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Seasonal Variations and Animal Related Factors Affecting Milk Traits in Hosstein -Friesian Dairy Cattle Under Subtropical Egyption Condition.

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ABSTRACT

dataset comprising 1434 lactation records from 700 Holstein-Friesian dairy cows on a private farm located in Wadi El-Natroun Road, Beheira Governorate, Egypt, was gathered between 2012 and 2020 to evaluate the effect of calving season and various animal-related factors, including parity order, days open, age at first calving, calving interval, calving season, and dry period on milk production. The overall average along with standard deviations for days in milk (DIM), total milk yield (TMY), and peak yield (PY) were calculated at 368.96±97.99 days, 12521.00±3142.67 kg, and 53.81±16.90 kg, respectively. The study revealed that TMY, DIM, and PY reached their peaks during the spring season and were lowest during the summer. Notably, both TMY and DIM showed a significant increase up to the 5th and 6th parities, while the lowest peak yield was observed in the 5th parity group. Calving interval emerged as another crucial factor influencing milk production, with the aforementioned milk traits being notably higher in cows with a calving interval of 12 months or more compared to those with intervals less than 12 months. Furthermore, an increase in days open and dry period was associated with a significant rise in milk production, particularly in cows with days open and dry periods exceeding 110 days and 60 days, respectively. TMY and DIM were significantly higher in cows with an age at first calving below 30 months compared to those calving at older ages. In conclusion, the calving season and animal-related factors, including parity order, days open, age at first calving, calving interval, calving season, and dry period, play a substantial role in influencing milk production traits in Holstein-Friesian dairy cows. Therefore, emphasizing good management practices is crucial for optimizing production performance of this breed in subtropical Egyptian conditions.

INTRODUCTION

Cows play a vital role in global dairy production, significantly contributing to milk output (Khan, 2020). The performance of dairy cows, especially in terms of milk production and fertility, is crucial for farm profitability (Dash et al., 2018). Among dairy cattle breeds, the Holstein-Friesian stands out as a widely used breed globally due to its high milk production capacity and its adaptability to hot climates (Ojango et al., 2005). In Egypt, the cow population is steadily rising and was recently estimated at around 4.95 million, playing a significant role in the country's red meat production (1.04 million tons) and total milk production (5.90 million tons) (FAO, 2015). Several studies have emphasized the significant influence of the dairy production sector on milk yield (MY) (Rehman et al., 2008; Petrović et al., 2015), which may be affected by variations in management practices (Hadad, 2020). Moreover, days in milk (DIM) can serve as a relevant metric of interest (Wondifraw et al., 2013). Lactation length is defined as the period between two consecutive calvings during which cows produce milk, notably affects total milk yield (Abdel Rahman and Alemam, 2008). Seasonal changes and animal-related factors such as parity order, dry period, days open, age at first calving, and calving interval have been identified as significant determinants impacting milk production traits in dairy cattle (Ratwan et al., 2017). Over the past thirty years, there has been a noticeable rise in milk yield per lactation, while health, fertility, and productive lifespan have shown a decline (Mirhabibi et al., 2018). To enhance the productivity and profitability of dairy cows, it is imperative to examine various variables that influence animal performance and farm economics.

The objective of this study was to assess the impact of environmental factors, together with animal related factors, including parity order, days open, age at first calving, calving interval, calving season, and dry period, on the productivity of Holstein-Friesian dairy cattle under subtropical Egyptian conditions.

MATERIALS AND METHODS:

Study period and location:

A dataset consisting of 1434 lactation records from 700 Holstein-Friesian dairy cows on a private farm along Wadi El-Natroun Road, Beheira Governorate, Egypt, was compiled between 2012 and 2020. Lactation records included total milk yield, lactation period, peak yield, parity order, days open, age at first calving, calving interval, calving season, and dry period.

Animals and management:

The cows were housed in open sheds and fed Total Mixed Ration (TMR) throughout the year, adhering to the National Research Council (NRC) guidelines. Heifers were inseminated within a specific age and weight range (350-375 kg), while cows were inseminated after the 45th day post-partum. Pregnancy was confirmed through rectal examination, and veterinary supervision ensured vaccinations and medical care. Cows were machine milked twice daily until two months before expected calving.

