	38.6 ± 0.26	38.7 ± 0.40	38.6 ± 0.23
	SC	0.13 ± 0.34	0.07 ± 0.25	0.12 ± 0.32	0.15 ± 0.36	0.18 ± 0.39	0.20 ± 0.40
Summer	PR	70.2 ± 4.45	78.62 ± 5.18	96.38 ± 5.48	65.77 ± 3.89	107.55 ± 3.67	89.43 ± 4.91
	BS	0.15 ± 0.36	0.77 ± 0.87	0.16 ± 0.37	0.11 ± 0.32	1.38 ± 0.49	0.43 ± 0.56
	RT	38.7 ± 0.30	38.9 ± 0.38	38.6 ± 0.26	38.6 ± 0.30	39.4 ± 0.22	38.6 ± 0.26
	SC	0.05 ± 0.22	0.00 ± 0.00	0.05 ± 0.22	0.23 ± 0.42	0.00 ± 0.00	0.00 ± 0.00

PR: Pulse rate (Beat per minute);
BS: Breathing Score (3 points scale: score 0 = no excessive breathing signs; score 1 = accelerated respiration with mouth close; scale 2 = Panting with open mouth and excessive salivation);
RT: Rectal Temperature (^{0} C);
SC: Shivering Score (3 points scale: score 0 = no signs of shivering; score 1 = Breathing hair on the back; score 2 = shivering with arced posture).

Cardinal physiological parameters were within the normal range for the small ruminants raised in semi–intensive systems during both winter and summer periods. The extensive system results, showed a high values of the pulse rate and the breathing score (107.55 ± 3.67 and 1.38 ± 0.49 respectively) during the summer period at noon when goats and sheep were exposed to high temperatures in direct sunlight. The shivering score did not show a high cold stress exposition for the small ruminants raised in both systems.

Results concerning the increase of pulse rate are explained by the fact that heart rate of small ruminant's increases in response to the requirements for additional blood flow to the lungs to support hyperventilation (Cezar *et al.*, 2004). The relatively high breathing score indicated a beginning of heat stress condition in some subjects of the cattle. Breathing score been described as the most sensitive cardinal physiological variables to heat stress (Gaughan *et al.,* 2000), this is because, changes in respiratory rate always precedes changes in other cardinal physiological variables such as rectal temperature and pulse rate during thermal stress (Singh *et al.*, 2016).

Experimented flocks did not show cold stress situation due to the fact that in winter period, small ruminants are confined in the farm with high density which keeps them in a warm condition.

It is important to mention that water is constantly available for the flocks in semi-intensive farms and during the night in the extensive farms. However animals on ranges have occasionally access to water (one or two times during the day),which leads to thirst signs manifested by a queuing at the drinking source especially after several hours of walking under the direct sun in hot weather.

4.4.2 Physical stressors

The results of the physical stressors are evaluated upon the housing conditions and humidity criterion and measured according to cleanliness, kneeling, allowed spaces, dryness and air circulation indicators. The below figures shows the average allowed space per animal, the cleanliness and the farms ventilation in the different Lebanese systems (Fig. 18).

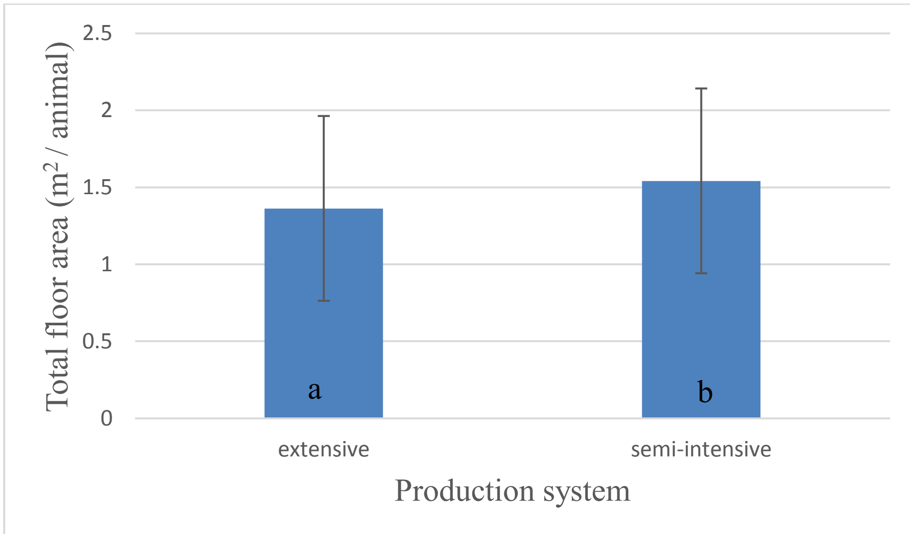

Figure 18. Total floor area allowed for small ruminant production in different Lebanese production systems

Sheep and goat houses were often inadequate in terms of design, materials and size.

The total floor area for small ruminants was below the space allowance norms (>1.65 m^2/animal) in both semi-intensive and extensive systems. This indicates that during winter period, when the weather conditions are bad, and during night animals are crowded and do not have enough space for resting, lying and feeding. This housing condition induces stress for animal and affects his welfare. A 2 m^2 space/animal has been recommended to sustain both production performances and health of lactating ewes (Sevi *et al*., 1999).

