ProYoungStock

Work Package 4

Impact of roughage feeding and pasture strategies on health traits of heifers and cows

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1. General Introduction

1.1. Cattle Breeding in France

France is the first European state for agricultural production, with 70 billion of euros in 2016, of which 35.2% derives from animal production (Ministère de l'Agricolture et de Alimentation, 2017).

Among European countries, France is leading when considering reared livestock bovines, with 18.58 million of cattle in 2017 (Eurostat, 2019a) and 7.55 million of heifers in 2017 (BSPCA, 2017). Heifers represent an important part of the cattle population, as they represent the 40.63% of the total (BSPCA, 2017).

France is also the European state with the most extended Utilised Agricultural Area (UAA): 27.74 million of hectares, of which 6.43 million of pastures and meadows (Eurostat, 2019b).

Beef cattle are mainly reared in the regions of the Massif Central (Nouvelle-Aquitaine, Auvergne-Rhône-Alpes, and Occitanie), comprising the 52% of the total beef cattle reared in France. From April to November the farming system is principally extensive, while in winter months the animals are confined. The most common beef breeds are Charolaise and Limousine.

Dairy cows are mainly reared in two geographical areas: North-West, in the regions of Bretagne, Normandie and Pays de la Loire, where about the 50% of the total animals can be found, and on the Massif Central, in Auvergne-Rhône-Alps, with about the 13% of dairy cows (Insitut de l'Élevage, 2015). According to the "Observatoire de l'alimentation des vaches laitières", these two largest areas of milk production have different rearing systems:

- the farms of the North-West are classified as "A-Specialized lowland dairy farming with more than 30% of maize into the forage surface";
- the farms of the Massif Central are classified as "E-Specialized mountain-piedmont dairy farming with less than 10% of maize into the forage surface".

Both systems are specialized but there is a noticeable difference between them regarding the feeding strategies, stocking rate, and milk production. The lowland farms are characterized by higher milk production (6,928 kg/cow/year *vs.* 5,343 kg/cow/year) and almost double stocking rate (1.62 Live Stock Unit (LSU) *vs.* 0.87 LSU) than the mountain-piedmont farms. The mountain-piedmont farms are a bit more extended, with 70 ha, whereas lowland farms have 60 ha of UAA. Feed self-sufficiency is for both around 82%, but in the lowlands the main feed ingredient is maize silage (59% of the ration) and fresh grass from pasture areas is limited (13%) while in mountain-piedmont farms the main feed ingredient is hay (32%) followed by fresh grass from grazed pasture areas (29%) and grass silage (13%).

1.2. Heifers

1.2.1. Management of Heifers

Heifers represent an important part of the French herd, reaching the 40.6% (BSPCA, 2017) or even the 50% (Le Cozler et al., 2009a) of the total animals.

Young stock do not produce and farmers perceive them as being only a cost for the farm. Often heifers are fed all year round with maize silage or other conserved roughages (a typical winter diet for lactating cows), in order to simplify the animal management. However, heifers are forage users and in mountain areas they are moved to upland and more marginal and uncomfortable pasture areas during the summer months (Le Cozler, 2009a).

During the rearing period, the farmer has to undergo some classical cares:

- to divide heifers in homogeneous groups for body weight and age, for an easier and a more correct management;
- to reduce cost, with two opposite solutions, limit time of rearing with high energy diet, normally in intensive dairy farming, or use poor pasture and forage and have a later age at first calving;
- to secure the success at first reproduction and, whatever the breed, age or nutritional level, to be sure to have a high percentage of heifers cycled when first mating;
- to optimize docility and friendly character against farmer.

1.2.2. Physiology and Development of the Heifer

During the rearing, the dynamics of heifers’ development comprise four main stages:

- Growth rate and tissue development. Tissue deposition varies with age in relation with breed, in the following order: nervous system, skeleton, muscles, and fat (Brody, 1945; Robelin, 1986). A deficiency of nutrients in this period can compromise the size and the weight of the future cow;

- Gut capacity, very important for the feed ingestion after the calving and during the highest milk production (Agabriel et al., 1987). The technique of compensatory growth at pasture can improve it;
- Development of the mammary tissue composed of adipocytes and parenchyma elements. Such development is allometric before puberty and after conception, while it is isometric from puberty to pregnancy. If the diet is too rich in energy during the wrong development (allometric development) period can increase the fat in udder and can reduce the parenchyma elements useful for milk production (Lacasse et al., 1993);
- Reproductive tract and puberty are influenced by breed and nutritional level. Dairy breeds are more precocious of 2 or 3 months than beef breeds. Puberty is reached at 18 months with a low level of energy <350g/d and at 9 months with a high energy level of 900 g/d (Troccon and Petit, 1989).

The compliance with these developmental phases is essential, otherwise the career of the heifer can be seriously prejudiced. The feeding technique of compensatory growth can be a good compromise between a correct development and a reduction of feeding costs.

1.3. Feeding Systems and Effects on Career

1.3.1. Compensatory Growth

The compensatory growth is a technique studied on heifers by Ford and Park (2001). It consists of applying an energy restriction and of giving *ad libitum* access to the feed during specific moments of the development. For example, a restrictive diet between 6 and 9 months of age, during puberty, and at the beginning of gestation and *ad libitum* diet before puberty, during breeding and before calving. This technique improves the metabolism, intensifies the development of the mammary gland and increases gut capacity. This involves a better metabolic efficiency, a higher milk production, a better recovery after calving and a better sustenance during the peaks of milk production.

A correct management of cattle during summer pasture can reproduce a compensatory growth, but it needs a control of birth, concentrated in autumn and winter. Therefore, the dam has a disposition nutriment *ad libitum* during her highest request of energy and the calf is ready for the cycle of compensatory growth.

1.3.2. Silage

Silage is a technique of conservation of moist forage for ruminants through the fermentation and anaerobiosis of the carbohydrates of the plant. Silage is used largely for ruminant feeding and usually it is made with crop, including sorghum, oat, alfalfa, grass and, especially, maize. Maize silage has many indisputable advantages, compared to others techniques of forage conservation: it is a feed with a constant nutritive quality, with high yield potential, of simple conservation, ease of complementation, rich of energy, highly digestible and easily ingested by the animals (Troccon, 1993), and maize is easy to cultivate.

Out of the agronomical aspects, the use of silage for dairy cows has important effects on milk and cheese quality. Feeding dairy cows with maize silage by comparison with hay or grass silage leads to whiter cheeses and sometimes to differences in flavour (Coulon et al., 2004). Conserving grass as silage, by comparison with hay, may lead to differences in the colour of dairy products, which is yellower with the use of grass silage (Martin et al., 2005). Conversely, major differences in the sensory characteristics of cheeses were observed between cheeses made with milk produced by cows fed winter diets (based on hay and grass silage) or turned to pasture in the spring (Coulon et al., 2004).

1.3.2.1. Fertility and Reproduction

A review by Dillon et al. (2006) documented that, in European seasonal pasture-based systems, the selection for increased milk production from 1990 to 2003 resulted in increased milk production per cow and led to undesirable side effects on reproduction. An economic analysis considering the European milk quota scenario over this period showed that only 41% of the potential improvement in farm profit was achieved because of impaired reproductive performance (Dillon et al., 2006).

For a best management and for lower costs, heifers should be inseminated at 15 months of age, so as to calve at 24 months, because it is a compromise between precocity and development (Shalloo et al., 2014). With a winter diet during all the year, it is not necessary to control the births, because there is always feed availability. Many studies demonstrated that the age at puberty is inversely correlated to average daily gain (Troccon and Petit, 1998;

Macdonald et al., 2005). Feeding with maize silage, very rich in energy, can sustain high request for a precocious puberty.

Studies about fertility are contrasting and results are disputable. According to Le Cozler et al. (2009b), fertility after one insemination for calving at 24 months was higher for heifers fed with silage compared to pasture feeding. Whereas based on a study by Macdonald et al. (2005), feeding heifers with silage moved up puberty but the fertility rate was the same as with a non-silage diet. On the contrary, Troccon et al. (1997) reported that fertility was lower in case of high energy level of feeding silage.

1.3.2.2. Milk Production

Scientific literature proves that feeding with or without silage is irrelevant on first lactation performance. First lactation performance was conditioned mostly by age at calving and average daily gain. Milk production was higher in calving at 36 months than in calving at 24 months (Le Cozler et al., 2009b). High average daily gain, during the development of the mammary gland, can compromise the development of parenchyma tissue (Lacasse et al., 1993) and so the milk production (Le Cozler et al., 2009b).

First lactation was the most influenced by feeding silage (Knaus et al., 2012). We must highlight that silage is the main source of spores of butyric acid producing bacteria, that may cause severe defects in hard cheeses, and maize silage is a more important source of these spores than is grass silage (Vissers et al., 2007).

1.3.2.3. Health

Literature about a correlation between silage feeding and diseases is very scarce. Some studies highlighted no influence of silage feeding (Troccon, 1993; Troccon et al., 1997). Feed imbalance could cause some illnesses, for example, a diet mainly based on wet grass silage before and after calving, provoked an increase of claw lesions (Offer et al., 2003). Also mastitis were not correlated with silage, but high level of concentrates fed the week before calving was associated with increased risk of mastitis (Barkema et al., 1999). Mastitis were correlated with management practices, for example average milk production per cow, number of cows milked per labour unit or stocking rate (Parker et al., 2007).

1.3.2.4. Longevity

The relationship between feeding silage and longevity is unclear. A study of Troccon (1993) revealed that dairy cows fed with or without silage had the same survival rate. However high level of concentrate and silage reduced lightly life expectation of dairy cows, because the main reason for culling was “poor reproductive performances”. Therefore, the reduction of survival rate was only an indirect cause of the problem of the fertility (Le Cozler et al., 2009b).

1.3.3. Upland Pasture

Grazed grass is a renewable resource, heterogeneous and potentially cheap because not demanding and harvested by the animal itself (Troccon, 1993). In addition, extensive grazing provides exercise and accustoms heifers to an environment that will be used by the cows for half of the year (Troccon, 1993). However, grass growth is largely dependent on climatic conditions and it is sometimes difficult to have sufficient grass availability throughout the whole grazing season (Troccon, 1993). It is verified that pasture is the cheapest forage; moreover, pasture is most enhanced by young stock, especially in marginal and uncomfortable areas. The grazing of young cattle gives an important benefit to the preservation of the upland pasture, which is a problem of social and environmental relevance (Krogmeier et al., 2015). In addition to economic advantages, the young livestock rearing on pasture is attributed significantly positive effects on animal health, with little meaningful research on this problem (Krogmeier et al., 2015).

1.3.3.1. Fertility and Reproduction

According to Le Cozler (2009b), maintaining a cyclical calving in autumn-winter at 24 months of age, heifers fed with fresh grass from pasture were less fertile than heifers fed with silage. However, for a later calving at 36 months of age, heifers grazing pasture areas were more fertile than heifers fed silage. Calving at 36 months of age is not sustainable from an-economic perspective, because the unproductive life of the animal is extended. According to Krogmeier et al. (2015), calving at 36 months is convenient, because fresh grass from pasture is the cheapest forage for ruminants and the conservation of upland pastures allows farmers to access to payment PAC. Moreover, heifers reared at pasture have greater longevity and greater milk production in first lactation (Ettema and Santos, 2004).

However, others studies conducted by Troccon (1993) and Le Cozler et al. (2009a) do not reveal significant effects of pasture on fertility of heifers and cows.