Data classification:

The dataset was categorized to assess the productive efficiency of Holstein Friesian dairy cows. Days open (DO) was divided into DO1 (≤90 days), DO2 (90-110 days), and DO3 (>110 days). Calving interval (CI) was categorized as CI (<12 months) and CI (≥12 months). Dry period (DP) was segmented into DP1 (<45 days), DP2 (45-60 days), and DP3 (>60 days). Age at first calving (AFC) was classified as AFC1 (<30 months), AFC2 (30-60 months), and AFC3 (>60 months).

Statistical analysis:

Data editing was performed using Microsoft Excel version 16, with a Shapiro-Wilk test confirming data normality for fitting the analytical model (Razali and Wah, 2011). Data points with residual standard deviations (SD) exceeding 3.5 or falling below -3.5 SD were excluded from the analysis (Tramonte et al., 2019). The PROC GLM procedure in the Statistical Analysis System (SAS, 2012) was utilized to analyze Least-squares means (LSM) and standard errors (SE) for each fixed effect level, with differences between means detected using Duncan's Multiple Range Test. The following model was used:

$$Y_{ijklmno}=\mu+DO_i+CI_j+AFC_k+DP_l+P_m+SE_n+e_{ijklmn}$$

Here,

$Y_{ijklmno}$= Individual observation,

μ = Overall mean,

DOi = Fixed effect of the ith days open (<90 days, 90-110 days, and >110)

CIj = Fixed effect of the j th calving interval (<12 months and >12 months)

AFCK= Fixed effect of the kth age at first calving (<30 months, 30-60 months, and >60 months),

DPl= Fixed effect of the lth dry period (<45 days, 45-60 days, and >60 days)

Pm= Fixed effect of the mth parity (1, 2…….and 7),

SEn= Fixed effect of the nth calving season (spring, summer, winter, and autumn).

$e_{ijklmno}$= Random error.

RESULTS AND DISCUSSION:

Descriptive statistics:

Descriptive statistics of studied traits are presented in Table 1.In this study, the overall average along with standard deviations of days in milk, total milk yield, and peak yield stood at 368.96±97.99 days, 12521.00±3142.67 kg, and 53.81±16.90 kg, respectively. Notably, the higher coefficient of variation values for the traits under study (ranging from 25.10% to 31.41%, as shown in Table 1) signify significant variability among individuals in these crucial production traits.

Table 1: Descriptive statistics for milk traits in Holstein-Friesian dairy cattle

Parameters	DIM	TMY	PY
Mean	368.96	12521.00	53.81
S.D.	97.99	3142.67	16.90
Min	139.00	2905.00	17.00
Max	840.00	27381.00	134.10
CV (%)	26.56	25.10	31.41

DIM, days in milk; TMY, total milk yield; PY, peak yield.

Seasonal variations:

This study underscores the significant impact of calving season on milk traits such as total milk yield, lactation period, and peak yield ($p<0.0001$; Figure 1), with peak yields and days in milk typically observed during the spring season and lower yields and days in milk during the summer season, which could be attributed to cows being housed in open barns without solid walls, leading to minimal isolation from external climatic conditions like temperature and humidity. The present results were in alignment with previous findings by Penev et al. (2014) and Stojnov et al. (2024). Elevated daytime temperatures during summer, coupled with inadequate cooling measures for dairy cows, notably affect milk yield, as highlighted by Hempel et al. (2019). Ravagnolo and Miztal (2000) further note that high summer temperatures coincide with the lactation peak, making cows more susceptible to heat stress, especially at the beginning of lactation. High-producing cows are particularly sensitive to heat, with significant milk yield reductions observed when body temperatures exceed 39°C, as reported by Kadzere et al. (2002). In contrast; Mohamed et al. (2017) found non-significant variations in milk yield between winter and summer for Holstein and Brown Swiss cows in Egypt, other studies like Baset et al. (2012) and Shibru et al. (2019) have reported contrasting effects of season on lactation milk yield. The influence of season on lactation length has shown varying results across different studies, with Maximillan et al. (2020) highlighting the significant impact of the calving season on lactation length in Ankole breed cows in Rwanda, showing how environmental factors like humidity and rainfall can accelerate or hinder production performance in indigenous dairy cows.