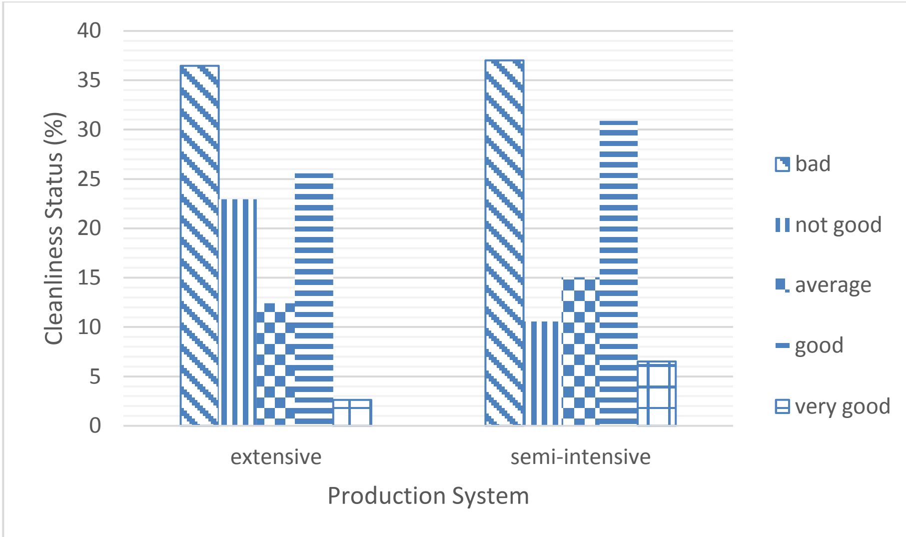

Figure 19. Barns cleanliness situation of the small ruminant production in different Lebanese production systems.

Concerning barns cleanliness (Fig. 19) around 37% of the farms were in bad condition (litter was removed twice a year) in both semi-intensive and extensive system, 23% and 10% scored not good (litter was removed four time a year) in extensive and semi-intensive system respectively. Between 12 and 15 % of the farms, in extensive and semi-intensive respectively, showed average score (litter being removed every two months). 25% and 31% of the farmers in extensive and semi-intensive system respectively kept their barns in good condition (litter was removed monthly). Only 2.5% and 6.5 % of the barns were in very good condition (litter being removed weekly) in extensive and semi-intensive system respectively.

Around 60% and 50% in extensive and semi-intensive farms showed poor management of litter, this situation leads to absence of hygiene condition, high humidity due to the big capacity of water retention and high level of ammonia NH_3. Those last two parameters coupled with bad ventilation (around 60% in both extensive and semi-intensive system as shown in figure 20) could lead to a very stressfull and unhealthy environment which affects the welfare of the flock.

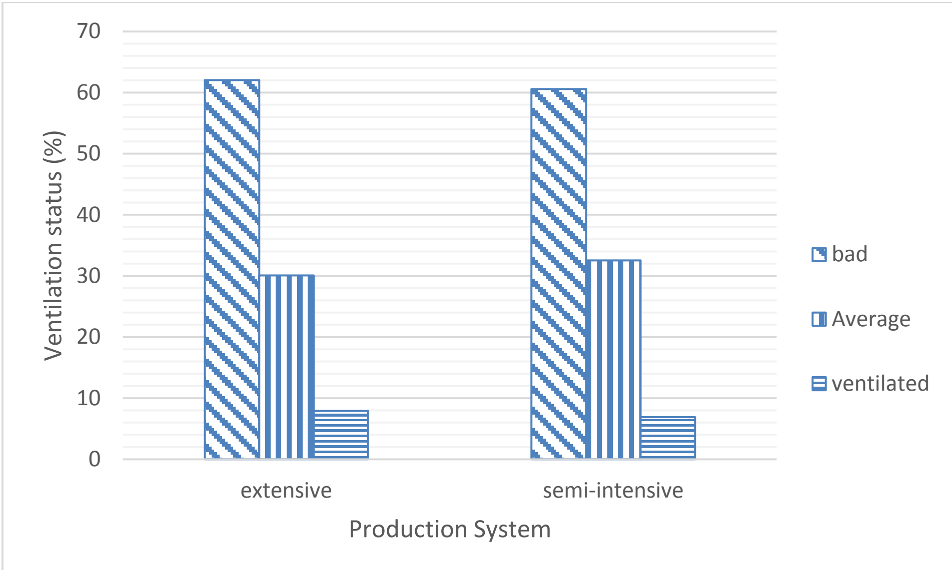

Figure 20. Small ruminant's farms ventilation status in different Lebanese production systems.

These observations are in accordance with Sevi and Casamassima (2009) who summarized the variations in the yield and quality of milk in response to some physical parameters, showing that reduction in space allowance (from 2 to 1 m_2/head), air space (from 7 to4 m_3/head) and air change (from 47 to 23 m_3/head) as well as 'no litter management', in comparison to 'litter removal', were detrimental leading to decrease in milk yield and quality up to -17%. This productivity reduction is explained by an accumulation of ammonia that decreases feed intake as well as body weight gain (Philips *et al.*, 2012).

4.4.3 Nutritional stressor

The results of the nutritional stressors are evaluated upon prolonged hunger, water availability and hair coat criterion and measured according to body condition score (BCS), feeding and water queue and hair status. The below figure 21 shows the body condition score variation around the year in different Lebanese production systems.

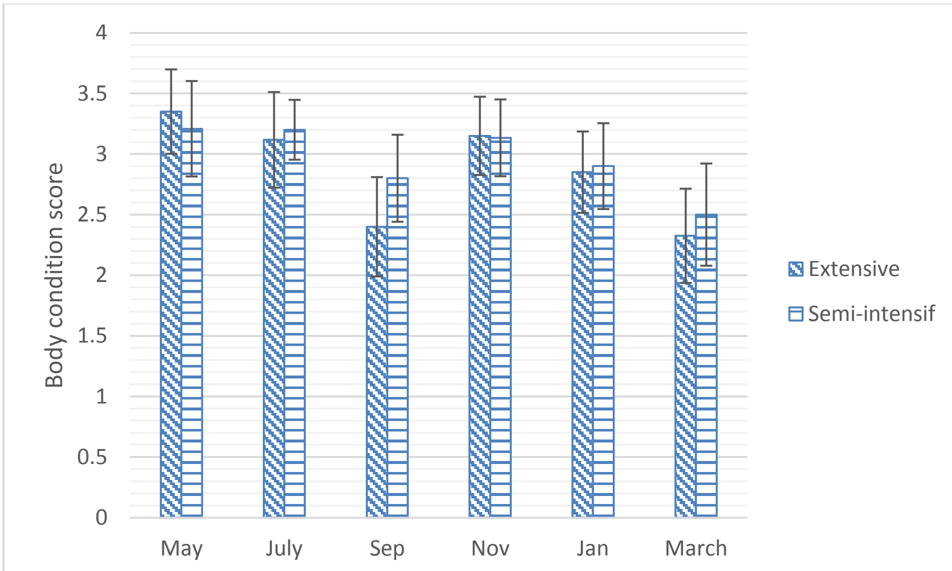

Figure 21. Small ruminant's body condition score variation around the year in different Lebanese production systems.

