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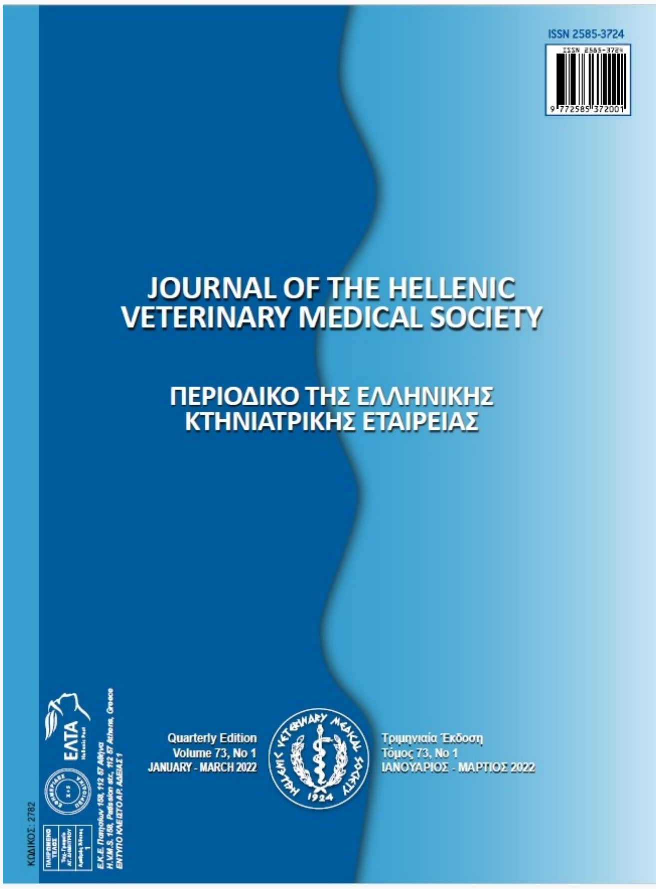

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Madjid AKKOU, Bouamra Mohamed, Soltani Fatiha

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Research article
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Effects of milk yield and quality at post-calving period on Algerians cows' reproductive performances

M. Bouamra[1], M. Akkou[2], F. Soltani[3]

[1] *Faculty of Sciences and Technology, Ain Temouchent University - Belhadj Bouchaib, Algeria*

[2] *Institute of Veterinary Science, University of Saad DAHLEB Blida, Algeria*

[3] *Faculty of Natural Sciences and Life, Abdelhamid Ibn Badis University, Mostaganem, Algeria*

ABSTRACT: This study was carried out to determine the association between milk production characteristics at the beginning of lactation (the first three month of lactation) and the performance of reproduction within dairy cows of Algeria. Data were collected from Holstein cows (n=920) that calved between October 2017 and October 2019. Reproductive parameters included in the study were: calving to first-service interval (CFSI, days), calving to conception interval (CCI, days), services per conception (SPC), and conception rate at first-service (CRFS %). The milk parameters retained in the present study were: peak milk yield, cumulative milk yield in the first 30 days (Milk30), 60 days (Milk60) and 100 days (Milk100) postpartum of the cows. The milk composition traits analyzed were milk fat concentration (MF %) and milk protein concentration (MP %). These variables were used to calculate fat to protein ratio (FPR) for each stage of lactation (stage 1: 15-30 days, stage 2: 45-60 days and stage 3: 75-90 days postpartum). Pearson's correlation analysis was used to determine the correlation between reproductive parameters and milk production variables.

The obtained results showed that peak milk yield, cumulative milk yield in the first 60 days (Milk60) and 100 days (Milk100) were significantly and positively ($P<0.05$) correlated with all the measured fertility parameters. Furthermore, fat to protein ratio (FPR) and milk fat content correlated significantly and positively ($P<0.05$) with CFSI, CCI and SPC in the first two stages. The correlation between milk protein content with CFSI, CCI and SPC were negative and significant in the all three stages. Further research is required to identify the cause of this association.

Keywords**:** Algeria, cows, milk quality, performance, reproduction.