Parity order

The results presented in Figure 2 highlight the least square means of total milk yield, days in milk, and peak yield as influenced by the parity number. Notably, there was a significant increase in both total milk yield and days in milk up to the 5th and 6th parities, after which a decline was observed. In terms of days in milk, cows in the 5th and 6th parities demonstrated the longest duration, significantly surpassing those in other parities. Conversely, the lowest peak yield was observed in 5th parities.

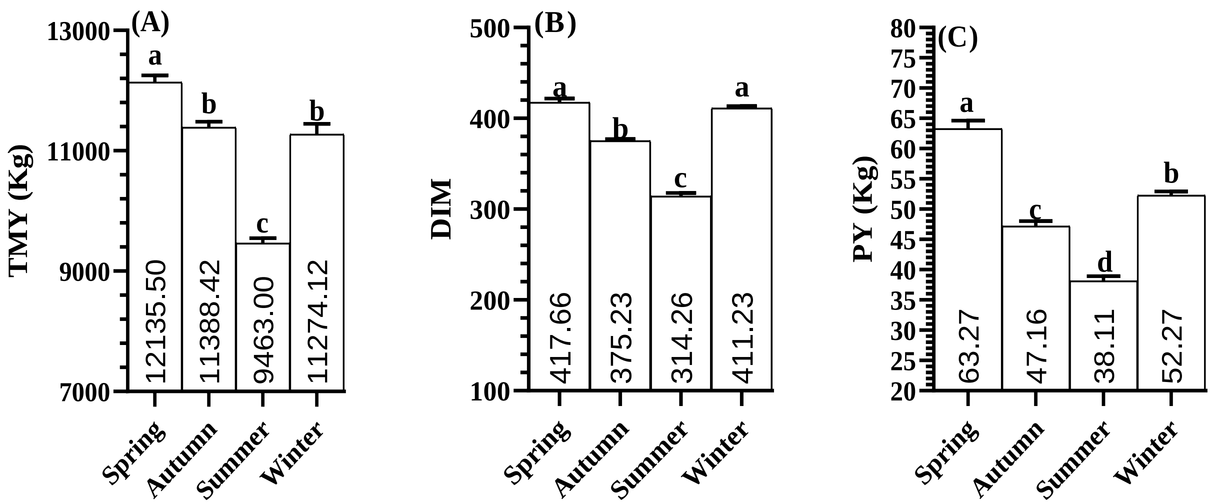

Figure 1: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to calving season

In this study, it is observed that the quantity of milk produced by the cow escalates with progressing lactations (age), possibly attributed to an augmentation in body weight. This increase in body weight leads to the development of a larger digestive system and an expanded mammary gland for milk secretion. Furthermore, the heightened milk production with age can also be ascribed to the impacts of successive pregnancies and lactation cycles. An alternative interpretation of the present results suggests that the udder reaches full physiological development in cows with higher parity compared to those with lower parity. Higher parity cows experience reduced competition for feed, which, along with their increased feed intake compared to younger cows, could explain the observed differences in milk production (Johnson et al., 2002). Cows at parity 6 might have enhanced milk production by having a greater number of newly formed active secretory cells. The current findings align with server researchers highlighted a substantial rise in milk yield and days in milk as parity order increased (Hatungumukama et al., 2007; Badri et al., 2011; Yilmaz and Koc, 2013; Al-Samarai et al., 2015; Gamaniel et al., 2019). Moreover, Chisowa (2023) indicated that repeated pregnancies and lactation cycles could lead to a 30% rise in milk production from the first to the fifth lactation, with 80% of this increment attributed to recurring pregnancies and lactations, and the remaining 20% attributed to improved body weight. In same context, Abd-El Hamed et al. (2020) observed significant variations in daily milk yield and 305-day milk yield across different parity levels and sectors. In the private sector, the third parity cows exhibited the highest values, whereas in the governmental sector, the sixth parity cows showed the lowest values. This disparity could be linked to the gradual increase in cow weight over time, udder tissue development, and the typical pattern of milk yield peaking around the age of 6 years before gradually declining, as noted by Çardak (2016), aligning with our study's findings.