During May, small ruminants raised in both extensive and semi-intensive system, showed the higher body score condition (3.45 and 3.3 respectively). In extensive system, BCS declined during the summer period to reach a 2.4 score in September. While in semi-intensive system BCS maintained the same score during July and decreased to a score of 2.8 in September. BCS increased in November (around 3.15) for both systems and decreased again during January and March with a more expressive trend in the extensive system.

The low BCS observed during the summer period in extensive system is due to the fact that quality of natural pastures decline in summer because of climatic conditions (high temperature and dryness). Several studies confirm that Mediterranean pastures are subject to important dietary decline as the summer season advances (Cabiddu *et al.*, 1999; Ben Salem *et al.*, 2004).

Feeding supplementation practices in semi-intensive system is the reason why BCS maintained a better level than in extensive system. In fact Chesworth, (1996) and Atti *et al*., (2004) have mentioned that when food supply is clearly insufficient, body condition degrades.

Feeding queue indicator was not relevant in extensive system however in semi-intensive system, some minor cases were noted due to food management (restricted amount of feed or inappropriate type and composition) which leads to competition between animals and queuing at the feed trough.

4.4.4 Management stressor

The results of the management stressors are evaluated upon trimming, tagging, weaning and management risk injury criterion and measured according to claw overgrowth, ear tears or ear inflammation, weaning age, dehorning and castration.

Routine trimming which is a required management procedure essential to maintain normal hoof structure (Smith and Sherman, 2009) is regularly done in intensive system. This practice is limited in Lebanese semi-intensive and extensive system, because permanent movement of animals reduces claw overgrowth. However during rainy period, when animals are confined in the farm with a limited movement, we noticed claw overgrowth in some subjects (<5%) with cases of lameness. Overgrown hooves make walking difficult and predispose the animal to other foot problems such as foot rot, especially when animals are in wet environment. In this situation sheep and goats go off feed and stop exercising.

Tagging procedure is not practiced in semi-intensive and extensive system and farmers are capable of recognizing each subject by visual observation.

Weaning as previously described is done at around 5 months of age; separation is done gradually and sometimes occurs naturally when milk yield decreases. This practice of weaning does not stress the mother and her offs springs and welfare of the animals is not affected.

Dehorning is practiced in a limited way in both semi-intensive and extensive system (7% and 10% respectively when needed). The absence of dehorning could pose risk of injuries to workers and other animals and cause in some cases carcass bruising (Schwartzkopf-Genswein *et al.*, 2012), thus affecting animal welfare.

4.4.5 Pathological stressor

The results of the Pathological stressors are evaluated upon absence of injuries and diseases criterion and measured according to Lameness, lesions, udder abnormalities, abscesses, discharges (vulvar, ocular and nasal) and vaccination.

Lameness (5% as previously mentioned) was observed in some subjects in both production systems. Lameness is an important indicator of pain (O'Callaghan *et al.*, 2003) and may lower productivity in dairy goats, reducing milk yield and fertility (Christodoulopoulos, 2009), as well as contributing to pregnancy toxemia (Lima *et al.*, 2012).

Lesion and udder abnormalities were rarely observed in the flocks. Subjects presenting these problems were eliminated from the herd because farmers appeal veterinary services only in rare cases to avoid extra costs.

Vaccination and parasite treatments are practiced in systems, vaccines and medicines being distributed for free by the Lebanese Ministry of Agriculture.

4.4.6 Psychogenic stressor

The results of the psychogenic stressors are evaluated upon isolation and human-animal relationship and measured according to vocal response, locomotive activity, avoidance distant test and latency to first contact.

Kids and lambs at around one week old, in both semi-intensive and extensive systems, are isolated from their mothers during the day period, when ewes and goats are on the pastures in search for water and food, and reunited at the evening when the mothers return at the farm. An increase in locomotive activity and vocalization was observed in around 80% of the kids, when the mothers came back to the farm at night. This change in activities is an attempt by the kids to to escape isolation, whereas vocal response is an attempt to communicate with their mothers. This temporary isolation of kids from their mothers can induce an emotional stress and fear which affects welfare of the animal. These observations are similar to those of Siebert *et al*., (2011) who mentioned that separation from the group cause social disruption that leads to increase stress response and metabolic changes in the animal.

4.5 Melatonin receptors in small ruminants Lebanese flock

4.5.1 Sheep population

In all the analyzed sheep samples (n= 164) amplification products resulted in a single fragment of 824-bp in length that correspond to the entire MTNR1A exon II (Fig. 22).

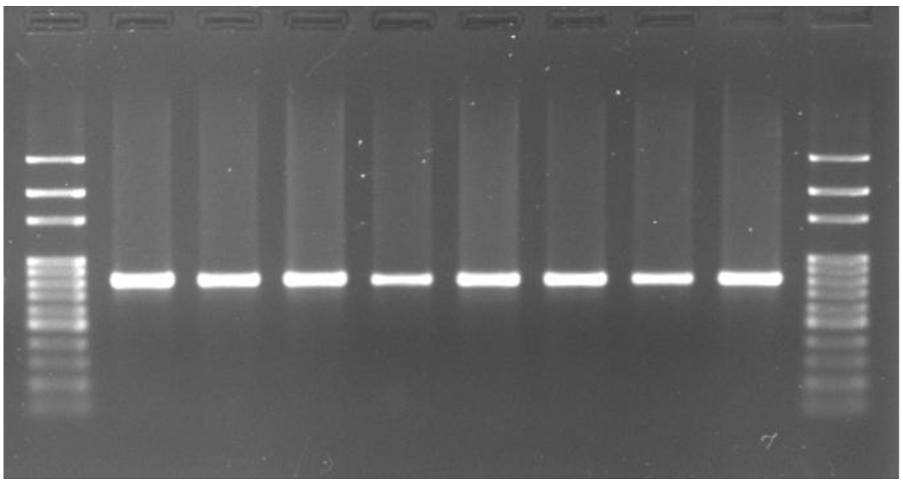

Figure 22. Electrophoresis after PCR analysis in sheep and goat samples (1.5% agarose gel). Lanes 1 and 10: 100-bp Ladder; lanes 2 to 5: 824-bp band in sheep samples, corresponding to the MTNR1A gene exon II; lanes 6 to 9: 824-bp band in goat samples, corresponding to the MTNR1A gene exon II.