Corresponding Authors:
Madjid Akkou, Institute of veterinary Science, University of Blida1, 09000, Blida, Algeria
E-mail address: akkoumadj@gmail.com, vetobouamra@yahoo.fr

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INTRODUCTION

Milk production and reproductive performance are two major determinants of dairy cows' profitability. While, genetic selection for milk yield has occurred, a reduction in fertility was observed. The question of possible antagonism between high milk production and reproductive performance was raised among the scientific researchers since long time. The relationship between fertility and milk production is often perceived, as a relatively current concern. Indeed, high reproductive efficiency is crucially important and has a high priority to maintain profitability in the dairy industry. The economic benefit in livestock is mainly associated with the reproduction of animals (Pryce et al., 2004). An efficient dairy production system should maximize the productivity of the individual by achieving the goal of one calve per cow per year. Effective reproduction results in optimal calving intervals, which, in turn, result in an optimal, milk production and calves per unit of time. In addition, low reproductive efficiency decreases herd gain by extending the calving interval, which results in less milk produced per cow and increasing replacement costs due to reproductive failure and veterinary charges. Therefore, well managing cows' fertility still a key element in ensuring the profitability and sustainability of the livestock.

After parturition, dairy cows in early postpartum period present a rapid increase in milk yield, nutritional requirements and a slow rise in dry matter intake. Most of them are unable to consume adequate quantity of feed needed for their milk production. As a result, cows enter the stage of negative energy balance (NEB) (Walsh et al., 2011). The severity and duration of the negative energy balance (NEB) may be influenced by genetic merit for milk yield and energy density or quantity of the feed offered (Buckley et al., 2003). According to Rossi et al. (2008), the extent of NEB is the main factor influencing the decline of reproductive efficiency in high-yielding dairy cows. The endocrine and metabolic signals associated with negative energy balance (NEB) signal to the reproductive tract, resulting in less regular estrous cycles and reduced embryo survival rates. Therefore, traits related to the extent and the duration of the postpartum negative NEB are of great interest as indicator traits to enhance improvement of reproductive performance. These important facts have to be elucidated in Algerian dairy herd in order to reduce the economic losses associated with non-professional farm management.

To estimate EB in early postpartum period, several traits have been associated with EB state and reproduction. Some authors put special attention to the rise in some metabolites and endocrine blood traits such as non-esterified fatty acids (NEFA) or beta hydroxyl butyrate (BHB) (Vanholder et al., 2005) ; body condition score (BCS) and milk composition (Friggens et al., 2007). In contrast to blood metabolites, which are invasive, difficult, and expensive to measure, milk composition data are easily available.

Recent research has demonstrated the potential of mid-infrared (MIR) analysis of milk to predict new phenotypes of interest such as milk composition; aptitude for transformation of milk and health status of cows. Because of its use by regular milk recording and milk payment systems to quantify the major milk components, MIR spectrometry is a rapid and cost-effective tool for recording phenotypes at the population level (De Marchi et al., 2014). Hence, MIR analysis of milk appears as a method of choice to provide indicators of fertility and EB that are collected routinely and that readily available. Furthermore, recent research has showed the importance of milk composition analysis for determining energy balance status and fertility in dairy cows (Buttchereit et al., 2010). These studies were conducted on Holstein dairy cows only. Despite, the well-known relationship between milk composition measures with fertility and EB Holstein cows, the expected beneficial effect of using these relationships as a management tool for evaluating the EB status and fertility of Holstein cows in Algeria is still unknown. Therefore, the objectives of this current study were to assess the reproductive performances of dairy cows in Algeria and their relationship with milk yield and milk composition in the first three months of lactation.

MATERIALS AND METHODS

Animals and management

The current study was performed from October 2017 to October 2019and included data from 920 purebred Holstein-Friesian dairy cows. Cows belong to eight commercial dairy herds located in the western of Algeria. An average lactation of the herd was 7600 kg of milk per 305 days and average parity of cows, included in the study was 2.8 (min.1-max. 4). The cows were kept in a free stall barn system and were feed with a mixed ration. Basic ration was composed of maize silage, grass and hay; lactating cows were supplemented with protein concentrate. All cows could access to food, water and salt lick *ad-libitum* during the whole year in the stall. The cows were examined during estrus period by visual observation using standing to be mounted as a sign of estrus, 30 min at least three times daily (in the morning, at noon, and in the late afternoon). Cows were inseminated artificially after detection of estrus by an experienced veterinarian, in accordance with the international am-pm rule following detection of estrus. After 60-70 days post artificial insemination, if cows did not return to estrus, an experienced veterinarian using rectal palpation performed a pregnancy diagnosis.

Measurement of fertility traits

Bi-monthly surveys were conducted in each farm to collect data related to milk production and reproductive events (calving, insemination, pregnancy diagnosis) of dairy cows. These latter, were recorded by the farm managers according to cow's identification number, dates of calving and inseminations. The collected records were used to calculate the reproductive parameters. Their productive performance was characterized by referring to the following intervals: calving to first-service interval (**CFSI**) which is the number of days between parturition and the subsequent first-artificial insemination; calving to conception interval (**CCI**), represented the number of days between parturition and the artificial insemination that resulted in a pregnancy; services per conception (**SPC**), which means the number of artificial in semination that a cow required to conceive during the current lactation and conception rate at first-service (**CRFS, %),** (number of cows pregnant after the first AI divided by number of cows inseminated ×100).