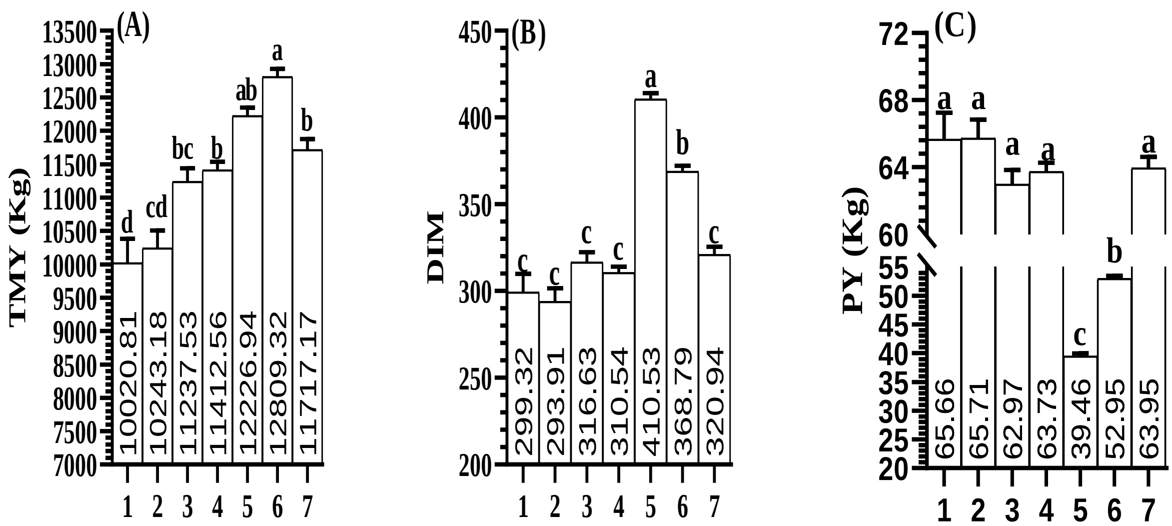

Figure 2: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to parity order

Calving interval

Results in Figure 3 indicated that the calving interval significantly affected total milk yield, days in milk, and peak yield ($p<0.001$), being significantly higher in cows with calving interval more than or equal to 12 months than their counterparts with calving interval lower than 12 months. The present results corresponded with the findings of Baul et al. (2013) showed significant increase in cow persistency of milk lactation with increasing calving interval. Also, Abo-Gamil et al. (2021) reported significant increase in milk yield with increasing calving interval, maximizing in cows with intervals more than 15 months.

Dairy cows that maintain a calving interval of at least 14 months exhibit higher milk yields during their initial lactations and enjoy extended productive lives compared to those re-calving more frequently. The extended interval between calvings allows these animals more time to recuperate body reserves post the first calving, thereby mitigating risks associated with the subsequent pregnancy (Stangaferro et al., 2018). Moreover, research by Lehmann et al. (2019) highlights that a shorter calving interval notably reduces the milk yield of first-parity cows in comparison to second-parity cows, emphasizing the advantage of expediting cows into their second lactation. These findings are consistent with studies conducted in Denmark (Lehmann et al., 2019) and the Netherlands (Burgers et al., 2019), supporting the positive relationship between milk yield and calving interval in the current study outcomes.

Cows exhibiting a mean calving interval exceeding 471 days achieved the highest milk yield (8481 kg) and fat yield (355 kg). In contrast, cows with intervals shorter than 382 days showcased the highest fat content (4.30%) and greatest protein yield (424 kg). Notably, cows with calving intervals ranging from 383 to 470 days attained the highest protein content (3.42%) (Czerniawska-Piątkowska, 2017).

Furthermore, Bortacki et al. (2016) explored the impact of interval length on milk yield in individual lactations, revealing that cows in their second and third lactations yielded the highest averages of 11493.38 kg and 11401.33 kg, respectively, with intervals exceeding 401 days (Czerniawska-Piątkowska, 2017).