The alignment of the sequences with that in GenBank indicated there was a total number of eight SNPs: six of which were silent (g.15099644 T > G, g.15099491C > T, g.15099485 A > G, g.15099314 G > A, g.15099296 G > A, g.15099206 T > C), while with the others there was an amino acid change (g.15099391 G > A causing p.Val220Ile, and g.15099204C > A causing a p.Ala282Asp substitution in the amino acid sequence.

0

Table 14. Nucleotide and amino acid changes within *MTNR1A* gene exon II in Sarda ewes (n=300 sequenced ewes)

SNP position [a]	Nucleotide change [b]	Codon change [c]	Amino acid change [d]
g.17355611	T>G	AC**T**/AC**G**	None: Thr135Thr
g.17355458	C>T	TA**C**/TA**T**	None: Tyr186Tyr
g.17355452	A>G	CC**A**/CC**G**	None: Pro188Pro
g.17355358	G>A	**G**TC/**A**TC	Val220Ile
g.17355281	G>A	CT**G**/CT**A**	None: Leu245Leu
g.17355263	G>A	AG**G**/AG**A**	None: Arg251Arg
g.17355173	T>C	CC**C**/CC**T**	None: Pro281Pro
g.17355171	C>A	G**C**C/G**A**C	Ala282Asp

[a] According to the latest genome version Oar4.0 (GenBank acc. number NW_014639035.1)

Using MnlI endonuclease 7 cleavage sites have been evidenced within the 824-bp band, producing up to 8 fragments of the size (in base pair) specified below: 236, 219, 134, 82, 67, 36, 28 and 22-bp, that added together precisely give a total length of 824bp. One polymorphic site was found at position g.17355452G>A of the Oar_rambouillet_v1.0 sequence (GenBank assembly accession number: GCA_002742125.1) caused by an A to a G substitution with a consequent different number of detectable fragments after electrophoresis. When a G is present at position g.17355452, electrophoresis showed all the 8 fragments specified above, and the 236 and a 67-bp bands must be carefully identified in order to recognize the G allele. On the contrary, when at the above position an A is present, the MnlI enzyme does not recognizes its reference sequence and does not cut the DNA strand, so that it can be found an entire 303-bp band, that is exactly the sum of 236+67-bp, so demonstrating the absence of cutting by the enzyme. In this way, genotype identification depends on the number and size of the electrophoretic fragments: the detection of 236 and 67-bp bands, and none 303-bp band, identify a subject carrying G/G genotype; the simultaneous presence of 303, 236 and 67-bp band, identify a sheep carrying G/A genotype; and finally, the presence of the 303-bp and none 236 and 67-bp band, identify an A/A genotype (Fig. 23). It is important to specify that fragments sized less than 80-bp are very small and light, so that they migrate faster along the agarose gel compared to those over 100-bp in length, that are greater and heavier. Thus, usually happens that the tiny fragments, running faster than the others, reach the end of the gel and fall into the TAE buffer, so that they are invisible in the agarose gel displayed under UV light. For this reason, particular attention should be paid to the identification of those bands which allows unequivocal recognition of the genotypes, i.e. 303 and 236-bp bands (Fig. 23).

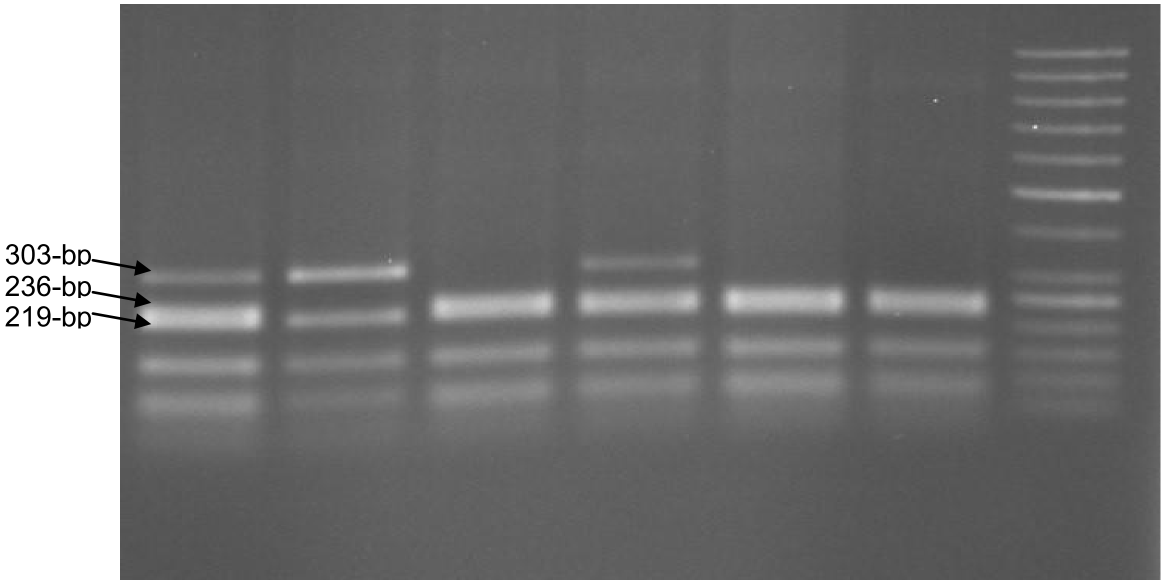

Figure 23. Electrophoresis after MnlI endonuclease digestion in sheep samples (1.5% agarose gel). Genotype assignment: lanes 1 and 4: G/A; lane 2: A/A; lanes 3, 5 and 6: G/G; lane 7: 50-bp Ladder.