Milk yield, sample collection and analysis

Cows were milked twice daily (morning and evening) by milking machines and the quantity of milk yield was measured by classical methods and was recorded daily at each milking for the first 90 days postpartum for individual cows. The daily recorded quantity of milk yield was used to calculate the peak milk yield, cumulative milk yield in the first 30 days (Milk30), 60 days (Milk60) and 100 days (Milk100) postpartum of the cows.

To determine milk composition variables, 2760 milk samples were collected during the first three month of lactation. In the post-partum period, each cow was sampled three times respectively at the 1st stage [1: 15-30 days]; 2nd stage [45-60 days] and 3rd stage [75-90 days].The milk samples were transported immediately after collection to the laboratory and stored overnight at 4^{o}C for further analysis.

The milk composition analysis was carried by near infrared spectrophotometer Milko-Scan (Foss Electric, Denmark). The milk composition traits analyzed were milk fat concentration (MF %) and milk protein concentration (MP %). These variables were used to calculate fat to protein ratio (FPR) for each stage of lactation.

Statistical analysis

Statistical analyses were performed with SPSS software (Version 20.0). Pearson's correlation analysis was used to determine the correlation between reproductive parameters and the milk production variables. The results were considered significant when P<0.05.

RESULTS

Data related to the parameters of reproduction and milk yield recorded in 30, 60 and 100 days of lactation in the dairy herds are summarized in Table 1.

Table 1. Reproduction parameters and milk yield at 30, 60 and 100 days of lactation in Holstein-Friesiandairy herds of Algeria

Parameters	Mean±SD
Peak milk yield	24.3 ±2.12
Milk yield 30 days (kg)	660.02 ±35.1
Milk yield 60 days (kg)	1150.2 ±71.5
Milk yield 100 days (kg)	2030.2 ±131.5
CFSI (days)	132.4±54.4
CCI (days)	159.1± 49.5
SPC	1.85±1.17
CRFS (%)	59.1

CFSI: Calving to first service interval**; CCI:** Calving to conception interval; **SPC:** Services per conception; **CRFS**: Conception rate at first service

Data showing variation of milk composition for dairy herds according to the stages of postpartum period are summarized in Table 2.

Associations Between milk data records and reproductive outcomes

Correlation between reproduction parameters and milk data records are presented in Table 3.

Table 2. Milk composition characteristics at the post-partum period in Holstein's -Friesian's dairy farms of Algeria

Stage of lactation	Milk composition		
	Fat contents (%)	Protein contents (%)	Fat to protein ratio
1st [15-30 days]	4.68± 0.72	3.37 ± 0.39	1.41 ±0.36
2nd [45-60 days]	4.42±0.52	3.19± 0.28	1.39 ±0.33
3rd [75-90 days]	3.97 ± 0.41	3.31± 0.25	1.29± 0.27

Table 3. Correlation coefficients between reproduction parameters and milk composition records

Milk characteristics	Stages	Reproduction parameters			
		CFSI	CCI	SPC	CRFS
Protein content	1st [15-30 days]	-0.30**	-0.43**	-0.28*	0.35**
	2nd [45-60 days]	-0.49**	-0.48**	-0.34*	0.52*
	3rd [75-90 days]	-0.37*	-0.30*	-0.24*	0.44**
Fat content	1st [15-30 days]	0.33*	0.42*	0.31*	-0, 45*
	2nd [45-60 days]	0.27*	0.35*	0.26	-0.31*
	3rd [75-90 days]	0.23	0.28	0.10	0.15
Fat to protein ratio	1st [15-30 days]	0.39*	0.51**	0.11	- 0.43*
	2nd [45-60 days]	0.37*	0.36*	0.19	-0.29*
	3rd [75-90 days]	0.15	0.21	0.12	0.17
Milk yield	At 30 days [M30]	0.12	0.21	0.10	-0.15
	At 60 days [M60]	0.23*	0.29*	0.18	-0.27*
	At 100 days [M100]	0.35*	0.37*	0.17	-0.52**
	Peak of yield	0.45*	0.39*	0.29*	-0.28*

CFSI: Calving to first service interval**; CCI:** Calving to conception interval; **SPC:** Services per conception; **CRFS**: Conception rate at first service; *****= P<0.01, *=P<0.05,***

Milk yield and reproductive performance

Peak milk yield, cumulative milk yield in the first 60 days (Milk60) and 100 days (Milk100) were significantly ($P < 0.05$) correlated with all the measured fertility parameters. Conversely, cumulative milk yield in the first 30 days (Milk30) was not associated with fertility parameters.