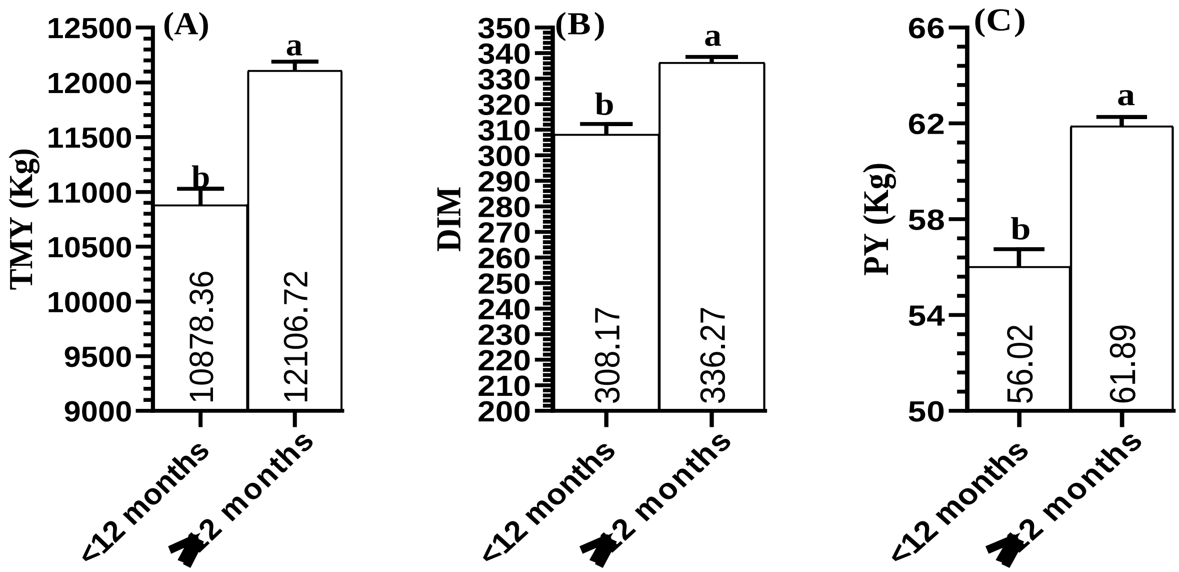

Figure 3: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to calving interval

Days open:

Days open showed highly significant effects on total milk yield, lactation length m and peak yield (Figure 4). Generally the least square means of total milk yield and days in milk were significantly increased with increasing cow days open. However, the maximum value of least square mean for peak yield was observed in cows with days open varied between 90 and 110 days compared to their counterparts with days open less than 90 days and those more than 110 days. The present results corresponded with the results of Toledo-Alvarado et al. (2021) and Nan et al. (2023) noted significant effects of days open on whole milk yield in Brown Swiss and Holstein cattle. Furthermore, Lee et al. (2018) established a significant correlation between days open (indicating pregnancy status) and the 305-day milk yield. Their findings revealed that even a minor alteration in days open (less than 10 days) had a noteworthy impact on milk production. However, they highlighted a crucial point that day open alone might not provide an accurate assessment of the pregnancy effect due to a potential bias of up to 70% caused by the likelihood of higher-yielding cows having longer days open. After adjusting for the influence of early lactation milk yield (within the first 100 days), Lee et al. (2018) still observed that pregnant cows produced 265 kg less milk, 9.8 kg less fat, and 9.2 kg less protein compared to nonpregnant cows over the span of 305 days. The reduced milk production observed in cows with shorter open periods may be attributed to the decrease in milk yield during pregnancy, especially post the 4th or 5th month of gestation. During this stage, a substantial portion of nutrients in the cow's bloodstream is directed towards supporting the growth and well-being of the developing fetus (Brotherstone et al., 2004; Leclerc et al., 2008; Bohmanova et al., 2009).

Typically, extremely short or long service periods lead to correspondingly brief or extended lactations, influenced in part by the varying intensity of milk secretion throughout the days of lactation. When aiming for lactation duration closest to 305 days for economic or breeding purposes, decisions can be influenced by managing both days open and lactation duration. However, it is important to note that both these factors are significantly influenced by non-genetic factors, making them primarily management-related aspects (Peeva, 2000; Aziz et al., 2001; Khan et al., 2007).