Allele and genotype frequencies were determined by direct counting of the observed genotypes and are shown in Table 15. On the basis of these results G allele frequency was 68.6%, while A allele frequency was 31.4%, in the analyzed 164 ewe samples. The found genotypes in the analysed sheep population were distributed as follows: 49.4% for G/G (n= 81), 38.4% for G/A (n= 63), and 12.2% for A/A genotype (n= 20). The population resulted in Hardy Weinberg equilibrium.

Table 15. Allele and genotype frequency in the examined sheep populations

Sheep (n=164)	g.17.355.458C>T	C/C	84.1%	C	87.0%
		C/T	10.9%	T	13.0%
		T/T	5.0%		
	g.17355452A>G	G/G	49.4%	G	68.6%
		G/A	38.4%	A	31.4%
		A/A	12.2%		

The other endonuclease used for the present research was RsaI that allows to recognize another polymorphic site within the MTNR1A gene exon II, exactly, at position g.17355458C>T of the above specified reference sequence. Precisely, RsaI digestion showed up to 4 cleavage sites producing up to 5 fragments, sized 411, 267, 67, 56, and 23-bp in length, at the electrophoresis analysis. The presence of a C at the above position produces all the 5 bands, and attention must be paid to the identification of the 267 and 23-bp fragments, which, precisely identify the C allele. Conversely, when A is present at g.17355458 position, the RsaI does not recognize its reference sequence and in place of the 267 and 23-bp bands, it must be seen a single 290-bp band (that is the sum of 267+23). In summarizing, the number and size of the visible fragments after electrophoretic run consent, also in this case to identify individual genotype, paying particular attention to 290 and 267-pb bands, for the reasons already explained above and related to the speed of migration of tiny fragments. Hence, when under the 411-bp bands there is also a 290-bp band, means that is a T/T genotype, when there is the 411, the 290, and the 267-bp bands together, means that is a T/C genotype, while with 411 and 267-bp band, is a C/C genotype. To note that the 290 and 267-bp fragments are close in size, so that it could be quite difficult the correct genotype recognition (Fig. 24).

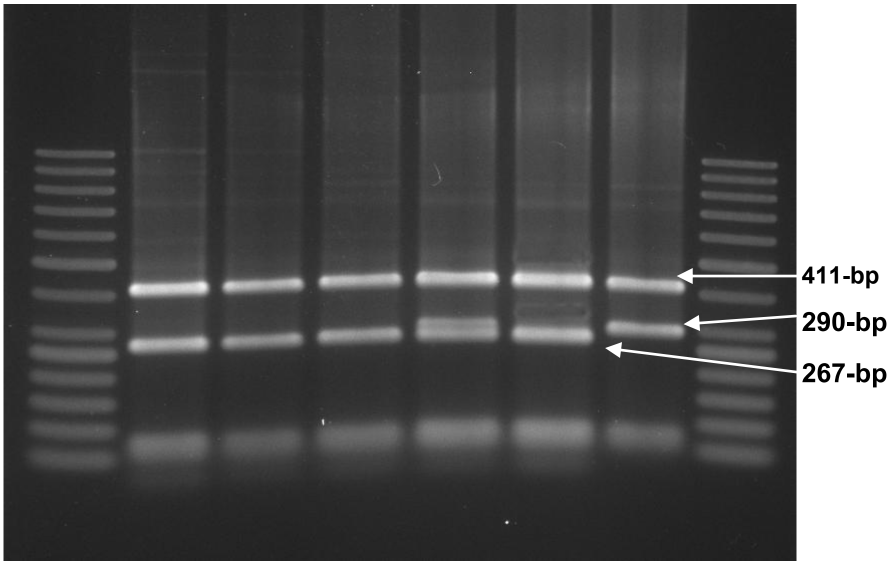

Figure 24. Electrophoresis after RsaI endonuclease digestion in sheep samples (1.5% agarose gel). Genotype assignment: lanes 1 and 8: 50-bp Ladder; lanes 2-4 and 6: C/C; lane 5: C/T; lane 7: T/T.

Also for RsaI endonuclease, allele and genotype frequencies were determined by direct counting of the observed genotypes and are shown in Table 15. The analyzed ewes population (n= 164 samples) showed a C allele frequency of 87.0%, while T allele frequency was 13.0%. The found genotypes were distributed as follows: 84.1% for C/C (n= 138), 10.9% for C/T (n= 18), and 5.0% for T/T genotype (n= 8) (Table 15). The population was in Hardy Weinberg disequilibrium, which was probably caused by a heterozygote deficiency.

4.5.2 Goat population

Also in goat samples PCR evidenced a single band of 824-bp in length (Fig. 25), corresponding to the MTNR1A exon II, according to the newest goat reference sequence ARS1 - Capra hircus melatonin receptor type 1A gene – GenBank assembly accession number: GCA_001704415.1.

In goats only RsaI endonuclease has been used to digest the 824-bp band, as in this specie no polymorphic site is detectable by MnlI endonuclease.

Table 16. Allele and genotype frequency in the examined goat's populations

	SNP location	Genotypes	Genotype frequency	Alleles	Allele frequency
Goat (n=174)	g.29169096G>A	G/G	97.7%	G	98.8%
		G/A	2.3%	A	1.2%
		A/A	0.0%		

Digestion with RsaI enzyme showed four cleavage sites, corresponding to 5 electrophoretic fragments sized 411, 267, 70, 53 and 23-bp that added together precisely re-compose the 824-bp band. One polymorphic site was found at position g.29169096G>A of the above sequence, and it consists of a G to an A substitution. When a G was present at position g.29169096, the RsaI endonuclease recognizes its reference sequence and cut the DNA strand, producing the 267 and 53-bp band, while when the G was substituted with a A, the cutting does not occur and a single 320-bp band was visible at the electrophoretic run. Thus, the genotype recognition depends on the number and size of the bands on the agarose gel: the presence of the 267-bp band, without the 320-bp band, designates a G/G subject, the simultaneous presence of the 267 and 320-bp band indicates a G/A genotype, while the 320-bp band, without that sized 267-bp band is for the A/A genotype (Fig. 25).