1.3.3.2. Milk Production

Scientific literature reported discordant results about the milk performance at first lactation while comparing grazing and non-grazing animals. Upland pasture had positive effects on milk yield but in face of a reduction of protein and fat contents (Krogmeier et al., 2015). However, when considering the total lifetime milk production, the total amount of protein and fat was greater on upland pasture than on indoor systems (Krogmeier et al., 2015). Hernandez-Mendo et al. (2007) revealed that cows moved to pasture reduced their milk productivity, probably as a consequence of the increase of exercise and the reduction of the nutrients ingested. However, in other researches, milk production did not show significant differences, but fat and protein percentage and yield were greater in heifers fed at pasture (Le Cozler et al., 2009b; Troccon 1993).

1.3.3.3. Health

Upland pasture had indisputable positive effects on the wellness and health of the animals, attributable to natural environmental stirring as light, oxygen and exercise (Zemp, 1985). In addition, exams of stress physiological parameters confirmed this theory, for example, the respiration rate, pulse rate, lactate, creatinkinease and lacatdehydrogenase levels were decreased (Ruhland et al., 1999).

Pasture caused benefits also to the mammary gland, with a reduction of clinical mastitis and of culling for mastitis (Washburn et al., 2002). The exercise reduced lameness and limb problems (Hernandez-Mendo et al., 2007; Troccon, 1993) and improved the fitness with less rate of dystocia and of stillbirth (Krogmeier et al., 2015).

1.3.3.4. Longevity

Scientific literature on longevity of heifers is scarce because setting proper experimental design is complicated and studies may take a long time. However, the few available studies indicated possible beneficial effects of pasture on longevity (Krogmeier et al., 2015; Burow et al., 2011).

1.4. Objectives of the Research

“The heifer of today will be the cow of tomorrow”. This affirmation means that the farmer needs to exploit and to invest in heifers, because they will be the future source of income for the dairy farm. The objective of this research is to investigate the long-term benefits produced by pasture rearing systems and non-silage feeding on the career of the dairy heifers, in terms of fertility, milk productivity, health and longevity. At this regard, literature is scarce and results are contrasting and unclear.

1.4.1. ProYoungStock

This research is part of the European project ProYoungStock. The aim of this project is to ameliorate young stock rearing systems concerning animal welfare-friendly husbandry, feeding and disease prevention.

ProYongStock is a four-year (2018-2021) European project supported by the CORE Organic funding bodies, which are partners of the Horizon 2020 ERA-Net project CORE Organic Cofund (ProYoungStock, 2019). The leader of the project is the Research Institute of Organic Agriculture (FiBL, CH). Other European partners include Universities and Research Institutes from France, Poland, Sweden, Slovenia, Austria and Germany.

The objective of the ProYoungStock project is to promote young stock and cow health and welfare by natural feeding systems, improving the rearing of pre-weaning calves and designing forage-based feeding strategies for heifers and adult cows. Among the results of this project are recommendations on the implementation of animal friendly and efficient dairy calf rearing and fattening systems, in which the use of antibiotics and anthelmintics is minimised.

The project is divided in 6 Work Packages (WP):

- 3 WPs for calves: increasing cow-calf contact, boosting the immune system with colostrum and rearing calves with the milk of dams;
- 2 WPs for heifers and cows: feeding with pasture and omission of silage in heifers and feeding plants containing bioactive compounds.

The research conducted in my Master Degree thesis falls within the aims of "*Impact of roughage feeding and pasture strategies on health traits of heifers and cows*". My research has been conducted at INRA of Saint-Genès-Champanelle (Clermont-Ferrand). The aim of my Master Degree is to study the long-term effects of different feeding and pasture strategies on health, fertility, and longevity of the animals and it is divided into two Tasks.

The first task concerns the "*Effect of omission of silage feeding on young stock and dairy cow health as well as milk performance traits*". The differences between farms with and without silage feeding are evaluated in terms of the effects on health, longevity, fertility and milking performance of the animals.

The second task concerns "*The impact of grazing on extensive pastures during heifer rearing*". An intensive system is compared with an extensive system where typically transhumance in high mountains or grazing on marginal pasture areas is practiced during the summer. Pasture feeding, movement and outdoor environment can have positive effects on the heifers' careers.

2. Introduction

In the so-called “hay-milk” farms (Commission Implementing Regulation (EU) 2016/304), no animal has to be fed with silage, moist hay or fermented hay. The focus of the research is on differences between farms with and without silage feeding as regards young stock and dairy cows. The use of silage for dairy cows has important effects on milk and cheese quality. Feeding dairy cows with maize silage by comparison with feeding hay or grass silage leads to whiter cheeses and sometimes to differences in flavour (Coulon et al., 2004; Martin et al., 2005). Scientific literature about long-term effects of different feeding (silage vs. non-silage) on health, milk production, longevity and reproduction, is scarce and contrasting. In this research, such effects will be analysed considering the reproduction, health, first milk production and longevity of the cows. The replacement of silage with hay could have positive effects on these parameters.

The age at puberty is inversely correlated to average daily gain (Troccon and Petit, 1998; Macdonald et al., 2005). Feeding rich in energy, as silage, can reduce age at puberty and so age at calving. Reducing age at calving means lower costs for maintaining animals that not produce, but a too early calving can compromise the correct development of the cow. A good compromise between correct development and precocity is to inseminate heifers at 15 months and to calve at 24 months (Shalloo et al., 2014). However, first lactation performance is conditioned mostly by age at calving and average daily gain. The mammary gland development is influenced by average daily gain, because high energy level in feeding can increase the fat in udder and can reduce the parenchyma tissue (Lacasse et al., 1993) and so milk production (Le Cozler et al., 2009b).

Relationship between silage feeding and diseases is very scarce and unclear. Probably, illnesses are caused by indirect problems. For example, mastitis are not correlated with silage feeding (Barkema et al., 1999), but they are correlated with management practices (Parker et al., 2007). In addition, it is unclear if longevity is correlated with silage feeding (Troccon, 1993). However, a high level of silage reduces life expectation for an indirect cause of the problem of the fertility (Le Cozler et al., 2009b).

Scientific literature about the effects of silage feeding is scarce and contrasting. It should be investigate further.

In the second part of the research it is compared young stock reared at least partially in extensive grazing systems with those reared in intensive systems. Extensive systems shall include mountainous areas. Typically, transhumance is practised; grazing livestock is seasonally moved between the farms in winter and high mountain land pastures in summer. Apart from the utilisation of additional forage resources as a benefit for the farm, these grazing systems may positively affect health in the animals' later lives due to the specific feed composition or increased exercise, with little meaningful research on this problem (Krogmeier et al., 2015).

In upland pasture, the calving at 36 months is convenient, because grass from pasture is the cheapest forage for ruminants and development of the heifers is slower. In addition, heifers reared at pasture have better development of mammary gland and so a greater longevity and greater milk production in first lactation (Ettema and Santos, 2004). However, cows moved to pasture reduced their milk productivity, probably as a consequence of the increase of exercise and the reduction of the nutrients ingested (Hernandez-Mendo et al., 2007).

Animals reared in upland pasture had benefits on health, because natural environment provides exercise, light and oxygen (Zemp, 1985). Upland pasture reduced stress physiological parameters (Ruhland et al., 1999), lameness (Hernandez-Mendo et al., 2007), limb problems (Troccon, 1993) and clinical mastitis (Washburn et al., 2002). In addition, upland pasture improved the fitness with less rate of dystocia and of stillbirth (Krogmeier et al., 2015). The few available studies indicated possible beneficial effects of upland pasture on longevity (Krogmeier et al., 2015; Burow et al., 2011).

Scientific literature on effects of upland pasture of heifers is scarce because setting proper experimental design is complicated and studies may take a long time. A detailed study should be necessary.

3. Materials and Methods

3.1. Data Collection

Data were collected by the Établissement Départemental de l'Élevage (EDE) of the department of Puy-de-Dôme. This institution is responsible for the traceability of the animals from birth to death. Every month, the EDE collects data on animals and offers an extension service of consultation for improving the performance of the farms. In this method, the farmer is constantly informed about his farm and about his cattle and he has a periodical consultation of an opinion on a professional. Recorded data include health, productivity, genetic parameters, type of feeding and costs of feeding of the animals, as well as farm management.

It was analysed a different dataset for both systems. For each system, 10 farms were selected, for a total of 40 farms. The farms were chosen according to the following parameters:

- completeness of farm and animals information;
- availability of the farm to show his data;
- sufficient historical data series;
- type of management and feeding (silage feeding or upland pasture in summer);
- number of heifers and ratio between number of heifers and number of cows;
- breed (only Holstein-Friesian HF and Montbéliarde MON);
- type of insemination (only artificial insemination (AI) or mixed insemination).

Data concern animals controlled after the 1st January 2005 to the 10th January 2019.

In the silage system, 10 farms were chosen that give feeding with silage, moist hay or fermented hay to the heifers. In the control group, 10 farms were selected that give only dry hay for feeding to the heifers.

In the second group of the upland pasture system, 10 farms were chosen that practice upland pasture during summer, and 10 control farms that not practice it.

It was analysed only the effects on the first lactation, because the effects are more evident on the lactation after the treatment (Macdonald et al., 2005).

Some farms had joined a service of EDE for the recording of the composition of cows feeding. Data are collected around every month and concern type and quantity of forage, of concentrates and of minerals, feeding autonomy of the farm, margin on feeding cost and feeding efficiency. We had available data of 14 farms: 6 for silage system, 3 for silage control, 1 for upland pasture system and 4 for upland pasture control. These data are not enough for doing statistical analysis, but they are representative of the productive system of these farms. These information will be utilized for the interpretation of the results in the discussion chapter.

3.2. Data Elaboration and Cleaning

Data was cleaned to homogenise and to eliminate outliers. For each system, silage and upland pasture, it was adopted the same process of data elaboration. Limit values of minimum and maximum were established following this method. For the data of duration of lactation, it was decided to consider a minimum of 6 months of lactation (180 days) and a maximum as the sum of two normal lactations, 610 days (305 days + 305 days). For data of dry period, it was fixed a minimum of 0 day and a maximum of a normal lactation, 305 days. For the parameter of interval calving it was considered a minimum as sum of the shortest lactation and a normal dry period, 240 days (180 days + 60 days). It was chosen a maximum value of interval calving as a sum of the longest lactation and the longest dry period, 915 days (610 days + 305 days).

Data concerns controls on lactations, there are not information about date of death or culling. To establish the longevity it was considered the date of the last control on the lactation. The longevity was calculated for animals that concluded lactation on December 2017, that is the duration of the longest dry period.

Data about health and diseases was gathered in groups for simplify the statistical analysis. It was also calculated the fat-protein ratio (FPR): greater than 1.3 in the first 3 months of lactation because it can be an indicator of subclinical ketosis (Krogh et al., 2011); and lower than 1 between the third and the sixth month, because it can indicate a sub-acute ruminal acidosis (Enemark , 2009). In Table 1 are summarized the group of diseases.

It was analysed 32 parameters: 6 parameters of fertility, 16 of milk productivity, 4 for the longevity and 6 for health. All parameters analysed are reported in Table 2.