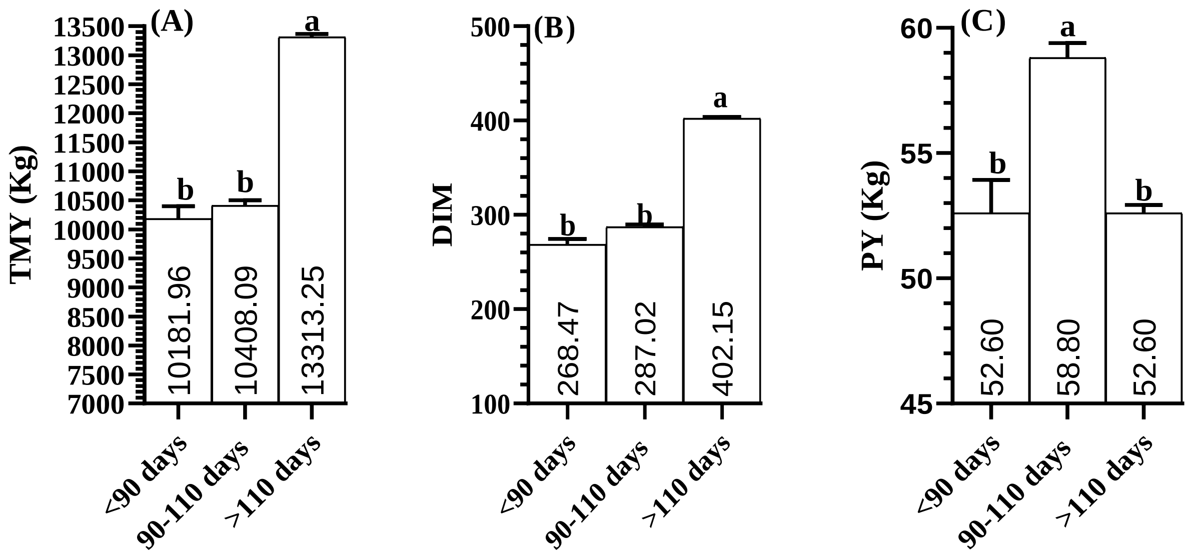

Figure 4: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to days open

Dry period:

The dry Period exhibited significant impacts on total milk yield, lactation length, while no significant effect was observed on peak yield (Figure 5). The least square means of total milk yield and days in milk notably increased with longer dry periods, peaking in cows with dry periods exceeding 60 days compared to those with fewer than 45 days open or those ranging between 45 and 60 days. These findings align with Lim et al.'s (2022) research, which highlighted the substantial impact of the dry period on total milk yield, showing that as the dry period increased, total milk yield also increased significantly. Numerous studies have demonstrated that milk yield decreased notably in cows with a 0-day dry period compared to those with a 60-day dry period. The milk yield reduction in cows with a 0-day dry period led to an 11% decrease over 10 weeks (Rastani et al., 2005) or a 15.5% decrease until 14 weeks (van Knegsel et al., 2014) in the subsequent lactation compared to cows with a short dry period.

In same context, previous studies have shown that cows managed for a dry period of less than 40 days experienced lower milk production in the following lactation compared to those managed for a 60-day dry period (Sørensen and Enevoldsen, 1991; Rastani et al., 2005). The diminished cell turnover and secretory capacity of mammary epithelial cells have been cited as reasons for this reduction in cattle (Annen et al., 2004). However, the extent of this reduction varies not only among individual animals but also across different herds (Santschi et al., 2011; Safa et al., 2013), indicating the presence of interactions among management practices, animal health, and physiology. For example, instances like abortion initiating a new lactation, leading to an unplanned short dry period; can negatively impact lactation productivity (Keshavarzi et al., 2020).