The analyzed goat population was composed of 174 does, and showed a G allele frequency of 98.8%, and a C allele frequency of 1.2%. A very small number of goat carrying G/C and none carrying C/C genotype has been found, so that the genotype distribution resulted 97.7% for G/G (n= 171) and 2.3% for G/A (n= 4) (Table 16). The population resulted in Hardy Weinberg equilibrium.

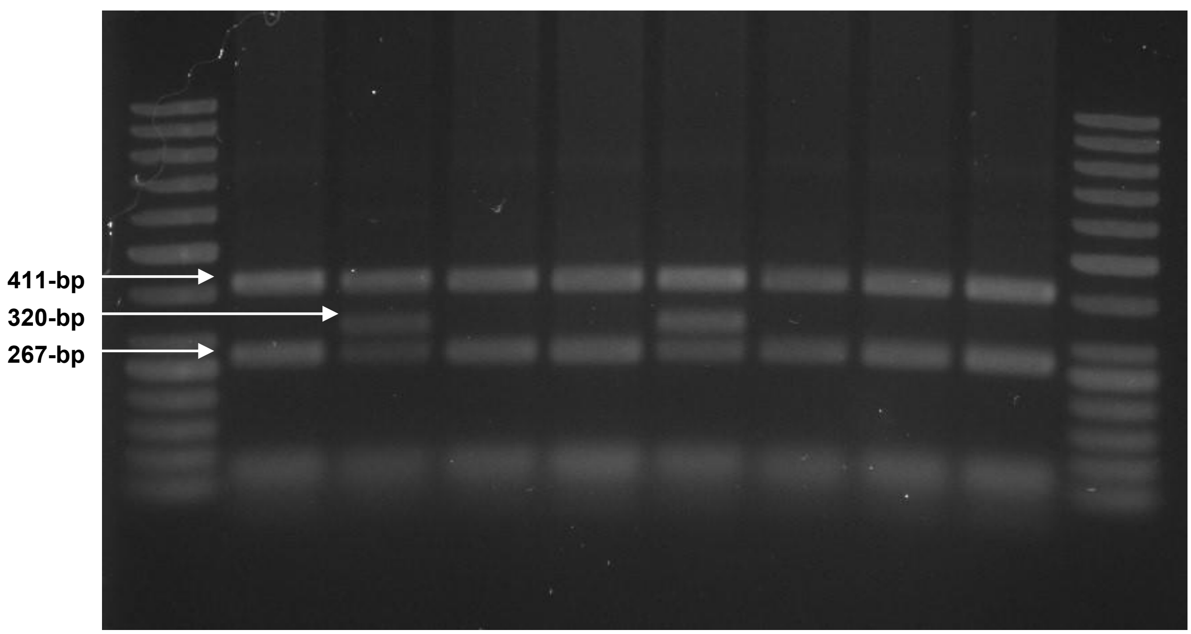

Figure 25. Electrophoresis after RsaI endonuclease digestion in goat samples (1.5% agarose gel). Genotype assignment: lanes 1 and 10: 50-bp Ladder; lanes 2, 4, 5, 7-9: G/G; lanes 3 and 6: G/A; lane 7: T/T.

The results show no relationship between the genotypes of the melatonin receptor and the lambing period of sheep and goats. The different genotypes do not show associations even with the litter size of the analyzed species.

5 Discussion

The production systems identified in our survey can be compared to those described by other studies, in the Bekaa, West Bekaa and North of Lebanon, that ranged between intensive sedentary, nomadic and transhumant (Hamadeh *et al*, 1996; Hosri and Nehme, 2006; Chedid *et al*, 2018) differing in their use of rangelands, crop residues and the flocks movement. The mentioned studies emphasized on specific areas of Lebanon that is why we focused only on three systems, which can be applied in all Lebanese districts: intensive, semi-intensive and extensive.

Intensive farms are well-known for their requirements in term of animal performances. However due to the absence of national breeding programs in Lebanon, farmers have turn to foreign goat breeds (Alpine and Saanen) imported for their high milk performance besides raising the dual purpose Awassi sheep. This system requires high expenditure (all the feed is imported) and a specific level of knowledge from the farmer (80% of the farmers had primary or university diploma). All these constraints explain the reason why farmers avoid these intensive systems (only 1% in our study) and adopt more extensive systems.

Semi-intensive systems presented a limited mobility to the lands surrounding their farms and villages. Available feed resources did not cover animal nutritional requirements; this problem was overcome by relying on the food supplement given to the flocks. While sheep breed adopted is the Awassi, Damasquine goat has been introduced next to the Baladi to improve the overall productivity of the flock as mentioned by Mavrogenis *et al*. (2006) who noted that under the semi-intensive system of production, the Damasquine breed performance is moderately high.

Extensive systems showed two majors patterns depending on the breed and the rangeland topography. Horizontal transhumance in the plain area with the dual-purpose Awassi sheep and vertical transhumance with the Baladi goat developed in hilly and marginal areas which are difficult to be used by other kind of livestock. Goats are able to utilize the woody vegetation dominating many marginal areas because of their particular metabolic efficiency (Silanikove, 2000) and anatomic characteristics, such as their small body size, the mobile upper lip and tongue and their ability to browse in a bipedal stance (Lebopa *et al.*, 2011). Mixed flocks are rarely observed in vertical transhumance (only 7 flocks), Awassi sheep are not able to climb mountains like goat.

Extensive systems faced major obstacles. The first constraint noted was the availability of pastures. Access to rangelands was greatly limited by agricultural expansion of orchards and vineyards coupled with the establishment of natural reserves, and the increase in pasture rental fees. Hamadeh (2014), Chedid *et al*, (2018) reported that pasture rental is one of the major constraints facing sheep and goats' production especially when added to the feed cost which itself is a major production cost particularly in the Arab world where feed production is limited (Nordblom and Shomo, 1995)

The second obstacle observed was the irregular rainfall (no rain from May till October) with recurring droughts during summer period which leads to a decrease in the quality of pasture and affects water availability. Abi Saab *et al*, (2008) mentioned that transhumance from winter pasture to summer pasture is beneficial for only two months (end of spring beginning of summer) when pastures are rich, with a protein percentage of around 15% whereas it is harmful for the rest of the period because of the long distances traveled by the animals, poor pastures (around 8% proteins) and coincidence of the sexual activity, leading to weight loss. These findings explain our results concerning BCS of small ruminants in extensive systems that showed a high decrease when quality of the pastures declined in summer. Cabiddu *et al*, (1999) stated that nutritive value of natural rangelands declines drastically in dry season.