Table 1 : Groups of diseases

Group of Disease	Type of Disease
Mammary Diseases :	Mammary edema
	Mastitis
	Various mammel problem
Articular Diseases :	Arthrosis
	Bleeding
	Lameness
	Muscle accident
	Paronychia
	Various members
Gestational Diseases:	Abortion
	Anoestrus
	Cesarean section
	Difficult calving
	Metritis
	Uterine prolapse
	Various reproduction problem
FPR > 1.3 :	Subclinical ketosis
FPR < 1 :	Sub-acute ruminal acidosis

Table 2 : Parameters analysed

Main Groups	Parameters	
Fertility:	Number AI	Gestation period
	Days 1st AI and conception	Interval calving
	Days calving and conception	Age 1st calving
Milk Production:	Duration dry period	Cumulated milk 305 days
	Duration lactation	Cumulated fat 305 days
	Cumulated milk in 1st lactation	Cumulated protein 305 days
	Cumulated fat in 1st lactation	SCC
	Cumulated protein in 1st lactation	Urea
	Fat %	Milk cumulated on life
	Protein %	Fat cumulated on life
	Milk yield	Protein cumulated on life
Longevity:	Longevity birth-last control	Lactation rank
	Longevity calving-last control	Cumulated lactation days on life
Health:	Mammary disease	FPR >1.3 in 1st month
	Gestational disease	FPR >1.3 until 3rd month
	Articular disease	FPR <1 3rd to 6th month

*SCC : Somatic Cell Count

Season of birth was considered in the statistical model of upland pasture system. Season was not calculated according to meteorological or astronomical season, but considering the season of upland pasture. In our model it was established winter starts from January to March, spring from Avril to June, summer from July to September and autumn from October to December.

3.3. Statistical Analyses

Statistical analyses were performed using the SPSS for Windows software package (version 17.0; SPSS Inc., Chicago, IL). All data of fertility, milk production and longevity were processed using the mixed model for each group of treatment, silage and upland pasture. For all parameters were tested homoscedasticity and normality. Not normal variables have been transformed with a logarithmic transformation. In the statistical model of the group of silage, it was considered different factors: fixed effects (system with or without silage; breed; interaction silage X breed); random effect (farm); covariates (age at first calving; genetic index of milk production). In the group of upland pasture, the parameters contemplated in the model was: fixed effects (system with or without upland pasture; breed; season of birth; interaction upland pasture X breed); random effect (farm); covariates (age at first calving; genetic index of milk production). In case of one or both the covariates are not significant, it was eliminated from the model the covariates not significant.

For the statistical analysis of the diseases, it was applied for each system a non-parametric test, the logistic regression. In this model, it was considered different covariates: system (silage or upland pasture), breed, age at first calving and genetic index of milk production. In case of age at first calving or genetic index are not significant, it was eliminated from the model the covariate not significant.

For all the analyses, the differences were considered significant below the threshold P value of 0.05 and a trend was considered at $0.05 < P < 0.10$.

4. Results

4.1. Farms Description

Farm data are summarized in Table 3 for silage feeding and in Table 5 for the upland pasture feeding. This information are referred to the year 2018 and it was utilized for the selection of the farms. Into the farms with silage feeding and control group were present respectively on average 37 ± 14 and 28 ± 14 heifers, with a ratio heifer per cow of 0.39 and 0.36 respectively. In the silage feeding group, the dominant breed was HF in the 50% of the farms and MON in the remaining. In the control group the dominant breed was MON in the 60% of the farms. Milk production cumulated 305 days in first lactation was 6972 ± 916 kg in silage feeding group and 6667 ± 1014 kg in control group. For the insemination of heifers, 20% of the farms with silage utilized Artificial Insemination (AI) and in control group 40%, the other farms used a mixed insemination. For the barn of the heifers, every farms, except one, had free-stall on permanent litter. Two farms had permanent litter with foraging lane. Only one farm in control group had tied-stall with central foraging lane, both for heifers and cows. In 30% of the farms, the cow stall was on permanent litter and in the others 65% farms on freee stall with bedding.

In silage group, in 7 farms feeding was distributed with total mixed ration, whereas in the others 3 farms silage was distributed with unified mixer. In control group, only 4 farms used to provide the feeding with total mixed ration, and the others farms debaled hay or unravelled hay. In Table 4 is summarized the feeding ration of silage group and control group, during summer (from May to September), during winter (from December to February) and annual average ration. It can be notated that farms used to distribuate hay or silage to fed heifers, generally continue to distribuate hay or silage to fed cows. These differences of feeding between the two groups could show significans differences in milk productivity.

Table 3 : Farms information of silage group and control group

	Silage				Control Group			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Utilised Agricultural Area (ha)	147	47	115	250	137	42	71	190
Principal Forage Area (ha)	130	29	94	180	119	35	63	153
Heifers (n)	37	14	24	61	28	14	12	63
Age 1st Calving (month)	31.3	3.50	24.3	36.6	31.0	2.60	26.6	35.0
AI/AIF[1] Heifers (n)	1.60	0.29	1.10	2.00	1.71	0.19	1.50	2.10
Cumulated Milk 305 Days in 1st Lactation	6973	916	5136	8279	6667	1014	4421	7875
Fat Content (%)	40.1	1.10	37.6	41.1	38.4	1.60	35.5	40.9
Protein Content (%)	32.9	1.30	29.9	34.5	32.9	1.40	30.6	35.8

[1] AIF : artificial insemination fertilizing

Table 4: Feeding ration of dairy cows in silage group and control group during summer, during winter and annual average

Period	Treatment	Dry Matter (kg/cow/day)	Silage	Hay	Concentrate	Pasture	Other
Annual Average Ration	Silage	20.5	34%	23%	34%	8%	0%
	Control Group	19.7	3%	43%	30%	16%	5%
Summer Ration	Silage	20.6	25%	25%	32%	18%	0%
	Control Group	18.8	3%	28%	24%	31%	6%
Winter Raion	Silage	20.1	52%	11%	36%	0%	0%
	Control Group	21.2	3%	61%	36%	0%	3%

Into the farms with upland pasture and control group were present respectively 23 ± 11 and 27 ± 11 heifers, with a ratio heifer per cow of 0.33 and 0.42 respectively. In upland pasture group, the dominant breed was HF in 60% of the farms and MON in the other. In control group, there were 60% of MON as dominant breed and in the other farms HF. Milk cumulated 305 days in first lactation was 5647 ± 853 kg in upland pasture group and 6196 ± 878 kg in control group. For the insemination of the heifers, 30% of the farms utilized AI and in control group 40%, the other farms used a mixed insemination. The heifer barn in upland pasture group was free-stall on permanent litter in 40% of the farms and free-stall with bedding in the others farms. In the control group every farms had heifers on free-stall on permanent litter, except one, that had tied-stall with foraging lane. For cow stall, only one farm in upland pasture group and two farms in control group had tied-stall, and all the others farms had free-stall with bedding.

Regarding the feeding distribution, we have available information of 6 farms in upland pasture group and 6 farms in control group. In upland pasture group, 3 farms distributed feeding with total mixed ration, 2 farms with debaled hay and 1 farm with desilaging-wagon. In control group, only 1 farm used to distribute feeding with total mixed ration and 1 farm with desilaging-wagon, the others farms used the unravelled hay or debaled hay. In Table 6 are summarized feeding ration of upland pasture group and control group during summer, winter and annual average ration.

Table 5 : Farm information of the upland pasture group and control group

	Upland Pasture				**Control Group**			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Utilised Agricultural Area (ha)	406	725	61	2040	145	54	71	246
Principal Forage Area (ha)	150	90	61	287	140	55	63	237
Heifers (n)	23	11	11	51	27	11	12	51
Age 1st Calving (month)	35.5	1.8	32.2	37.5	32.3	3.0	29.3	40.1
AI/AIF Heifers (n)	1.80	0.39	1.40	2.40	1.69	0.26	1.40	2.10
Cumulated Milk 305 Days in 1st Lactation	5647	853	4340	6712	6196	878	4421	7140
Fat Content (%)	37.8	1.2	36.0	39.6	38.3	1.4	36.6	40.8
Protein Content (%)	31.7	1.2	30.3	33.9	32.5	1.3	29.9	33.9

Table 6: Feeding ration of dairy cows in upland pasture group and control group during summer, during winter and annual average

Period	Treatment	Dry Matter (kg/cow/day)	Silage	Hay	Concentrate	Pasture	Other
Annual Average Ration	Upland Pasture	19.2	0%	52%	36%	13%	0%
	Control Group	20.3	2%	55%	31%	11%	6%
Summer Ration	Upland Pasture	18.6	0%	40%	28%	29%	0%
	Control Group	20.1	2%	41%	26%	26%	9%
Winter Raion	Upland Pasture	19.8	0%	61%	42%	0%	0%
	Control Group	20;2	3%	64%	35%	0%	3%

4.2. Silage Group

Results about silage system are reported in Table 7. The system with silage feeding showed few differences. The only difference on fertility was for the days between calving and conception, with 109 days and 99 days in not silage group. The others parameters of fertility were not significant. Milk production was not influenced by silage system. However all parameters of longevity were significant or show a trend for the days of lactation cumulated on life, group treated with silage feeding had lifespan higher than control group treated with hay feeding.

In Table 8 are described the results of breed variables. Breed effect is significant for some parameters of fertility and milk production. MON breed had a shorter period calving-conception (95 days vs. 113 days). However, HF had a shorter gestation period of 5 days and an earlier first calving 68 days. Regarding milk production variables, HF was generally more productive in quantity, but not in concentration of fat and protein. Cumulated milk and cumulated fat were higher in HF (7534 kg and 290 kg), than in MON (6776 kg and 267 kg). In addition, milk yield, milk, fat and protein cumulated in 305 days were higher in HF than in MON. However, MON had a high concentration of fat and protein than HF, with a fat concentration of 3.95% vs. 3.88% respectively, and a concentration of protein of 3.33% and 3.17% respectively. Others parameters of longevity were not influenced by the breed.

