Relationship between body condition score, body weight, some nutritional metabolites changes in blood and reproduction in Algerian Montbeliad cows

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Abstract

The objective of this study was to investigate through a nutritional and biochemical approach the variability of reproductive performance in dairy cows of semi arid area herds. Seventy four multiparous females reared in four farms were tracked from one month before calving to the third month postpartum. Information about reproductive events were taken once a month, and the body condition score evaluated on a 1 to 5 scale according to the EDMONSON method (1989). Blood samples were taken on a sample of 23 cows chosen according to body condition score before calving for biochemical analysis of energy, nitrogen and minerals parameters. Maximum concentrations depended to physiological stage. Blood glucose and calcium are stable at around 0.60g / l and 0.76 g / l respectively ($p>0.05$). Uremia (0.27g/l vs 0.16g/l) and triglycerides (0.74g/l vs 0.48g/l) are higher in the first month of lactation ($p <0.05$). Cholesterol (1.42g/l vs 1.03g/l) is higher in the 3rd month post-partum. The results show also that best performances are recorded in cows with BC before calving around 3 and 3.5 ($p<0.05$) and for those loosing less BC in the first months postpartum. The nutritional and metabolic profiles of females were used to characterize high female performance which has a reduces format and losses of BC in post-partum are minimal and late; They express the moderate concentration of glucose (0.60g / l), elevated cholesterol (> 1.20 g / l) and low triglycerides (about 0.60 g / l). Great format Cows with early and significant loss of BC after calving. They express a poor reproductive performance with high triglycerides concentration (1.02 g / l) in the 1st month of lactation.

Keywords: Reproduction, Dairy cows, Body condition, Biochemical parameters, Semi arid.

Introduction

The body condition (BC) of dairy cows in pre and post-partum modulate reproductive performance (Castaneda-Guti´errez *et al*. 2009) and milk production (Jilek *et al*. 2008). The effects of nutrition on reproductive efficiency of females were clearly demonstrated by several studies. Short *et al*. (1990) reported that lactating cows reduced feed intake before calving is reflected by lowest body condition at calving accompanied to long postpartum anoestrus. Also, it was demonstrated that undernutrition and low body condition score during the first phase of lactation is accompanied by disorders in plasma concentrations of reproductive hormones (Westwood *et al*. 2002), low follicle development (Fassi Fihri *et al*. 2005) and poor oocytes quality (Jorritsma *et al*. 2003).

A distinction has been made by researchers between body condition score and energy balance during the first period of lactation. For Baumgard *et al*. (2006), most dairy cows come in negative energy balance after parturition, which is a normal adaptation to lactation. This situation is independent of the genetic potential of milk yield. Bukley *et al*. (2003) reported that it is the severe energy balance which causes metabolic disorders and impaired fertility. Contrariwise, Grimard *et al*. (2003) observed an improvement in fertility by equilibration of energy balance even if the body condition score remains low.

The estimation of body condition scoring by notation though is simple and subjective it allows an indirect measure of the energy status of females. However, it can be enhanced by objective measure-ments such as biochemical analysis of blood parameters to understand and explain biologically loss or recovery in BC and its impact on reproduction (synthesis and secretion of sex hormones, toxicity, etc.).

This study aims to clarify through a nutritional

Table-1 : Means and ratios of BCS before calving class in cow population and sample

Particulars	n	BCS before calving					
		< 2.75		2.75 – 3.50		> 3.50	
		Means ± SE	%	Means ± SE	%	Means ± SE	%
Population	74	2.38±0.07	16	3.16±0.04	46	4.16±0.07	38
	23	2.25±0.14	13	3.00±0.04	39	4.23±0.11	48

and metabolic approach the effects of body condition before calving and its evolution dynamics in post partum on the changes of blood biochemical parameters related to food energy, nitrogen and mineral and reproductive behaviour of cows. In addition, the accuracy of best BC and evolution type adapted to a good reproductive rate and dietary recommendations needed to establish the ideal BC when desired.

Materials and methods

Animal material**:** The study was done in four larges farms in eastern semi arid area of Algeria. Seventy four Montbeliard cows of different ages are followed-up around one month before calving to the 4th months of lactation. Twenty three of them are chosen for blood sampling.

Body condition score and body weight measurement: The body condition score (BCS) was estimated monthly on a 1-5 scale (Edmonson *et al*. 1989). A tape measure for cattle is used to estimate the body weight (BW) by measuring the girth.