Shortage of on-farm human and financial resource constituted a main challenge threatening farm sustainability. The low level of investment in farming and the absence of policies regulating the sector did not encourage youth to get involved in this field (almost 93% of farmers interviewed were above 41years old). In absence of on-farm family labor, farmers had recourse to hired labor which increased financial costs. Dubeuf, (2011) noticed that hired labor is considered a major constraint to the sustainability of pastoral and livestock farming.

All these ascertainments are similar to those of Galal *et al*, (2008); Shomo *et al*, (2010) and Hamadeh *et al*, (2001) in the Middle East area who suggested, shifting extensive systems towards intensification, to improve the productivity of the small ruminants and to overcome repeated droughts, pasture deterioration and the lack of interest among younger generations to work as shepherds.

Sheep and goats presented both a pronounced seasonal reproductive cycles with a period of silent or absent reproductive activity (anestrous season) and a period of high reproductive activity (breeding season). Breeding season started in July and extended till November. However, in some sheep flocks (12%), we noticed early parturitions in November which indicate an insemination during the anestrus period. Insemination occurred naturally without any hormonal treatment. Males were separated from the flock in May and reintroduced upon the flock wintering condition to ensure parturitions in the best weather conditions and to make profit of the best rangelands quality.

Prolificacy and fertility of both goats and sheep were higher in the intensive system than the more extensive systems (semi-intensive and extensive systems). These results are related to the feeding management of the flocks where small ruminants are hand fed on concentrate and forage in intensive systems, supplemented with little amount of concentrate beside moderate grazing in semi-intensive system and raised exclusively on grazing in extensive systems. Animals in the latter system showed a decrease of BCS in summer period which is a relevant indicator of poor nutritionals conditions. Kridli *et al*., (2007) as well mentioned low pregnancy rates due to breeding of the animals during the hot summer months.

Nutrition influences ruminant fertility directly by the supply of specific nutrients required for the processes of oocyte and spermatozoa development, ovulation, fertilization, embryo survival and the establishment of pregnancy. It also influences fertility indirectly thoughts impact on the circulating concentrations of the hormones and other nutrient-sensitive metabolites that are required for the success of these processes (Robinson *et al*., 2006; Vinoles *et al*., 2009, Martin *et al*., 2004).

In a study done by Abi Saab and Hosri (2002), Baladi goats raised in intensive system and hand fed with concentrate showed a prolificacy of 1.8 similar to that of foreign breed which indicates the importance of good nutrition to improve reproductive performance of the local breed.

Weight at birth showed different results between sheep and goats in the different systems. Kids and lambs born in the intensive system presented the lowest weight at birth due to the high prolificacy which is in accordance with the findings of Thomson *et al*. (2004) and Morris *et al*. (2003). Weight at birth of lambs in semi-intensive and extensive system was higher than that of kids in the same systems. It could be explained by the fact that Awassi ewes, characterized by the fat tail, are able to store and mobilize more fat than goat which allows them to partially cover feed scarcity. This finding is in accordance with Yousefi *et al.* (2012) who mentioned that fat-tailed sheep are known to deposit up to 20% of their carcass weight as tail fat. Atti and Mahouachi (2011) mentioned that fat-tail is developed for storing nutrients when food is plentiful and utilized as a metabolic energy at the time of food scarcity, particularly during harsh seasonal fluctuations and migration Gursoy *et al.* (1992, 1993) also noticed that Awassi possesses very desirable characteristics such as endurance to nutritional fluctuations.

Abortion rates recorded the highest percentage in the extensive system and the lowest in the intensive system in both ewe and goat flocks. Abortion in small ruminants can be caused by various non-infectious and infectious agents. Noninfectious agents include feeding and housing management while infectious agents are related to hygiene and diseases control. (Givens and Marley, 2008; Holler, 2012).

In extensive system, small ruminants go through a period of food scarcity especially during the summer (high temperature and dryness). Malnutrition affects embryo survival and thus abortion rate. This observation is in accordance with Robinson *et al*. (2006) that have mentioned the effect of nutrition on embryo survival and the establishment of pregnancy.

On the other hand, during the night and the winter rainy period, animals are confined in the farms in small areas (bellow space allowance) with bad litter management (litter being removed twice a year). These bad hygienic conditions coupled with bad ventilation and high animal density affect animal health with repercussion on pregnancy and abortion rate.

Kids and lambs were weaned earlier in intensive system (2 months) than in the more extensive system (around 5 months), milk being the main target in intensive farms and is sold directly to intermediate collectors or processed into an array of dairy products (Hosri *et al*., 2016). Offspring are fed on milk replacer following the recommended protocol of the used product, which allows them to achieve the target weight during short periods. Consequently, kids and lambs reach puberty age earlier in this system which leads to achieve a first lambing around one year old. However in the more extensive system, bad feeding management leads to a delay of first lambing which occurs around 2 years old.

Ewes and goats raised under intensive systems showed the highest milk production between the three systems (336.7 l/year and 587.5 l/year respectively) with a lactation length of 240 days and 265 days respectively. These results are related to both breed and feeding management. Goat being from the imported breed (Saanen and Alpine) and animals are hand fed on concentrate and forages during the whole year.

In the semi-intensive system, milk production recorded 198.7 l/year and 163.5l/year with a lactation length of 210 days and 190 days for goats and ewes respectively. In extensive system, production was lowest with 133l/year and 129.9l/year for 150 and 130 days in goats and sheep respectively. This drastic decline in milk production and lactation length in extensive systems is mainly due to the rangeland quality that decreases in summer period. Both feed availability and quality affect BCS that runs low leading to a reduction in milk length and production. Despite the animal's capacity to mobilize and then reconstitute its body reserves to survive and maintain its milk production until food is available again is an advantage, however, a maintained low dietary regime during lactation can diminish the animal's adaptive responses (body condition and milk production). The same findings were mentioned by Chesworth (1996); Chilliard *et al*. (1999); Bocquier *et al*. (2002); Blanc *et al*. (2006); Sauvant *et al*. (2005).