The correlation coefficients between cumulative milk yield in the first 60 days (Milk60) and fertility parameters were 0.23, 0.29 and -0.27 for CFS, CCI and CRFS, respectively, while the correlation coefficients between cumulative milk yield in the first 100 days (Milk100) and fertility parameters for CFS, CCI and CRFS were 0.35, 0.37 and -52, respectively. Furthermore, the correlation coefficients between peak milk yield and CFS, CCI, CRFS were 0.45, 0.39 and -0.28, respectively.

Milk protein and reproductive performance

This study identified significant associations between early-lactation milk composition and subsequent fertility performance. Correlation coefficients between fertility traits and milk protein content was low in the first stage [15-30 days postpartum] and the third stage[75-90 days postpartum]. However, in the second stage[45-60 days postpartum], milk protein content was strongly and significantly, (P<0.05-0.01) correlated with all the fertility traits measured; calving to first service interval (CFSI), calving to conception interval (CCI), services per conception (SPC) and conception rate at first service (CRFS).

The correlation coefficients between milk protein concentration and calving first service interval were -0.30, 0.49 and -0.37 for first, second and third stages of lactation, respectively, while the correlation coefficients between milk protein concentration and CCI in first, second and third stage of lactation were -0.43, -0.48and -0.30, respectively. The strong relationship between the number of SPC and conception rate at first service with milkprotein concentration observed in stage 2 whose correlation coefficient was respectively -0.34 and 0.52.

Milk fat and reproductive performance

The strong relationship between calving to first service interval (CFSI), calving to conception interval (CCI), services per conception (SPC) and conception rate at first service (CRFS) with milk fat content was found in first stage. The correlation coefficients were respectively 0.33, 0.42, 0.31 and -0.45.

Fat to protein ratio and reproductive performance

The correlation coefficients magnitude between fertility parameters and fat to protein ratio was strong in first and second stage; except for service per conception (SPC) which was not significantly correlated with fat to protein ratio. Furthermore, in the third stage, fat to protein ratio was not significantly correlated with all fertility parameters.

DISCUSSION

This study was carried out to determine the association between milk production characteristics in the first three month of lactation and the performance of reproduction within dairy cows of Algeria. A negative correlation between the amounts of milk produced and the fertility of cows was observed in our survey. Similar results were reported by Walsh et al. (2011). This result might be related to the fact that higher milk production increased the difference between feed intake and dairy potential in early lactation stage, making cows genetically predisposed to a higher risk of negative energy balance (Patton et *al*. 2006).Dairy cows may present an energy deficiency situation at the post-partum period; as their low ingestion capacity does not cover the high energy requirements for milk production (Wathes et al., 2012). The deficit of energy could contribute to a decrease in fertility. This latter has particular consequences on the expression and duration of heat. Other studies have also shown that energy deficiency induced a decrease in the frequency of LH (luteinizing hormone) pulses and the development of ovarian insensitivity to LH (Walsh et al., 2011). Butler (2001) reported that high milk production in the first weeks of cows' lactation (between 20 and 180 days according to the studies) may decrease the ovulation frequency of the first dominant follicle, the frequency of LH peaks and thus delay the first ovulation. It also increases the predisposition for developing ovarian cysts and associated dysfunctions (Vanholder et al., 2006). Disenhauset al. (2002) observed a higher rate of abnormal cyclicity profiles within large dairy production in the first three weeks postpartum.

The most important findings from this study were that, early lactation milk protein concentration and reproductive performance was negatively associated. Our results were similar to other studies in which a positive association between milk protein concentrations and conception rate at first service were reported in early lactation (Alphonsus et al., 2014; Morton et al., 2016; Morton et al., 2017; Morton et al., 2018; Carty et al., 2020).The highest association ($P<0.01$) between protein concentration and the conception rate at first service was observed in the 3rd stage [75-90 days]. Catherine et al. (2020) showed a high probability of pregnancy in cows with high protein concentration in milk from 61 to 90 DIM. Cook and Green (2016) showed a positive relationship between probability of conception by 100 and 150 DIM and milk protein concentration at both first [0-30 days] and second [31-60] test days.