Table 7 : Table of silage effect

			Silage			Effect and significance[1]				
	Item	**n**	**No**	**Yes**	**SEM**	**S**	**B**	**X**	**G**	**A**
Fertility	**Number AI (n)**	3437	1.54	1.53	1.54	ns	ns	ns		
	Days 1st AI and conception (n)	2463	28.7	35.9	30.6	ns	ns	ns		
	Days calving and conception (n)	2411	109	99	102	*	***	ns		
	Gestation period (days)	2336	283	284	284	ns	***	ns		
	Interval calving (days)	1711	409	396	405	ns	†	ns	*	***
	Age 1st calving (days)	5436	960	980	963	ns	***	ns	***	
Milk production	**Duration dry period (days)**	3724	57.0	58.5	56.7	ns	ns	ns		
	Duration lactation (days)	4641	334	328	330	ns	ns	ns		
	Cumulated milk in 1st lactation (kg)	4641	7112	7161	7254	ns	***	ns	***	***
	Cumulated fat in 1st lactation (kg)	4641	275	282	283	ns	*	ns	***	***
	Cumulated protein in 1st lactation (kg)	4641	231	233	236	ns	†	ns	***	***
	Fat % (%)	4641	3.88	3.95	3.92	ns	*	ns	**	***
	Protein % (%)	4641	3.25	3.25	3.26	ns	***	ns	**	***
	Milk yield (kg/day)	4641	21.6	22.2	22.4	ns	***	ns	***	***
	Cumulated milk 305 days (kg)	4641	6598	6772	6818	ns	***	ns	***	***
	Cumulated fat 305 days (kg)	4641	255	266	266	ns	***	ns	***	***
	Cumulated protein 305 days (kg)	4641	214	220	222	ns	***	ns	***	***
	SCC (1000 cells/mL)	4641	108	105	108	ns	ns	**		*
	Urea (mg/cL)	2573	269	268	269	ns	†	ns	*	**
	Milk cumulated on life (kg)	2597	17212	19703	18711	ns	ns	†		
	Fat cumulated on life (kg)	2597	672	774	731	†	†	*		
	Protein cumulated on life (kg)	2597	558	637	608	ns	ns	†		
Longevity	**Longevity birth-last control (months)**	2824	62.4	67.8	64.4	*	†	ns	***	***
	Longevity calving-last control (months)	2816	25.0	31.0	27.5	**	†	ns		
	Lactation rank (n)	2824	2.43	2.74	2.60	*	ns	ns		
	Cumulated lactation days on life (n)	2597	771	854	806	†	ns	†		

[1] S = silage system ; B = breed ; X = interaction between silage system and breed ; G = genetic milk index ; A = age at first calving

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

Table 8 : Table of breed effect

			Breed			Effect and significance[1]				
	Item	**n**	**MON**	**HF**	**SEM**	**S**	**B**	**X**	**G**	**A**
Fertility	**Number AI (n)**	3437	1.52	1.55	1.54	ns	ns	ns		
	Days 1st AI and conception (n)	2463	32.3	32.4	30.6	ns	ns	ns		
	Days calving and conception (n)	2411	95	113	102	*	***	ns		
	Gestation period (days)	2336	286	281	284	ns	***	ns		
	Interval calving (days)	1711	396	409	405	ns	†	ns	*	***
	Age 1st calving (days)	5436	1004	936	963	ns	***	ns	***	
Milk production	**Duration dry period (days)**	3724	55.9	59.6	56.7	ns	ns	ns		
	Duration lactation (days)	4641	328	333	330	ns	ns	ns		
	Cumulated milk in 1st lactation (kg)	4641	6776	7534	7254	ns	***	ns	***	***
	Cumulated fat in 1st lactation (kg)	4641	267	290	283	ns	*	ns	***	***
	Cumulated protein in 1st lactation (kg)	4641	225	238	236	ns	†	ns	***	***
	Fat % (%)	4641	3.95	3.88	3.92	ns	*	ns	**	***
	Protein % (%)	4641	3.33	3.17	3.26	ns	***	ns	**	***
	Milk yield (kg/day)	4641	20.6	23.3	22.4	ns	***	ns	***	***
	Cumulated milk 305 days (kg)	4641	6275	7094	6818	ns	***	ns	***	***
	Cumulated fat 305 days (kg)	4641	249	273	266	ns	***	ns	***	***
	Cumulated protein 305 days (kg)	4641	209	225	222	ns	***	ns	***	***
	SCC (1000 cells/mL)	4641	100	112	108	ns	ns	**		*
	Urea (mg/cL)	2573	274	262	269	ns	†	ns	*	**
	Milk cumulated on life (kg)	2597	17470	19412	18711	ns	ns	†		
	Fat cumulated on life (kg)	2597	683	762	731	†	†	*		
	Protein cumulated on life (kg)	2597	577	616	608	ns	ns	†		
Longevity	**Longevity birth-last control (months)**	2824	63.4	66.8	64.4	*	†	ns	***	***
	Longevity calving-last control (months)	2816	26.4	29.4	27.5	**	†	ns		
	Lactation rank (n)	2824	2.56	2.60	2.60	*	ns	ns		
	Cumulated lactation days on life (n)	2597	785	839	806	†	ns	†		

[1] S = silage system ; B = breed ; X = interaction between silage system and breed ; G = genetic milk index ; A = age at first calving

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

Results about interaction between silage system and breed are summarized in Table 9. Interaction between breed and silage was tested only between the two systems, not between breed. It was not showed a significant interaction for variables of fertility and longevity. It needs to highlight an interaction in variables of SCC and in fat cumulated on life. In breed HF there was a significant difference between system with or without silage feeding, group with silage is higher than the other of 207 kg. In MON, there was not difference. In variable

SCC, the two breed had opposite response to the interaction. In MON breed, the SCC was higher in the group with silage (114 vs. 89). On the contrary, HF had a higher level of SCC in the control group without silage (131 vs. 96).

Table 9 : Table of interaction between silage system and breed

			Silage X breed									
			MON		HF			Effect and significance[1]				
	Item	**n**	**No**	**Yes**	**No**	**Yes**	**SEM**	**S**	**B**	**X**	**G**	**A**
Fertility	**Number AI (n)**	3437	1.56	1.48	1.52	1.59	1.54	ns	ns	ns		
	Days 1st AI and conception (n)	2463	27.5	30.0	37.1	34.7	30.6	ns	ns	ns		
	Days calving and conception (n)	2411	101	90	119	108	102	*	***	ns		
	Gestation period (days)	2336	286	287	281	281	284	ns	***	ns		
	Interval calving (days)	1711	405	388	413	405	405	ns	†	ns	*	***
	Age 1st calving (days)	5436	1005	1002	914	958	963	ns	***	ns	***	
Milk production	**Duration dry period (days)**	3724	54.7	57.1	59.3	59.9	56.7	ns	ns	ns		
	Duration lactation (days)	4641	335	322	332	334	330	ns	ns	ns		
	Cumulated milk in 1st lactation (kg)	4641	6699	6855	7551	7499	7254	ns	***	ns	***	***
	Cumulated fat in 1st lactation (kg)	4641	264	272	287	292	283	ns	*	ns	***	***
	Cumulated protein in 1st lactation (kg)	4641	222	229	239	237	236	ns	†	ns	***	***
	Fat % (%)	4641	3.94	3.97	3.83	3.93	3.92	ns	*	ns	**	***
	Protein % (%)	4641	3.33	3.33	3.17	3.17	3.26	ns	***	ns	**	***
	Milk yield (kg/day)	4641	20.3	20.8	22.9	23.6	22.4	ns	***	ns	***	***
	Cumulated milk 305 days (kg)	4641	6202	6349	6994	7195	6818	ns	***	ns	***	***
	Cumulated fat 305 days (kg)	4641	244	253	266	280	266	ns	***	ns	***	***
	Cumulated protein 305 days (kg)	4641	206	212	223	228	222	ns	***	ns	***	***
	SCC (1000 cells/mL)	4641	89 d	114 b	131 a	96 c	108	ns	ns	**		*
	Urea (mg/cL)	2573	277	272	261	263	269	ns	†	ns	*	**
	Milk cumulated on life (kg)	2597	17420	17520	17006	22158	18711	ns	ns	†		
	Fat cumulated on life (kg)	2597	679	687	665 b	872 a	731	†	†	*		
	Protein cumulated on life (kg)	2597	573	582	543	698	608	ns	ns	†		
Longevity	**Longevity birth-last control (months)**	2824	61.5	65.5	63.4	70.3	64.4	*	†	ns	***	***
	Longevity calving-last control (months)	2816	24.1	29.0	26.0	33.2	27.5	**	†	ns		
	Lactation rank (n)	2824	2.43	2.70	2.43	2.79	2.60	*	ns	ns		
	Cumulated lactation days on life (n)	2597	784	786	758	927	806	†	ns	†		

[1] S = silage system ; B = breed ; X = interaction between silage system and breed ; G = genetic milk index ; A = age at first calving

*** : $P < 0.001$; ** : $P < 0.01$; * : $P < 0.05$; † : $P < 0.10$; ns : $P \geq 0.10$

Results about health in silage group are reported in Table 10. Silage system or breed did not influence mammary diseases. Increasing the genetic potential of milk, increased also the probabilities of mammary problems, like mastitis.

Feeding with silage and the increasing of the age at first calving could increase the probabilities of articular diseases, for examples lameness. Breed had not significant effects.

For gestational diseases, silage was not a risk factor. HF had more probabilities to have gestational problems than the MON. Higher genetic milk index increased the probabilities of gestational diseases.

The indicator of subclinical ketosis, FPR > 1.3, was ever influenced positively by genetic milk index and by age at first calving and MON breed was protected by subclinical ketosis. In first month, hay feeding could protect by subclinical ketosis, but until third month this difference was not significant.

The indicator of sub-acute ruminal acidosis, FPR < 1, showed that hay feeding and MON were more subject to this problem.

Table 10 : Table of diseases in silage group

Item	Effects	β	S.E.	Significance	Odds ratio
Mammary diseases	Not silage	0.037	0.080	ns	1.038
	Breed MON	-0.005	0.080	ns	0.995
	Genetic milk index	0.000	0.000	***	1.000
Articular diseases	Not silage	-0.497	0.215	*	0.608
	Breed MON	0.216	0.200	ns	1.241
	Age 1st calving	0.002	0.001	**	1.002
Gestational diseases	Not silage	0.169	0.216	ns	1.184
	Breed MON	-0.754	0.226	**	0.470
	Genetic milk index	0.001	0.000	**	1.001
FPR >1.3 in 1st month	Not silage	-0.150	0.073	*	0.861
	Breed MON	-0.781	0.076	***	0.458
	Genetic milk index	0.000	0.000	***	1.000
	Age 1st calving	0.001	0.000	***	1.001
FPR >1.3 in 1st month	Not silage	-0.044	0.070	ns	0.957
FPR >1.3 until 3rd month	Breed MON	-0.701	0.071	***	0.496
	Age 1st calving	0.002	0.000	***	1.002
FPR <1 3rd to 6th month	Not silage	0.540	0.179	**	1.716
	Breed MON	0.866	0.191	***	2.376

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

4.3. Upland Pasture Group

In Table 11 are described the results of upland pasture system. The system with upland pasture did not have effects on longevity and milk production. In fertility, the only variable significant was the age at first calving. The upland pasture system had the first calving later than the control group, 1111 days vs. 1009 days respectively.

Breed effects are summarized in Table 12. Breed effect had significant value in fertility, milk production and longevity. In fertility variables, HF had a longer period between calving and conception than MON breed and a longer interval calving of 19 days. However, MON had longer gestation period of 5 days and a later first calving of 53 days. For milk production, generally HF had a higher level of productivity than MON. HF had a longer duration of lactation, higher production of milk cumulated, fat cumulated and protein cumulated. In addition, milk yield was higher in HF 2.1 kg/day, and cumulated milk 305 days, fat 305 days and protein 305 days were higher in HF (6330 kg, 240 kg, 198 kg) than in MON (5697 kg, 219 kg, 187 kg). The level of SCC was higher in HF +27 than MON, but urea was lower in HF than in MON -24. In longevity, the only variable significant was lactation rank, HF had a lower rank than MON, 2.42 and 2.79 respectively.

In Table 13 are reported the results of season of birth. Season of birth influenced age at first calving. Heifers born in spring had the later calving at 1077 days, and heifers born in autumn were earlier with 1051 days. The heifers born in summer and winter had an intermediate value of 1058 days and 1056 days respectively. Regarding fat concentration, heifers born in autumn and summer had the higher level (3.85%), an intermediate in spring (3.82%) and the lower level in winter (3.80%). Concentration of protein was the highest in autumn with 3.23% and the lowest in winter with 3.18%, intermediate values for heifers born in summer (3.21%) and in spring (3.20%). The highest milk yield was for heifers born in spring with 20.1 kg/day, and in the others seasons was lower with 19.5 kg/day and 19.7 kg/day. For cumulated milk 305 days, spring was the season with higher accumulation (6116 kg), and the others seasons were lower and did not have significant difference (autumn: 5939 kg; summer: 6002 kg; winter: 5997 kg). Cumulated fat 305 days and cumulated protein 305 days had the same tendency, heifers born in spring had the highest production with 223 kg of fat and 195 kg of protein. In winter and autumn, heifers had the lowest production, 227 kg and 228 kg of fat respectively, and 190 kg and 191 kg of protein respectively. Heifers born in summer had an intermediate production, 230 kg of fat and 192 kg of protein. Season of birth did not influence the longevity.