Concerning animal welfare, our survey showed that farmers in semi-intensive and extensive systems were unwary of this notion. All the stressors environmental, physical, nutritional, management, pathological and psychogenic were completely or partially unrespected. Whereas in intensive system, we noticed that all the stressors parameters were fully controlled. Absence of welfare knowledge could be related to the educational level of the farmers, in fact in both semi-intensive and extensive systems, none of the farmers had a university degree and more than 70% did not went to school. Whereas, in intensive systems, more than 80% of the farmers had either a school or a university degree or both.

As a rule of thermodynamics the performance of farm animals depends on how much energy they consume and how much energy they spend for maintenance. This energy balance, in extensive system, was negative mainly during summer period and appeared by a decline of BCS. Thus, in semi-intensive controlling the factors affecting dry matter intake and energy expenditure (such as feeding supplementation) was sufficient to partially maintain the performance and efficiency of the small ruminant production.

The thirst signs in extensive system manifested by a queuing at the drinking source especially after several hours of walking under the direct sun in hot weather is in contradiction with welfare recommendations that stipulate the following: "ready access to fresh water is important to maintain full health and vigor; welfare can be compromised if animals cannot drink whenever they feel the need to, either because fresh water is not available or because of competition with other goats."(Darcan *et al*., 2007).

Concerning housing conditions, sheep and goats farms were most of the time inadequate in term of design, materials and space allowance coupled with bad litter management. These conditions leaded to health problems that aggravate in absence of easy access to veterinary services.

Regarding the MTNR1A receptor gene, the sequence showed 8 mutations that are those that are usually found also in other breeds including the Sardinian breeds (Carcangiu *et al*., 2009; Notter and Cockett, 2005; Pelletier *et al.*, 2000; Saxena *et al*., 2014). The allelic and genotypic frequencies found in the Awassi breed in the position g.17355452 are similar to those observed in the Sarda breed (Carcangiu *et al*., 2009) and are similar to those found in other European, Sub temperate, and Sub tropical sheep breeds (Calvo *et al*., 2018; Mateescu *et al*., 2009; Messer *et al*., 1997; Mura *et al*., 2014; Saxena *et al*., 2015, 2014). The allelic and genotypic frequency at the position g.17355458C>T found in this research showed a high frequency of the C allele and of the genotype C/C. These differences in allele distribution have also been observed in other studied breeds and are linked to the different selective pressures of the different breeds (Martínez-Royo *et al*., 2012; Notter and Cockett, 2005).

In different sheep breeds the SNP at position g.17355452G>A showed a relationship with seasonal reproductive activity and the G/G genotype improved out-of-season reproductive activity (Luridiana *et al*., 2016; Mateescu *et al*., 2009; Mura *et al*., 2014). In Sarda breed, animals carrying the G/G genotype showed a better response to the male effect, in spite of factors like age and body weight (Luridiana *et al*., 2015).

The two most representative SNPs of the MTNR1A gene in the Awassi breed did not show any association with reproductive seasonality. This finding could be mainly related to the fact that the Awassi breed does not present a very marked reproductive seasonality and therefore the polymorphisms of the melatonin receptor have less influence on the reproductive activity. In fact, considering that they started lambing in December with a mating in July it could be that they are less affected by the reproductive seasonality. However, it would be necessary to anticipate the couplings to the month of May or June to understand if the different SNPs can have any relation with the reproductive seasonality.

As far as the two breeds of goats analyzed in this research are concerned, the very limited variability found does not make it possible to investigate the relationship between melatonin receptor polymorphism and reproductive seasonality. This fact is in line with the findings of

Migaud in the Alpine breed where precisely the polymorphism found did not manifest relations with the reproductive activity. Moreover in this case the introduction of males in full reproduction period could have distorted the result and hidden the effect of the receptor (Migaud *et al*., 2002).

6 Conclusion

The systems analyzed in this study can be distinguished according to their use of rangelands and crop residues and to the flock's movement into three clusters: the intensive systems, the semi-intensives and the traditional extensive systems.

The intensive system, specialized in Awassi sheep and foreign goat breeds, was managed with zero grazing and appeared to be satisfying in term of animal productivity and welfare. Despite the efficiency of this system, the number of intensive farms remains limited due to the high requirements in term of investment and know-how. In addition, intensive system depends on machinery and technology and is in line with the industrial concept that contradicts the importance of small ruminants which plays an essential socio-economic role in the Mediterranean countries.

The semi-intensive system relied on food supplementation with a reduced mobility of the flocks. Animals raised were from the Awassi sheep breed and both Damasquine and Baladi goats. This system showed an average productivity, with a limited application of animal welfare norms. Productivity can be ameliorated by a more adequate management of the feed supplementation (quality, quantity and costs) to cover nutritionals need of the flocks. Furthermore, awareness campaigns should be raised to draw the attention of the farmers to the importance of animal's welfare especially when it comes to housing conditions (space allowance, humidity, ventilation and litter management), management (dehorning, trimming) and diseases control (vaccination and importance of veterinary services).

The extensive system showed two majors patterns depending on the breed and the rangeland topography. Horizontal transhumance in the plain area with the dual-purpose Awassi sheep and vertical transhumance with the Baladi goat developed in hilly and marginal areas. Small ruminants in this system contribute to the livelihoods of a large numbers of small scale resource-poor farmers in Lebanon. However, extensive system showed a poor productivity of the animals coupled with a low BCS mainly during summer drought and winter rainy days. These periods of under nutrition are simultaneous with the critical reproduction periods: insemination and late pregnancy. In addition, welfare knowledge and conditions were practically inexistent.

Several studies recommend the shift to a more intensive system in order to improve the efficiency of the small ruminant's flocks. However, to work in a sustainable perspective, we suggest keeping the entity of each system with improving the zootechnical and welfare operations to valorize the natural rangelands and benefit from the native breeds characteristics and potentials.

7 Literature

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