Nutritional parameters in blood: A sample (23 cows) of the initial population was chosen to perform blood tests to make determinations of energy, nitrogen and mineral metabolites. The choice was made so as to cover all classes of body condition before calving (Table-1).

The samples were taken in the last month of gestation, 30, 60 and 90 days of lactation. For each animal a sample of 10ml of blood was taken from coccygeal vessels on a Vacutainer ® tube without anticoagulant. Then 5ml of the sample is poured immediately into a lithium heparin tube. All blood samples were carried early in the morning before the distribution of concentrate. At laboratory, blood was centrifuged at 3000rpm for 5 minutes. The plasma and serum are passed directly back to a multi autoanalyzer for determination of glucose, cholesterol, triglycerides, urea, creatinine and calcium concentration using enzymatic reactions with commercial kits (Spainreact ®) for metabolites considered.

Reproduction parameters: Five reproductive traits were analyzed:

- Calving to first service interval (FSI);
- Calving to conception interval (CI);
- First service to conception interval;
- Number of services per conception;
- Conception rate at 60, 90 and 120 day after calving (CR)

Statistical analysis: All data are then subjected to several statistical analyses to study the relation between body condition and the variability of blood metabolites and its impact on reproduction.

The data were presented as least square means (LS mean ±S.E.). A two step classification was used to separate classes with different BC before calving. Class distribution is only accepted if the cohesion and separation index is greater than 0.5. PCA follows a hierarchical classification of reproductive parameters is performed to identify the different types of performances. The analysis of variance single factor (SPSS Procedure 18) was used to analyse the effect of age and season on reproductive parameters. The evolution of the BC, BW and nutritional metabolites was subjected to analysis of variance with repeated measures (LGM procedure) indicating the variability between physiological stage.

Given the small size of the sample, the Kruskal-Wallis nonparametric analysis was conducted to describe the variability of reproductive parameters and blood metabolites by BC classes. The significance level was set at 0.05. When the effect of class was significant, regression test were established to determine the type of evolution. All analysis were performed by SPSS (18).

Results

Dynamic changes of BCS and BW: Similar evolution shape of BC and BW in pre and post partum was observed. The best records are stored in dry periods (3.46 and 638kg of BC and BW respectively). Both parameters undergo a decrease equivalent to 5 to 6% in post-partum to reach a minimum in the 2nd month of lactation ($p < 0.001$). The recovery status is established from the 3rd month when BC and BW represent 96% and 98% of initial situation.

Dynamic changes of metabolite profile

Energetic metabolites: Changes in blood

Table-2: Reproduction traits in Montbeliard cow

Reproductive parameters	n	Mean	SE
FSI (day)	74	58	4.03
CI (day)	74	86	6.56
FSCI (day)	74	28	5.43
SPC	74	1.85	0.15
CP (60%)	33	45	---
CP (90%)	45	61	---
CP (120%)	58	79	—

concentrations of energy metabolites revealed three profiles. Glucose variability is low and stagnant at a concentration of 0.6 g / l. However, the blood concentration of cholesterol shows low around calving 1g / l, but increases rapidly and significantly ($p < 0.05$) from the 2nd month to be higher than 1.4 g / l. Triglycerides are moving in the opposite direction. This rate is relatively moderate in dry (0.62g/l) increases rapidly and significantly ($p < 0.05$) after calving and then decreases in the 2nd month to stabilize around 0.50 g / l.

Nitrogen metabolites: Uraemia average in dry is approximately 0.17g/l , then increases ($p<0.05$) in the 1st months of lactation (0.27 g / l) and begins to decline from 2nd month 2 (0.24 g / l) to return to the dry value in 3rd month of lactation (0.19 g / l).

However, the variability of creatinine is low with a high relative value before calving (0.20g/l) and a low in post partum (0.16g/l).

Mineral metabolites: The calcium concentration does not vary significantly ($p>0.05$) around calving and the differences between stages are less than 0.08 g / l.

Reproductive parameters: The reproductive performances of cows are summarized in the table-2. The averages FSI, CI, FSCI and NSC are 58, 86, 28 and 1.85 respectively. Indeed, 45% of cows are seen pregnant at 60 days and 79% to 120jours. These performances are related to calving season ($p < 0.001$) but are independent at the age of females ($p > 0.05$). The best performances were recorded in summer.