Table 11 : Table of upland pasture effect

			Upland pasture			Effect and significance[1]					
	Item	**n**	**No**	**Yes**	**SEM**	**U**	**B**	**S**	**X**	**G**	**A**
Fertility	**Number AI (n)**	2490	1.77	1.67	1.71	ns	ns	†	ns	*	
	Days 1st AI and conception (n)	1792	31.2	25.7	27.2	ns	†	†	ns	***	*
	Days calving and conception (n)	1751	102	93	99	†	**	ns	ns	*	
	Gestation period (days)	1712	284	285	284	ns	***	ns	ns		
	Interval calving (days)	2902	409	403	410	ns	**	ns	ns	**	
	Age 1st calving (days)	4034	1009	1111	1059	*	***	*	**	***	
Milk production	**Duration dry period (days)**	2885	63.5	67.5	66.5	ns	ns	ns	ns	***	
	Duration lactation (days)	3465	330	319	327	ns	**	ns	*	***	
	Cumulated milk in 1st lactation (kg)	3465	6804	6232	6715	ns	***	ns	†	***	**
	Cumulated fat in 1st lactation (kg)	3465	261	238	256	ns	***	†	**	***	***
	Cumulated protein in 1st lactation (kg)	3465	219	199	214	ns	***	ns	**	***	***
	Fat % (%)	3465	3.84	3.82	3.82	ns	ns	*	***	***	
	Protein % (%)	3465	3.22	3.19	3.19	ns	***	***	**	***	
	Milk yield (kg/day)	3465	20.2	19.2	20.1	ns	***	***	ns	***	***
	Cumulated milk 305 days (kg)	3465	6163	5864	6134	ns	***	***	ns	***	***
	Cumulated fat 305 days (kg)	3465	236	223	234	ns	***	**	*	***	***
	Cumulated protein 305 days (kg)	3465	198	186	195	ns	***	**	*	***	***
	SCC (1000 cells/mL)	3465	107.1	90.3	186.8	ns	***	ns	ns	*	**
	Urea (mg/cL)	1907	275	267	266	ns	***	†	ns		
	Milk cumulated on life (kg)	2102	17219	17140	17632	ns	ns	ns	ns	***	
	Fat cumulated on life (kg)	2102	659	656	676	ns	ns	ns	ns	**	
	Protein cumulated on life (kg)	2102	551	545	560	ns	ns	ns	ns	***	
Longevity	**Longevity birth-last control (months)**	2310	67.9	68.9	67.8	ns	†	ns	ns	**	***
	Longevity calving-last control (months)	2302	27.6	28.4	27.9	ns	ns	ns	ns	***	
	Lactation rank (n)	2310	2.59	2.61	2.55	ns	**	ns	†		
	Cumulated lactation days on life (n)	2168	787	805	792	ns	ns	ns	ns		

[1] U = upland pasture system ; B = breed ; X = interaction between upland pasture system and breed ; G = genetic milk index ; A = age at first calving

*** : $P < 0.001$; ** : $P < 0.01$; * : $P < 0.05$; † : $P < 0.10$; ns : $P \geq 0.10$

Table 12 : Table of breed effect in upland pasture group

			Breed			Effect and significance[1]					
	Item	**n**	**MON**	**HF**	**SEM**	**U**	**B**	**S**	**X**	**G**	**A**
Fertility	**Number AI (n)**	2490	1.66	1.79	1.71	ns	ns	†	ns	*	
	Days 1st AI and conception (n)	1792	23.9	33.0	27.2	ns	†	†	ns	***	*
	Days calving and conception (n)	1751	91	105	99	†	**	ns	ns	*	
	Gestation period (days)	1712	287	282	284	ns	***	ns	ns		
	Interval calving (days)	2902	397	416	410	ns	**	ns	ns	**	
	Age 1st calving (days)	4034	1087	1034	1059	*	***	*	**	***	
Milk production	**Duration dry period (days)**	2885	66.1	64.9	66.5	ns	ns	ns	ns	***	
	Duration lactation (days)	3465	318	331	327	ns	**	ns	*	***	
	Cumulated milk in 1st lactation (kg)	3465	6075	6961	6715	ns	***	ns	†	***	**
	Cumulated fat in 1st lactation (kg)	3465	234	265	256	ns	***	†	**	***	***
	Cumulated protein in 1st lactation (kg)	3465	200	218	214	ns	***	ns	**	***	***
	Fat % (%)	3465	3.85	3.81	3.82	ns	ns	*	***	***	
	Protein % (%)	3465	3.29	3.13	3.19	ns	***	***	**	***	
	Milk yield (kg/day)	3465	18.7	20.8	20.1	ns	***	***	ns	***	***
	Cumulated milk 305 days (kg)	3465	5697	6330	6134	ns	***	***	ns	***	***
	Cumulated fat 305 days (kg)	3465	219	240	234	ns	***	**	*	***	***
	Cumulated protein 305 days (kg)	3465	187	198	195	ns	***	**	*	***	***
	SCC (1000 cells/mL)	3465	85.9	112.6	186.8	ns	***	ns	ns	*	**
	Urea (mg/cL)	1907	283	259	266	ns	***	†	ns		
	Milk cumulated on life (kg)	2102	16943	17418	17632	ns	ns	ns	ns	***	
	Fat cumulated on life (kg)	2102	649	667	676	ns	ns	ns	ns	**	
	Protein cumulated on life (kg)	2102	551	545	560	ns	ns	ns	ns	***	
Longevity	**Longevity birth-last control (months)**	2310	70.0	66.7	67.8	ns	†	ns	ns	**	***
	Longevity calving-last control (months)	2302	28.6	27.4	27.9	ns	ns	ns	ns	***	
	Lactation rank (n)	2310	2.79	2.42	2.55	ns	**	ns	†		
	Cumulated lactation days on life (n)	2168	827	765	792	ns	ns	ns	ns		

[1] U = upland pasture system ; B = breed ; X = interaction between upland pasture system and breed ; G = genetic milk index ; A = age at first calving

*** : $P < 0.001$; ** : $P < 0.01$; * : $P < 0.05$; † : $P < 0.10$; ns : $P \geq 0.10$

Table 13 : Table of season of birth

	Item	n	Season birth[1]				SEM	Effect and significance[2]					
			AU	SU	WI	SP		U	B	S	X	G	A
Fertility	**Number AI (n)**	2490	1.79	1.71	1.78	1.61	1.71	ns	ns	†	ns	*	
	Days 1st AI and conception (n)	1792	28.5	24.1	34.2	27.0	27.2	ns	†	†	ns	***	*
	Days calving and conception (n)	1751	99	99	99	94	99	†	**	ns	ns	*	
	Gestation period (days)	1712	285	284	284	284	284	ns	***	ns	ns		
	Interval calving (days)	2902	405	405	410	405	410	ns	**	ns	ns	**	
	Age 1st calving (days)	4034	1051 b	1057 ab	1056 ab	1076 a	1059	*	***	*	**	***	
Milk production	**Duration dry period (days)**	2885	65.5	65.0	64.9	66.4	66.5	ns	ns	ns	ns	***	
	Duration lactation (days)	3465	326	326	321	324	327	ns	**	ns	*	***	
	Cumulated milk in 1st lactation (kg)	3465	6461	6555	6449	6609	6715	ns	***	ns	†	***	**
	Cumulated fat in 1st lactation (kg)	3465	248	252	245	253	256	ns	***	†	**	***	***
	Cumulated protein in 1st lactation (kg)	3465	209	210	205	211	214	ns	***	ns	**	***	***
	Fat % (%)	3465	3.85 a	3.85 a	3.8 b	3.82 ab	3.82	ns	ns	*	***	***	
	Protein % (%)	3465	3.23 a	3.21 ab	3.18 c	3.20 b	3.19	ns	***	***	**	***	
	Milk yield (kg/day)	3465	19.5 b	19.7 b	19.7 b	20.1 a	20.1	ns	***	***	ns	***	***
	Cumulated milk 305 days (kg)	3465	5938 b	6002 b	5997 b	6115 a	6134	ns	***	***	ns	***	***
	Cumulated fat 305 days (kg)	3465	228 b	230 ab	227 b	233 a	234	ns	***	**	*	***	***
	Cumulated protein 305 days (kg)	3465	191 b	192 ab	190 b	195 a	195	ns	***	**	*	***	***
	SCC (1000 cells/mL)	3465	94.9	99.1	103.5	96.1	186.8	ns	***	ns	ns	*	**
	Urea (mg/cL)	1907	271	275	269	270	266	ns	***	†	ns		
	Milk cumulated on life (kg)	2102	16788	17539	17100	17258	17632	ns	ns	ns	ns	***	
	Fat cumulated on life (kg)	2102	646	678	649	659	676	ns	ns	ns	ns	**	
	Protein cumulated on life (kg)	2102	540	561	541	551	560	ns	ns	ns	ns	***	
Longevity	**Longevity birth-last control (months)**	2310	67.5	68.7	68.2	68.9	67.8	ns	†	ns	ns	**	***
	Longevity calving-last control (months)	2302	26.5	27.9	28.2	29.5	27.9	ns	ns	ns	ns	***	
	Lactation rank (n)	2310	2.50	2.64	2.60	2.66	2.55	ns	**	ns	†		
	Cumulated lactation days on life (n)	2168	777	806	806	794	792	ns	ns	ns	ns		

[1] AU = autumn ; SU = summer ; WI = winter ; SP = spring

[2] U = upland pasture system ; B = breed ; X = interaction between upland pasture system and breed ; G = genetic milk index ; A = age at first calving

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

Results about interaction between upland pasture system and breed are reported in Table 14. Interaction between breed and upland pasture system was calculated only between systems, not between breed. The only significant effect on fertility was on age at first calving of HF. Heifers in upland pasture had the first calving later than the control group of 140 days. On parameters of milk production, HF did not show effects of the treatment. Generally, heifers MON reared in upland pasture were less productive than control group. Duration lactation was shorter in upland pasture (307 days vs. 328 days). Fat cumulated, fat concentration, protein cumulated and protein concentration were lower in upland pasture than in control group. Following the precedent tendency of fat cumulated and milk cumulated, also cumulated fat 305 days and cumulated protein 305 days were lower in upland pasture group (210 kg, 179 kg) than in control group (229 kg, 194 kg). Longevity had not significant effects.

Results about health in upland pasture group are summarized in Table 15. Mammary diseases were not influenced by upland pasture. However, MON was "protected" by mammary problems. Increasing genetic milk index, also mammary diseases increased.

It was more probable to incur articular diseases for heifers that went in upland pasture than in control group. Breed MON had less probability to have articular problems. Genetic milk index could be a risk factor for articular problems, like lameness.

Gestational diseases were not influenced by system or by breed.