Douglas et al. (2016) showed that cows with high milk protein concentration have plasma profiles of selected metabolites and hormones that indicate greater partitioning of nutrients to physiological processes other than milk synthesis at the benefit of body condition. Morton et al. (2018) attributed the positive phenotypic associations between milk protein concentration and reproductive performance traits to factors affecting both milk protein concentration and reproductive performance. This relationship has been attributed to energy balance during early lactation (Madouasse et al., 2010; Alphonsus et al., 2014). In our study, the tested samples of milk showed content in proteins varying from 3.19 to 3.37. Negative energy balance has been associated with reduced reproductive performance, and milk protein concentration in early lactation is higher in cows with less negative energy balance (Patton et al., 2007). Buckley et al. (2003) and Patton et al. (2007) concluded that milk protein percentage in early lactation is a good indicator of a cow's energy balance and reproductive performance in dairy cows during this period. It is influenced by the level of energy supply to cows (Eicher, 2004). The energy balance of cows is only very weakly related to protein intakes. Only the essential amino acids (mainly methionine and lysine) digestible in the intestine (protected from digestion in the rumen) can have a positive effect on milk protein concentration. This latter is higher in the first week and decreases to its lowest level at the peak lactation. Further studies are needed by determining the content of methionine and lysine in milk of caws at the post-partum.

Most severe and prolonged NEB were observed in cows producing milk with lowest protein content (2.89%) (Fulkerson et al., 2001). Furthermore, milk protein content was positively associated with submission rate, pregnancy rate to first service, and pregnancy rate after 21 days breeding in a large field study (Morton, 2016). In line with findings, Madouasse et al. (2010) stated that cows with low milk protein content in the second month of lactation were less likely to be pregnant within 145 days of calving.

The milk fat of the first milk control is crucial because it allows quantifying somewhat the negative energy balance, which prevails at the very beginning of the lactation. In the present study, milk fat was decreased from 4.68 at the first stage to 3.97 at the third stage. The milk fat of the first milk control reflects the intensity of themobilization of reserve fats at the beginning of lactation. Kristula et al. (1995) demonstrated that Holstein cows with a milk fat > 45 g/L at the first dairy control subsequently had a significantly lower initial insemination rate than cows with lower milk fat. Milk fat concentration was positively associated with hazard of pregnancy in stage 1 (0-30 DIM). Other studies have identified higher fat concentrations in early lactation (<30 DIM) as negatively associated with subsequent fertility (Madouasse et al., 2010; Cook and Green, 2016). Cook and Green (2016) identified a negative association between milk fat percentage in the first 30 days in milk (DIM) with the probability of pregnancy at 100 DIM but not at 150 DIM. It suggests that the use of fat concentration to predict reproductive performance may be limited and that early lactation changes in fat concentration may be indicative of energy balance troubles. The higher mobilization of fat at the beginning of lactation may induce ketosis, which could be suspected indirectly through milk/protein ratio.

Our results, showed a significant relationship between the FPR ration in milk samples and CFSI, CCI and CRFS in the 60 days post-partum. In line with our findings, Podpecan et al. (2008), Löf et al. (2014) showed significant correlations between FPR and fertility. The fat to protein ratio is a calculated indicator of the nutritional status of dairy cows. It can be used to evaluate the energy balance and the level of the mobilization of reserve fats, especially at the beginning of lactation, a negative correlation between the fat to protein ratio and the energy balance. This relationship is stronger at the beginning than at mid-lactation (Buttchereit et al., 2010; Toni et al., 2011).

In the present study, fat to protein ratio decreased from 1.41 at the first stage to 1.29 at the third stage. In the case of an energy deficiency, the fat to protein ratio increased significantly. The maximum threshold value is set at 1.5 (Buttchereit et al., 2010; Toni et al., 2011). High fat to protein ratios in early lactation were associated with decreased reproductive performance, either by decreasing fertility or an extension of postpartum anestrus due to excessive loss of an increase in the rate of reform for infertility (Podpecan et al., 2008; Löf et al., 2014).

No relationship between FPR and fertility parameters was observed at the third stage [75-90 days] of lactation in post-partum. Dubois et al. (2006) indicated that cows with a fat to protein ratio >1.5 at the first postpartum control have a high incidence of cyclicity abnormalities (39.4%), compared to cows with <1.5 (25%), an increased risk of ovarian cyst, a lower conception rate at the first artificial insemination, delayed calving to conception interval and induce multiple services per conception.

CONCLUSION

Our study identified several associations between reproduction performance and milk protein concentration, milk fat and milk yield. In fact, high milk production decreases reproductive performance and higher milk protein concentration is associated with shorter calving to first service and calving to conception intervals. Furthermore, milk high fat concentration increased the number of days for conception. These results suggest that milk composition at early stage of lactation is likely to predict reproductive performance.It seems appropriate to carry outsimilar studies in other provinces of Algeriato better understand the association between reproductive performance and milk quality.

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CONFLICT OF INTEREST

None declared.

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