BC, metabolites and reproduction

Impact of BCS before calving: According to the classes previously identified by two step classification it was found that BCS before calving affects reproductive parameters mainly FSI and CI ($p < 0.05$). Regression analysis shows a strong relationship between these parameters. The BC before caving is strongly correlated with FSI ($p = 0.012$, $r = 0.61$) and relatively correlated with CI ($p = 0.097$, $r = 0.47$). The best performances were recorded in females with medium BCS (2.75 to 3.50) whose reproductive intervals were shorter (54 and 81days of FSI and CI respectively), obese cows show average performance (71 and 85days). However, lowest performances were observed in thins cows (131 and 150 days).

For the biochemical parameters of energy metabolism, the Kruskal Wallis test shows that the BC before calving has little effect that manifests only in one stage. Regression confirms the significant effect of the BC before calving on blood glucose of dry cows for obese cows (0.67 g / l vs. 0.52 g / l). Cholesterol in the first months of lactation is higher in cows with medium BCS (1.18 g / l) compared to obese cows (0.89 g/l). However, the level of triglyceride in serum is greater in thins cows (0.91g / L vs 0.51g / l).

Uraemia in dry evolves linearly according to the BCS before calving, it is lower in thins cows (0.09 g / l) and higher among those obese (0.23g / l).

Nutritional and Metabolic Characteristics of high, medium and low cow performance

The principal component analysis (PCA) followed by hierarchical cluster analysis of reproductive parameters data allowed us to identify three classes of cows whose performances are distinguished (table-3). However, there are also differences in dynamics change of body condition and blood concentrations of triglycerides, cholesterol and urea. The first class includes adult cows (older than 5 years). Their reproductive performance is better; FSI and CI are equivalent to 43 and 56 respectively. Body condition is characterized by a good rating in dry, a low and early

Table-3: Reproduction traits in classes identified by PCA

	Significant	Class 1 (50%)		Class 2 (40%)		Class 3 (10%)	
		Mean	SE	Mean	SE	Mean	SE
FSI	$p<0.001$	43^a	5.01	115^b	6.16	44^a	0.00
CCI	$p<0.001$	56^a	6.04	123^b	7.87	157^b	0.50
FSCI	$p<0.001$	13^a	6.58	8^a	4.26	114^b	0.50
NSC	$p>0.05$	1.55	0.28	1.33	0.16	2.00	0.00

loss and significant recovery. The concentration of glucose is constant around 0.60 g / l but cholesterol appears very high compared to other groups with a max at 3rd months. In contrast, the plasma triglyceride concentration is low. Changes in blood urea concentration are low and stagnant in 0.20g / l level.

Class 2 contains cows with bad performances. The FSI and CI are 115 days and 123 days respectively. They were thin cows who suffer loss continues until the 2nd month of lactation, the recovery is tardy. Blood glucose of cows is stable at around 0.58g/l.

Cholesterol is low in dry and early lactation and increases thereafter. Triglycerides are higher compared to the first. Uraemia is low before calving increases and stabilizes around 0.25 g/l after 1st month of lactation.

Class 3 includes repeat breeding cows. Making in breeding is early (44 days) but conception will occur after 5 months. The FSCI is very long (113 days). Females of this class have a good body condition at calving who suffers a significant loss in the first months of lactation (24%). Cows in this group express blood glucose concentrations relatively higher compared to other groups. Cholesterol is low before calving increase continually until the 2nd month and decrease after. Triglycerides are low in dry and early lactation, increased significantly in the 2nd month post partum and decrease later. Uraemia follows the same profile of blood cholesterol with a peak in the 2nd month and minimum values for dry and 3rd months of lactation.

Discussion

The study of reproduction in Montbeliard race reared in Algerian semi arid region shows relatively good performance. Calving to first service interval and calving to conception interval evaluated at 58 and 86 days was similar to the performances in temperate countries (Gillund *et al*. 2001; Pryce *et al*. 2001; Veerkamp *et al.* 2001) and are best compared to the results in similar conditions (Madani and Mouffok 2008; Sraïri and Baqasse, 2000; Van Sanh *et al*. 1997). The intra-annual variability is much documented, but the differences are different in direction and value. Pryce *et al.* (2000) showed that in the United States and in Ireland, females calving in the period from January to May realize the longer intervals. However, Gillund *et al*. (2001), observed in the Scandinavian country a better performances for summer calving resulted in a gain of 10 to 14 days compared to winter. In contrast, N'dama cow in Africa realize low performance in summer (Kang'mate *et al.* 2000). Contrwise, other authors reported that the calving season had no effect on reproductive performance (Mouffok *et al* 2007; Resken *et al*. 1999).