The indicator of subclinical ketosis, FPR > 1.3, was never influenced by system with upland pasture, both in first month and until third month. MON breed was protected by subclinical ketosis. Increasing the age at first calving and genetic milk index could increase probabilities to incur subclinical ketosis.

The indicator of sub-acute ruminal acidosis did not showed significant differences in upland pasture system. However, MON breed was more subject to sub-acute ruminal acidosis.

Table 14 : Table of interaction between upland pasture system and breed

			Upland pasture X breed										
			MON		HF			Effect and significance[1]					
	Item	**n**	**No**	**Yes**	**No**	**Yes**	**SEM**	**U**	**B**	**S**	**X**	**G**	**A**
Fertility	**Number AI (n)**	2490	1.75	1.56	1.79	1.78	1.71	ns	ns	†	ns	*	
	Days 1st AI and conception (n)	1792	25.8	22.0	36.7	29.4	27.2	ns	†	†	ns	***	*
	Days calving and conception (n)	1751	93	90	113	97	99	†	**	ns	ns	*	
	Gestation period (days)	1712	287	287	281	283	284	ns	***	ns	ns		
	Interval calving (days)	2902	403	391	416	415	410	ns	**	ns	ns	**	
	Age 1st calving (days)	4034	1055	1119	964 b	1104 a	1059	*	***	*	**	***	
Milk production	**Duration dry period (days)**	2885	62.4	70.0	64.7	64.9	66.5	ns	ns	ns	ns	***	
	Duration lactation (days)	3465	328 a	307 b	331	331	327	ns	**	ns	*	***	
	Cumulated milk in 1st lactation (kg)	3465	6471	5680	7138	6785	6715	ns	***	ns	†	***	**
	Cumulated fat in 1st lactation (kg)	3465	253 a	216 b	269	261	256	ns	***	†	**	***	***
	Cumulated protein in 1st lactation (kg)	3465	215 a	184 b	223	213	214	ns	***	ns	**	***	***
	Fat % (%)	3465	3.90 a	3.80 b	3.78	3.84	3.82	ns	ns	*	***	***	
	Protein % (%)	3465	3.32 a	3.25 b	3.12	3.13	3.19	ns	***	***	**	***	
	Milk yield (kg/day)	3465	19.2	18.1	21.2	20.3	20.1	ns	***	***	ns	***	***
	Cumulated milk 305 days (kg)	3465	5865	5530	6461	6199	6134	ns	***	***	ns	***	***
	Cumulated fat 305 days (kg)	3465	229 a	210 b	243	237	234	ns	***	**	*	***	***
	Cumulated protein 305 days (kg)	3465	194 a	179 b	201	194	195	ns	***	**	*	***	***
	SCC (1000 cells/mL)	3465	88.2	83.5	130.1	97.5	186.8	ns	***	ns	ns	*	**
	Urea (mg/cL)	1907	288	279	263	256	266	ns	***	†	ns		
	Milk cumulated on life (kg)	2102	16634	17258	17824	17022	17632	ns	ns	ns	ns	***	
	Fat cumulated on life (kg)	2102	641	655	678	656	676	ns	ns	ns	ns	**	
	Protein cumulated on life (kg)	2102	545	558	558	531	560	ns	ns	ns	ns	***	
Longevity	**Longevity birth-last control (months)**	2310	68.4	71.6	67.3	66.1	67.8	ns	†	ns	ns	**	***
	Longevity calving-last control (months)	2302	27.0	30.3	28.1	26.7	27.9	ns	ns	ns	ns	***	
	Lactation rank (n)	2310	2.67	2.91	2.51	2.33	2.55	ns	**	ns	†		
	Cumulated lactation days on life (n)	2168	796	860	778	753	792	ns	ns	ns	ns		

[1] U = upland pasture system ; B = breed ; X = interaction between upland pasture system and breed ; G = genetic milk index ; A = age at first calving

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

Table 15 : Table of diseases of upland pasture system

Item	Effects	β	S.E.	Significance	Odds ratio
Mammary diseases	Not uplandpasture	-0.149	0.142	ns	0.862
	Breed MON	-0.921	0.168	***	0.398
	Genetic milk index	0.000	0.000	**	1.000
Articular diseases	Not uplandpasture	-1.178	0.262	***	0.308
	Breed MON	-0.850	0.267	**	0.428
	Genetic milk index	0.001	0.000	**	1.001
Gestational diseases	Not uplandpasture	-0.414	0.646	ns	0.661
	Breed MON	-0.032	0.646	ns	0.969
FPR >1.3 in 1st month	Not uplandpasture	-0.119	0.087	ns	0.888
	Breed MON	-1.295	0.101	***	0.274
	Age 1st calving	0.001	0.000	***	1.001
	Genetic milk index	0.000	0.000	***	1.000
FPR >1.3 until 3rd month	Not uplandpasture	0.044	0.082	ns	1.045
	Breed MON	-1.126	0.088	***	0.324
	Age 1st calving	0.001	0.000	***	1.001
FPR <1 3rd to 6th month	Not uplandpasture	0.086	0.091	ns	1.089
	Breed MON	0.568	0.092	***	1.765

*** : P < 0.001 ; ** : P < 0.01 ; * : P < 0.05 ; † : P < 0.10 ; ns : P ≥ 0.10

5. Discussion

The aim of this study was to investigate the long-term benefits produced by pasture rearing systems and non-silage feeding on the career of the dairy heifers, in terms of fertility, milk productivity, health and longevity. The literature is scarce and results are contrasting and unclear.

5.1. Breed Effect

Until recently, many breeding programs placed the most emphasis on milk production, without concern for functional traits, fertility or longevity (Inchaisri et al., 2010). Intense genetic selection for milk yield, as in HF, has predisposed animals to increased negative energy balance, greater disease susceptibility (Pryce and Veerkamp, 2001) and decreased fertility (Veerkamp et al., 2003). However, results of our study of fertility are in contrast with Veerkamp et al. (2003). Breed effect showed significant differences only in some variables of fertility. Gestation period was longer of 5 days in MON and this is agreement with Ledos and Moureaux (2013). We can however consider the difference we found on interval between calving and conception and interval calving not truly an expression of differences in fertility, but as indicators of a different approaches to insemination for optimizing the milk yield in the peak production. Indeed a later insemination permits to make longer lactation and to better exploit the yield in peak of lactation (Inchaisri et al., 2010).

Milk production revealed the most obvious breed differences of our research. Breed of dairy cow influenced most milk yield variables. HF cows were more productive than MON cows in terms of milk volume. It is evident that milk production had been the most important trait in their breeding objective for HF (Andersen-Ranberg et al., 1998). Milk quantity was inversely proportional to the concentration of fat and protein, so MON had an higher fat and protein concentration. However, our results were in contrast with Walsh et al. (2008) and Dillon et al. (2003a), in which HF was more productive also in fat and protein concentration, attributable probably at their different nutritional plane.

Longevity showed opposite results between the two groups of system, silage and upland pasture. In silage dataset, HF showed a higher longevity than MON, although they are only in tendency. However in upland pasture dataset, MON was basically more long-lived than HF, with a significant difference in lactation rank. Generally, the reasons of culling are caused by fertility problems (Le Cozler et al. 2009b). A study of Dillon et al. (2003b) revealed that HF had a lower survival rate than MON, due to a higher fertility problems in HF than in MON. Our dataset is too limited, in available information and in duration of the lactation observation, to explicate the reason of culling and to explicate the differences of longevity. An investigation of following lactations could explain a relationship between fertility and longevity in these two breeds.

Regarding health, some variable had different results depending on the dataset. In particular, mammary diseases, articular diseases and gestational diseases had or not significant differences in the two dataset. Mammary diseases didn't show any differences in silage dataset, on contrary, there is a difference in upland pasture dataset, in which MON cows were protected by mastitis. Several studies (Emanuelson and Funke, 1991; Koivula et al., 2005; Parker et al., 2007; Pomiès et al., 2013) highlighted a correlation between production and udder health. This indicates that animals with genetically high productivity are more susceptible to mastitis, like HF cows. However, this hypothesis was verified only in one experimental test of the present study.

In our research, articular diseases were influenced by the breed only in the upland pasture dataset, in which MON was protected by lameness. Literature is contrasting for the relation between lameness and breed. On one hand, our research is in agreement with the results of Sjöström et al. (2018), in which generally lameness are more frequency in HF cows. On other hand, Balandraud et al. (2018) observed two experimental farms: in first one there was not significant difference between HF and MON, and in the other farm MON cows were more regularly subject to lameness. A possible other explanation is the increased milk yield associated with the HF breed. HF cows were at a greater risk of metabolic disorders which might lead to a greater risk for horn-associated lameness as metabolic imbalance predisposing to lameness (Becker et al., 2014).

Probabilities to incur in gestational diseases increased with HF cows in silage dataset. These results highlighted that HF cows could be more subject to calving difficulty than other breeds, like MON (Heins et al., 2006). Moreover, an high genetic potential, like in HF cows, was probably one of the causes of metritis and anoestrus. These two reproductive problems can have origin from environmental factors, like scarce hygiene during calving or season of calving (Mwaanga and Janowski, 2000; Sheldon et al., 2006), but also from a nutritional imbalance. We can suppose that breeds with an high milk genetic potential, like HF, have a high nutritional requirement to carry out her productivity. The energetic priory of this breed is for the milk production. If these nutritional requirements are not satisfied, energetic deficiency is deleterious for its health. This involves some complications and problems, for examples metritis, anoestrus, mastitis or ketosis. Same reasoning could be do for subclinical ketosis, in which energy requirement increased with increase of milk production. In the present study, HF breed was a risk factors for subclinical ketosis, because the higher energetic requirement (Sakha et al., 2007). Although MON is known to be less prone to metabolic diseases, this aspect has not been studied in comparative studies because of the lack of sufficient and accessible data (Balandraud et al., 2018). In our study, risk factors of acidosis were feeding without silage and MON breed. MON was more subject to subacute acidosis because MON, compared to HF, needs a slightly richer ration in nitrogen (Montbéliarde association, 2019), due to the MON's double capacity to produce both milk and meat (Balandraud et al., 2018). A lack of soluble nitrogen during the lactation induces a strong decrease of the dairy production along with a higher protein level, an excessive fattening and a risk of acidosis (Montbéliarde association, 2019).

5.2. Silage System

Literature about effects of feeding heifers with silage on their fertility are contrasting. On one hand, according to Le Cozler et al. (2009b), heifers fed with silage are more fertile. On the other hand, Troccon et al. (1997) found that fertility was lower in heifers with a silage feeding. In the present study we did not show differences on fertility between a diet with or without feeding silage to heifers, in agreement with Macdonald et al. (2005). We can hypothesize fertility is influenced by other factors not considered in our model. Silage feeding only showed a significantly shorter interval between calving and conception. As mentioned above, we can evaluate the difference we found on interval between calving and conception as an indicator of herd management for optimizing the success at first insemination (Inchaisri et al., 2010).

Milk production in first lactation was not influenced by silage feeding, in agreement with Le Cozler et al. (2009b). These results agreed with those of Troccon (1996), who observeted that milk performances in first lactation were conditioned by age at first calving and by genetic milk index. Regarding the accumulation on life, for MON cows were indifferent to silage or not-silage feeding; whereas, HF cows increased their milk and protein (in tendency) and fat life cumulative production with silage, in relation to an higher cumulated lactation days on life with silage feeding.