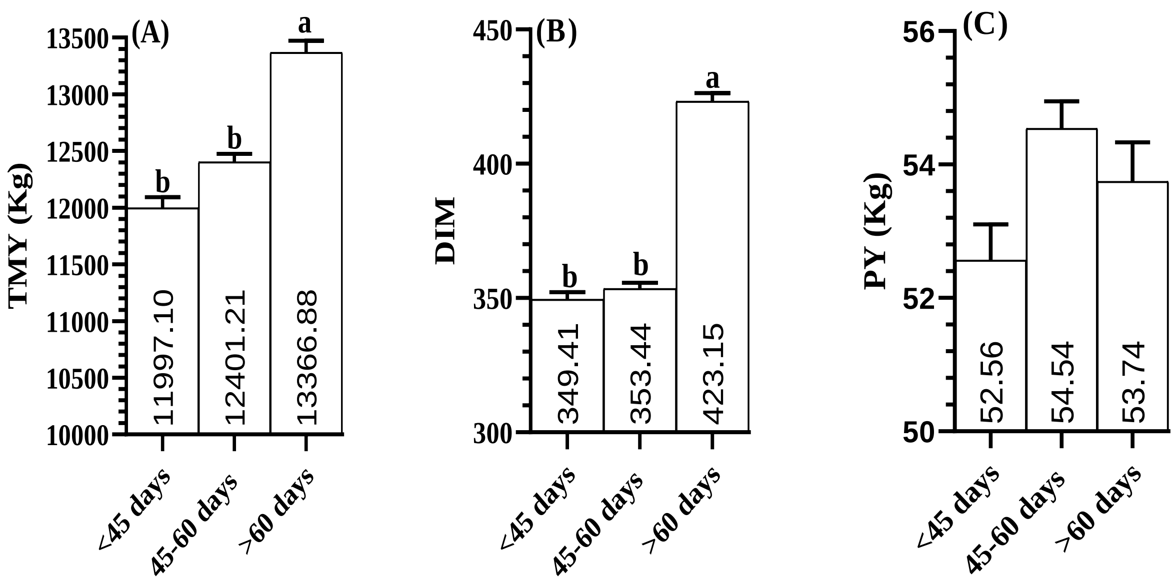

Figure 5: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to dry period

Age at first calving:

The age at first calving plays a crucial role in determining total milk yield, lactation length, and peak yield, as detailed in Figure 6. Notably, the total milk yield and days in milk decreased significantly as the age at first calving increased, with cows calving after 60 months showing lower yields compared to those calving earlier. Non-significant differences were observed between cows with age at first calving <30 months and those more than 60 months for peak yield. Linear regression analysis in Table 11 supported these findings, indicating a decrease in total milk yield and days in milk as age at first calving increased, while peak yield showed an increase with each additional day at calving age.

These results align with Nilforooshan and Edriss (2004), who highlighted the significant relationship between age at first calving and milk production. Froidmont et al. (2013) observed that increasing the age at first calving decreased milk yield and lactation period in Holstein cows. They noted that cows calving between 22 and 26 months had more productive days, higher milk production in the first and second lactations, and increased lifetime milk production.

Given the optimal age at first calving for milk yield is 24 months, delaying calving is deemed cost-ineffective. It is recommended that heifers calve between 23 and 25 months, preferably at 24 months. Pirlo et al. (2000) found that reducing age at first calving to under 26 months had a positive impact on the difference between milk yield returns and rearing costs. Furthermore, reducing age at first calving to 23 or 24 months proved more profitable than aiming for 22 months, with the most favorable range being between 23 and 24 months (Nilforooshan and Edriss, 2004). The study results suggest that the maximum milk yield is achieved when the age at first calving is less than 30 months, in line with the optimal AFC range of 24-30 months observed in the study by Haworth et al. (2008).