In our case improvement is observed from winter to summer. This variability can be explained by animal level of body reserves recovered during spring (period of high forage potential) and its effects on post partum energy balance (EB). The relationship of EB with reproductive performance has been well documented. For BANOS *et al*. 2004, the negative energy balance is associated with difficulties encountered by the cow to receive and maintain the fetus. These problems are more noticeable in highly productive cows' milk. Royal *et al*. (2002) reported that in dairy cows, negative EB is the result of strong activity of hormones that regulate metabolism through the mobilization of body reserves. This activation promotes the alteration of reproductive hormones flow. An adequate energy supplements before and after calving can correct this negative balance (Staples *et al*. 1998; Pruit, 2001). Cavestony *et al* (2009) reported the correction of EB is valid only in multiparous. Primiparous continues to lose, at all level of complementation. In this study reproductive parameters are correlated to BC before calving. The best performances are expressed by cows with BCS between 3 to 3.5 points. Shrestha et al. (2005) and Jilek *et al.* (2008) observed that no significant effect of the BCS at dry period resumption of luteal activity and breeding in the Holstein and Fleckvieh breed. However, the authors report that cows that loses more express longest postpartum intervals (Escobedo-Amezcua *et al*. 2010). In addition the BC is positively correlated with glucose and urea, a sign of good food practice. Blood concentrations of glucose and urea are higher in obese dry cows thus confirming works of Tillard *et al* (2007) in Holstein in Indian pacific conditions. From that, urea concentration increased significantly in the first months in thins and declines then. However, urea evolution is regular in obese cows. The energy deficit decrease insulin and IGF-I secretion and inhibits hypothalamic GnRH, pituitary LH and FSH secretion (Castaneda *et al*. 2009) and reducing maturity and production of estrogen by ovarian follicles (Butler 2000).

However, triglycerides are moving in the opposite direction. Thin cows have the highest concentrations at dry following an intense lipolysis (3c). In postpartum, triglycerides values increase to the 1st month result mobilization of body reserve to support milk production but will go down from the 2nd

month to be at low levels indicating that recovery of body condition are established. According to Chillard (1998) triglycerides are produced by the liver from free fatty acids released from adipose tissue at the time of mobilization of corporal reserves. In contrast, average concentrations were observed in cows with higher BCS (> 3.5).

In our study, cholesterol is negatively correlated with protein intake. Its content is higher in cows with medium BC at any stage result a better reproductive performance. Obese and thin cows reveal similar low levels before calving and diverge from the 1st month of lactation when we observe a decrease of cholesterol concentration in obese cows and an increase in thin cows. At the 3rd month rates return to base value.

Three groups of cows of various reproductive performances are identified by PCA. Poor reproductive cows with a body condition, plasma glucose and cholesterol relatively low. But high triglycerides and moderate urea concentration were observed. Although glucose is no considered as a very sensitive indicator of energy status due to homeostasis (Kronfeld *et al* 1982) cholesterol is considered the most reliable among the blood parameters. Ruegg *et al*. (1992) found that cholesterol is inversely correlated to loss of BC in post-partum; more than energy deficit is higher cholesterol is low. However, Roche (2006) reported that cows with a low body condition at calving tend to prolong postpartum anoestrus probably due to the low frequency pulses of LH, reflecting a decrease in estradiol concentration becomes ineffective to induce LH discharge and ovulation.

Both cows with best performances reproduction and repeat breeding start with a high BCS at dry. A high significant loss of BC at 1st month is observed in repeat breeding cows. Plasma concentrations of glucose and cholesterol levels are high and cows come into heat early (43 et 44 day). However, these females recorded relatively low concentrations of triglycerides and urea before calving and rapidly and significantly increasing in repeat breeding cows' post-partum. The increase in postpartum blood triglycerides is an indicator of a strong mobilization of body reserves that interfere with the success of conception. The increase in blood urea can decrease fertility rate (Ling *et al.* 2003) by increasing the plasma concentration of progesterone (Barton *et al*. 1996). However, Elrod and Butler (1993) reported that high levels of uraemia may reduce fertility by destroying sperm or embryo mortality in early stages of development.

Conclusion

The results show that best performances are recorded by cows having BC before calving overweight between 3 and 3.5 and for those who lose less in the first months postpartum. The nutritional and metabolic profiles of females was used to characterize high female performance which has a reduces format and losses of BC in post-partum are minimal and late; They express the moderate concentration of glucose (0.60g /l), elevated cholesterol (> 1.20 g / l) and low triglycerides (about 0.60 g / l). Great format Cows with early and significant loss of BC after calving. They express a poor reproductive performance with high triglycerides concentration (1.02 g / l) in the 1st month of lactation.

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