This research showed a longer longevity for system with silage, that is in contrast with the results of Troccon (1993) and Le Cozler et al. (2009b), which observed a same longevity or a shorter longevity. The cause of a short longevity in Le Cozler (2009b) was attributable to fertility problem. In our research, the two systems, with or without silage, showed the same fertility rate, so it could be possible to hypothesize a different origin. We suppose that the higher energy and/or protein density of silage, compared to hay (at similar intakes), better satisfies the nutritive requirement of cows and so extends the longevity.

SCC showed an opposite reaction to effect of the interaction between breed and silage feeding. On one hand in MON cows, silage increased SCC; on other hand in HF cows, silage reduced SCC. Our results of SCC are difficult to explain. Somatic cell can be an indicator of clinical mastitis, when its count is higher than 200000 cells/ml (Harmon, 1994; Sharma et al., 2011). Under this count, it can be considered a physiological level. Although our results showed a significant difference, they can be considered into a physiological level.

Regarding health, mammary diseases and gestational diseases were not related to type of forage fed. Articular diseases were more frequency in heifers fed with silage. This confirmed the result of Becker et al. (2014), in which silage feeding was a risk factor for lameness. Feeding silage might cause metabolic disorders because of rapid fermentation in the rumen and a subsequent increase in acidity (Abel et al., 2001) which is known to reduce the quality of claw horn development (Mulling et al., 1999).

Regarding subclinical ketosis, in spite of silage is a feeding rich in energy, in a critical moment as post calving period, only an energetic feeding could be not enough to satisfy nutritional requirement. A diet with only hay in heifer could reduce probabilities of subclinical ketosis. Hay is a feeding voluminous, so it expands rumen capacity and the quantity of feeding ingestible after calving. However, hay feeding increased probabilities of subacute ruminal acidosis. We suppose it depends on type of distribution of feeding. In silage system is favourite total mixed ratio, in which forage, silage and concentrates are mixed. So, forages and hay can express better his buffer capacity against ruminal acidity. On contrary, control group distributed feeding ration principally in the form of unravelled hay and debaled hay separated by the concentrates, that was provided during milking. Normally concentrates are composed principally by cereal grains, like wheat or barley (Ishler et al, 2006), that are feed very fermentable. The fermentation of this feed in rumen reduces the pH level and could cause subacute ruminal acidosis (Kleen et al., 2003). The distribution of hay separated by concentrates could reduce buffer effect, with peak of fermentation of the concentrates after the milking and a general acidification of the rumen.

In our study about health, generally genetic milk index was associated with HF breed as risk factor. High milk productivity increased probabilities of mammary diseases, like mastitis. Our results are in agreement with the researches of Troccon (1993), Troccon et al. (1997) and Parker et al. (2007), in which mastitis are related to the increase of milk yield and not to the feeding. Concerning gestational diseases and subclinical ketosis, genetic milk index is linked with HF breed. As mentioned in previous chapter, cows with high productivity could not satisfied their nutritional requirement causing an energetic deficiency and health complications, like metritis, anoestrus, calving difficulty or subclinical ketosis.

The age at first calving was a risk factor for articular diseases and subclinical ketosis. Articular diseases could be caused by the weight of the cow. Generally a heifer that calves later is more heavy than a cow that calves earlier (Abeni et al., 2000), increasing the risk of lameness. Moreover, a cow that calves later is more productive (Le Cozler et al., 2009b). Consequently, nutritional requirement increases, increasing the risk to not satisfy its and to incur in metabolic imbalance, like subclinical ketosis.

5.3. Upland Pasture System

The results of upland pasture system didn’t reveal significant differences on fertility, in agreement with Troccon (1993) and Le Cozler et al. (2009a). The only variable with significant difference was the age at first calving. The same reasoning of previous chapters, can be applied for the parameter of age at first calving. Age at first calving is not truly an expression of differences in fertility, but as an indicator of a different management of the herd of heifers. Normally, the farmer tries to concentrate the calving after the season of upland pasture, when the heifers have already returned in the winter location.

Some parameters of milk production were influenced by interaction between breed and upland pasture. In particular, HF cows didn’t show effects on milk production. On contrary, MON cows were negatively conditioned by upland pasture. Upland pasture reduced duration lactation and cumulated fat and protein production in MON cows. However, milk, fat and protein cumulated on life and longevity variables didn’t reveal significant differences, and lactation rank revealed a tendency with more lactations for MON cows in upland pasture. We hypothesize MON is less productive because it is able to preserve itself in a poor and hard environment as upland pasture, reducing milk production but increasing longevity. Regarding productive lifetime, MON is productive as much as HF. Considering that HF has a high genetic potential for the milk production, this implicates an energetic priory to the milk production, but it could cause a reduction of the lifetime. We could define it an adaptation of the MON breed to the rural mountain environment.

Season of birth showed a significant difference on the age at first calving, later for the cows born in spring. As already mentioned above, age at first calving is an indicator of management of the herd. Heifers calves on average after 3 years, so heifers born in autumn calves the first time in autumn. We think that in autumn the calves are earlier than in spring because these heifers didn't complete the season in upland pasture or they don't go in upland pasture for calving in winter farm. Moreover, heifers that calves in spring spend less time in upland pasture, because they are not already weaned or ready for a hard season in upland pasture. Moreover, in upland pasture, the energetic value of the grass is heterogeneous and quickly variable, so the development of the animal could be slower. Considering number of seasons spend in upland pasture and the age at first calving, cows born in spring were more productive than cows born in the other months. Spring had higher milk, fat and protein cumulated in 305 days and a higher daily milk yield, but generally a lower concentration of protein and fat, in agreement with the results of Garcia and Holmes (1999).

Regarding health, our results are in contrast with the scientific literature. For several authors (Zemp, 1985; Ruhland et al., 1999; Washburn et al., 2002; Hernandez-Mendo et al., 2007; Troccon, 1993; Krogmeier et al., 2015) upland pasture has positive effects on the health of the heifers and cows. However, our study didn't show any positive effects, but only a negative influence on articular diseases. We hypothesize that a various and irregular ground, as upland pasture, could increase the risk of traumatic events, that are cause of lameness, muscular accidents or paronychia.

Also in upland pasture dataset, genetic milk index increased probabilities of incurring in mammary diseases. As mentioned above, mastitis are not associated with feeding (in this case upland pasture), but it is influenced by genetic milk index and so by milk yield (Troccon, 1993; Troccon et al. 1997; Parker et al., 2007). Moreover, a high genetic milk potential corresponds a high nutritional requirement and so a risk to not satisfy its. An energetic imbalance could be the origin of articular problems, like lameness, or metabolic diseases, like subclinical ketosis (Dohoo and Martin, 1984).

In present study of upland pasture dataset, the age at first calving was a risk factor for subclinical ketosis. The same reasoning of above could be applied also in this case: generally a heifer that calves later is more heavy and more productive (Le Cozler et al., 2009b). So, subclinical ketosis are more frequent probably because energetic requirement could not be satisfy.

6. Conclusions

The objective of the present study was to investigate the long-term benefits produced by pasture rearing systems and non-silage feeding on the career of the dairy heifers, in terms of fertility, milk productivity, health and longevity. The results obtained evidenced that these two rearing system can have effects on productive life of the cows. The presence of positive and at the same time negative aspects do not allow us to give an unidirectional opinion on the evaluation of this system.

Fertility was not influenced by neither of the systems. Some fertility variables showed significant differences, but they was considered as an indicator of herd management for improving fertility and for better exploiting milk yield in peak production (Inchaisri et al., 2010). Heifers fed with silage had a longer life expectancy, calculated both since birth and as productive life since the first calving. Therefore, a longer longevity influenced significantly milk, fat and protein cumulated on life. Whereas the others variables of daily milk production and milk production in lactation were not significantly different.

Regarding health, silage feeding could increase the risk of lameness (Becker et al., 2014) and reduce the risk of subacute ruminal acidosis. Attributable probably because feeding distribution happened in different moment of the day, reducing the buffer effect of the hay. However, heifers fed with hay had less probabilities to have subclinical ketosis, because hay is a voluminous feed, so a feeding with hay increase the rumen capacity and the ingestion capacity. Breed MON was protected by gestational diseases and by subclinical ketosis because its energy requirement are less than HF. MON cows were more subject to subacute rumen acidosis because needs a slightly richer ration in nitrogen for dual-purpose breed (Montbéliarde association, 2019).

Upland pasture system idn’t reveale significant differences on fertility and longevity. The two breed had a different response to the system: for HF cows was indifferent, but MON cows reduced their milk productivity. However, regarding milk cumulated on life, MON and HF didn’t show differences. We hypothesize MON is less productive because it is able to preserve itself in upland pasture system, reducing milk production but increasing longevity. Moreover, season of birth had effects on milk productivity: cows born in spring were more productive than cows born in the other months. This difference depends probably by the number of seasons spend in upland pasture, heifers that calves in spring spend less time in upland pasture, and thei development can be more rapid and complete.

Regarding health, our results are in contrast with the scientific literature (Zemp, 1985; Ruhland et al., 1999; Washburn et al., 2002; Hernandez-Mendo et al., 2007; Troccon, 1993; Krogmeier et al., 2015). Our study showed only a negative influence on articular diseases. We suppose that a various and irregular ground, as upland pasture, could increase the risk of traumatic events, that are cause of lameness, muscular accidents or paronychia.

References

Abel H., Immig I., Gomez C., Steinberg W., 2001. *Research note: effect of increasing dietary concentrate levels on microbial biotin metabolism in the artificial rumen simulation system (RUSITEC)*. Arch. Tierernahr. 55: 371 – 376

Abeni F., Calamari L., Stefanini L., Pirlo G., 2000. *Effects of daily gain in pre- and postpubertal replacement dairy heifers on body condition score, body size, metabolic profile, and future milk production*. J. Dairy Sci. 83: 1468-1478

Agabriel J., Petit M., 1987. *Recommandations alimentaires pour les vaches allaitantes.* Bull. Tech. C.R.V.Z. Theix, INRA. 66: 43-50

Andersen-Ranberg I.M., Steine T., Klemetsdal G., 1998. *Breeding for female fertility – Current status and future possibilities in Norway*. Interbull Bull. 8: 87-90

Balandraud N., Mosnier C., Delaby L., Dubief F., Goron J.-P., Martin B., Pomiès D., Cassard A., 2018. *Holstein ou Montbéliarde: des différences phénotypiques aux conséquences économiques à l'échelle de l'exploitation*. INRA Prod. Anim. 31: 337-352

Barkema H.W., Schukken Y.H., Lam T.J.G.M., Breiboer M.L., Benedictus G., Brand A., 1999. *Management practices associated with the incidence rate of clinical mastitis*. J. Dairy Sci. 82: 1643-1654

Becker J., Steiner A., Kohler S., Koller-Bähler A., Wüthrich M., Reist M., 2014. *Lameness and foot lesions in Swiss dairy cows: II. Risk factors*. Schweizer Archiv für Tierheilkunde 79-89

Brody S., 1945. *Bioenergetics and growth*, Rheinhold Publishing, New York

Burow E., Thomsen P.T., Sørensen J.T., Rousing T., 2011. *The effect of grazing on cow mortality in Danish dairy herds*. Preventive Veterinary Medicine. 100: 237-241

Coulon J.-P., Delacroix-Buchet A., Martin B., Pirisi A., 2004. *Relationship between ruminant management and sensory characteristic of cheeses: a review*. Lait, 84: 221-241

Dillon P., Buckley F., O'Connor P., Hegarty D., Rath M., 2003a. *A comparison of different dairy cow breeds on a seasonal grass-based system of milk production, 1. Milk production, live weight, body condition score and DM intake*. Livest. Prod. Sci. 83: 21-33

Dillon P., Snijders S., Buckley F., Harris B., O'Connor P., Mee J.F., 2003b. *A comparison of different dairy cow breeds on a seasonal grass-based system of milk production, 2. Reproduction and survival*. Livest. Prod. Sci. 83: 35-42

Dillon P., Berry D.P., Evans R.D., Buckley F., Horan B., 2006. *Consequences of genetic selection for increased milk production in European seasonal pasture based system of milk production*. Livest. Sci. 99: 141-158

Dohoo I.R., Martin S.W., 1984. *Subclinical ketosis: prevalence and associations with production and disease.* Canadian Journal of Comparative Medicine 48: 1-5

Emanuelson U., Funke H., 1991. *Effect of milk yield on relationship between bulk milk somatic cell count and prevalence of mastitis*. J. Dairy Sci. 74: 2479-2483

Enemark J.M.D., 2009. *The monitoring, prevention and treatment of sub-acute ruminal acidosis (SARA): a review*. The Veterinary Journal 176: 32-43

Ettema J.F., Santos J.E.P., 2004. *Impact of age at calving on lactation, reproduction, health, and income in first-parity Holsteins on commercial farms*. J. Dairy Sci. 87: 2730-2742

Ford J.A., Park C.S., 2001. *Nutritionally directed compensatory growth enhance heifer development and lactation potential*. J. Dairy Sci. 84: 1669-1678

Garcia S.C., Holmes C.W., 1999. *Effects of time calving on the productivity of pasture-based dairy system: a review.* New Zealand Journal of Agricultural Research 42: 347-362

Harmon R.J., 1994. *Symposium: mastitis and genetic evaluation for somatic cell count*. J. Dairy Sci. 77: 2103-2112

Heins B.J., Hansen L.B., Seykora A.J., 2006. *Calving difficulty and stillbirths of pure Holsteins versus crossbreds of Holstein with Normande, Montbéliarde, and Scandinavian Red*. J. Dairy Sci. 89: 2805-2810

Hernandez-Mendo O., von Keyserlingk M.A.G., Veira D.M., Weary D.M., 2007. *Effects of pasture on lameness in dairy cows*. J. Dairy Sci. 90: 1209-1214

Inchaisri C., Hogeveen H., Vos P.L.A.M., van der Weijden G.C., Jorrisma R., 2010. *Effect of milk yield characteristics, breed, and parity on success of the first insemination in Dutch dairy cows*. J. Dairy Sci. 93: 5179-5187

Institute de l'elevage, 2015. *Observatoire de l'alimentation des vaches laitières*. Édition 2015-2018

Ishler V.A., Adams R.S., Heinrichs A.J., Varga G.A., 2006. *Concentrates for dairy cattle*. Dairy & Animal Sciene DAS 94-06

Koivula M., Mäntysaar E.A., Negussie E., Serenius T., 2005. *Genetic and phenotypic relationships among milk yield and somatic cell count before and after clinical mastitis*. J. Dairy Sci. 88: 827-833

Kleen J.L., Hooijer G.A., Rehage J., Noordhuizen J.P.T., 2003. *Subacute ruminal acidosis (SARA): a review*. J. Vet. Med. 50: 406-414

Knaus W., Schipflinger F., Moder K., Baumung R., 2012. *Effekt einer silagefreien Fütterung auf die Leistung von Milchkühen in Tirol.* Züchtungskunde. 84(2): 191-198

Krogh M.A., Toft N., Enevoldsen C., 2011. *Latent class evaluation of a milk test, a urine test, and the fat-to-protein percentage ratio in milk to diagnose ketosis in dairy cows*. J. Dairy Sci. 94: 2360-2367

Krogmeier D., Kimmerle A., Schmidt E., Götz K.-U., 2015. *Einfluss einer Jungviehalpung auf die Nutzungsdauer und die Leistungseigenschaften von Kühen der Rassen Braun vieh und Fleckvieh.* Züchtungskunde, 87(2): 107-119

Lacasse P., Block E., Guilbaut L.A., Petitclerc D., 1993. *Effect of plane nutrition of dairy heifers before and during gestation on milk production, reproduction, and health*. J. Dairy Sci. 76: 3420-3427

Le Cozler Y., Peccatte J.-R., Porhiel J.-Y., Brunschwig P., Disenhaus C., 2009a. *Pratiques d'élevages et performances des génisses laitières: état des connaissances et perspectives.* INRA Prod. Anim. 22(4): 303-316

Le Cozler Y., Peyraud J.L., Troccon J.L., 2009b. *Effect of feeding regime, growth intensity and age at first insemination on performances and longevity of Holstein heifers born during autumn.* Livest. Sci. 124: 72-81

Ledos H., Moureaux S., 2013. *Durée de gestation pour les principals races de l'espèce bovine. Moyenne et variabilité.* Institut de l'élevage. Collection résultats. Janvier 2013

Macdonald K.A., Penno J.W., Bryant A.M., Roche J.R., 2005. *Effect of feeding level pre- and post-puberty and body weight at first calving on growth, milk production, and fertility in grazing dairy cows*. J. Dairy Sci. 88: 3363-3375

Martin B., Verdier-Metz I., Buchin S., Hurtaud C., Coulon J.-B., 2005. *How do the nature of forage and pasture diversity influence the sensory quality of dairy livestock products?* Animal Science. 81: 205-212

Mulling C. K., Bragulla H. H., Reese S., Budras K. D., Steinberg W., 1999. How structures in bovine hoof epidermis are influenced by nutritional factors. Anat. Histol. Embryol. 28: 103 – 108

Mwaanga E.S., Janowski T., 2000. Anoestrus in dairy cows: causes, prevalence and clinical forms. Reprod. Dom. Anim. 35: 193-200

Offer J.E., Leach K.A., Brocklehurst S., Logue D.N., 2003. *Effect of forage type on claw horn lesion development in dairy heifers*. The Veterinary Journal. 165: 221-227

Parker K.I., Compton C.W.R., Anniss F.M., Weir A.M., McDougall S., 2007. *Management of dairy heifers and its relationship with the incidence of clinical mastitis*. New Zealand Veterinary Journal. 55(5) : 208-216

Pomiès D., Martin B., Pradel P., Verdier-Metz I., Constant I., Delbès-Paus C., Troquier O., Fournier F., Montel M.C., Farrugia A., 2013. *Design of low-input dairy farming systems in mountain areas: animal performances and cheese sensory properties*. In: 17th Meet. FAO-CIHEAM Mountain Pasture Network. Trivero, Italy, 22-26

Pryce J.E., Veerkamp R.F., 2001. *The incorporation of fertility indices in genetic improvement programmes*. Br. Soc. Anim. Sci. 26 : 237-249

Robelin J., 1986. *Composition corporelle des bovins: évolution au cours du développement et differences entre races.* Thèse d'état, Université de Clermont-Ferrand II, E-368, pp 392

Ruhland K., Gränzer W., Groth W., Pirchner F., 1999. *Blood levels of hormones and metabolites, erythrocytes and leukocytes and respiration and pulse rate of heifers after alpage*. J. Anim. Breed. Genet. 116: 415-423

Sakha M., Ameri M., Sharifi H., Taheri I., 2007. *Bovine subclinical ketosis in dairy herds in Iran*. Veterinary Research Communications 21: 673-379

Shalloo L., Cromie A., McHugh N., 2014. *Effect of fertility on the economics of pasture-based dairy system.* Animal. 8(1): 222-231

Sharma N., Singh N.K., Bhadal M.S., 2011. *Relationship of somatic cell count and mastitis: an overview*. Asian-Aust. J. Anim. Sci. Vol.24 No.3: 429-438

Sheldon I.M., Lewis G.S., LeBlanc S., Gilbert R.O., 2006. *Defining postpartum uterine disease in cattle*. Theriogenology 65: 1516-1530

Sjöström K., Fall N., Blanco-Penedo I., Duval J.E., Krieger M., Emanuelson U., 2018. *Lameness prevalence and risk factors in organic dairy herds in fourEuropean countries*. Livest. Sci. 208: 44-50

Troccon J.L., 1993. *Élevage des génisses laitières avec ou sans pâturage.* Annales de zootechnie, INRA/EDP Science. 42(3): 271-288

Troccon J.L., 1996. *Élevage de génisses laitières et performances ultérieures*. Renc. Rech. Rum. 3: 201-210

Troccon J.L., Muller A., Peccatte J.R., Fargetton M., 1997. *Effet du niveau d'alimentation énergétique de génisses laitières de races Holstein et Normande jusqu'à l'âge de 14 mois sur les performances durant les périodes d'élevage et de lactation.* Ann. Zootech. 46: 27-41

Troccon J.L., Petit M., 1989. *Croissance des génisses de renouvellement et performances ultérieures*. INRA Prod. Anim. 2(1): 55-64

Veerkamp R.F., Beerda B., van der Lende T., 2003. *Effect of genetic selection for milk yield on energy balance, levels of hormones, and metabolites in lactating cattle, and possible links to reduced fertility*. Livest. Prod. Sci. 83: 257-275

Vissers M.M., Driehuis F., Te Giffel M.C., De Jong P., Lankved J.M., 2007. *Concentrations of butyric acid bacteria spores in silage and relationship with aerobic deterioration*. J. Dairy Sci. 85: 105-111

Walsh S., Buckley F., Pierce K., Byrne N., Patton J., Dillon P., 2008. *Effect of breed and feeding system on milk production, body weight, body condition score, reproductive performance, and postpartum ovarian function.* J. Dairy Sci. 91: 4401-4413

Washburn S.P., White S.L., Green Jr. J.T., Benson G.A., 2002. *Reproduction, mastitis, and body condition of seasonally calved Holstein and jersey cows in confinement or pasture system*. J. Dairy Sci. 85: 105-111

Zemp M., 1985. *Einfluss der Alpung auf produktionstechnische und physiologische Parameter von Kühen mit mittleren bis hohen Michleistungen.* Eidgenössisch Technische Hochschule. Diss. ETH Nr. 7868

Website Citations

Bureau de Statistique sur les Productions et les Compatibilités Agricoles (BSPCA), 2017. *Effectives des animaux en fin d'année*. Last update 21.01.2019
http://agreste.agriculture.gouv.fr/IMG/pdf/saa2018T10bspca.pdf

Eurostat, 2019a. *Bovine population – annual data*. Last update 10.01.2019
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=apro_mt_lscatl&lang=en

Eurostat, 2019b. *Permanent grassland: number of farms and areas by agricultural size of farm (UAA) and size of permanent grassland area*. Last update 16.01.2017
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ef_pograss&lang=en

Ministère de l'Agricolture et de l'Alimentation, 2017. *Mémento, statistique agricole*. Agreste. Last Update 21.01.2019
http://agreste.agriculture.gouv.fr/IMG/pdf/memo17_integral.pdf

Montbéliarde association, 2019. *Adapting the food at the beginning of lactation*. Monbéliarde association. Last Update 05.04.2019
https://www.montbeliarde.org/en-1708.html

ProYoungStock, 2019. Last Update 30.04.2019
https://www.proyoungstock.net/