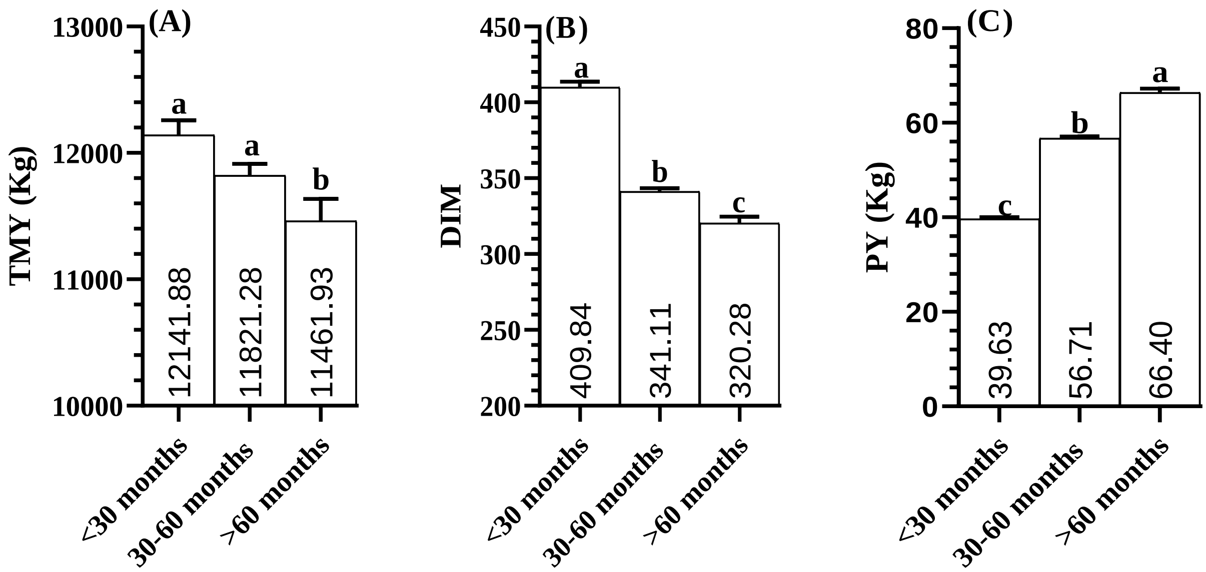

Figure 6: Changes in total milk yield (TMY; A), days in milk (DMI; B), and peak yield (PY; C) as response to age at first calving

Conclusion:

The timing of calving and various factors related to the animals, such as parity order, days open, age at first calving, calving interval, calving season, and dry period, significantly impact the milk production characteristics of Holstein-Friesian dairy cows. Thus, prioritizing effective management practices is essential to enhance the production performance of this breed under subtropical Egyptian conditions.

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الملخص العربى

التغيرات الموسمية والعوامل المرتبطة بالحيوان التي تؤثر على صفات اللبن في أبقار الهولشتاين فريزيان الحلابة في ظل الظروف شبه الاستوائية المصرية

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تم الحصول علي مجموعة من السجلات تضم 1434 سجل انتاج من 700 بقرة من سلالة ابقار الهولشتاين فريزيان الحلابة في مزرعة خاصة تقع في طريق وادي النطرون بمحافظة البحيرة في مصر. بين عامي 2012 و 2020 لدراسة تأثير بعض العوامل المتعلقة بتلك الابقار علي انتاج اللبن الخاص بها، بما في ذلك ترتيب مواسم الولادات والفترة المفتوحة والعمر عند اول ولادة والفترة بين ولادتين وموسم الولادة وفترة الجفاف. ثم بعد ذلك تم حساب المتوسط الإجمالي جنبًا إلى جنب مع الانحرافات المعيارية لعدد ايام الحليب (DIM) وإجمالي إنتاج اللبن (TMY) واعلي انتاج (PY) عند 368.96 ± 97.99 يومًا و 12521.00 ± 3142.67 كجم و 53.81 ± 16.90 كجم على التوالي.

كشفت الدراسة أن اجمالي انتاج اللبن (TMY) وعدد ايام الحليب (DIM) واعلي انتاجية (PY) وصلت إليها تلك الابقار خلال فصل الربيع وكانت في أقل مستوي انتاجي لها خلال فصل الصيف. ويلاحظ أن كل من اجمالي الانتاج (TMY) وعدد ايام الحليب (DIM) قد أظهرا زيادة كبيرة في موسم الولادات الخامس والسادس، في حين ان اقل إنتاجية كانت في مجموعة مواسم الولادات الخامسة. وظهرت الفترة بين ولادتين كعامل مؤثر آخر يؤثر على إنتاج اللبن، حيث كانت صفات اللبن المذكورة أعلاه اكبر بشكل ملحوظ في الأبقار ذات الفترة بين ولادتين 12 شهرًا أو أكثر مقارنة بتلك التي تقل فيها عن 12 شهرًا. وايضا ارتبطت الزيادة في الفترة المفتوحة وفترة الجفاف بارتفاع كبير في إنتاج اللبن، وخاصة في الأبقار ذات الفترة المفتوحة وفترة الجفاف التي تتجاوز 110 أيام و60 يومًا على التوالي. وكان اجمالي الانتاج (TMY) وعدد ايام الحليب (DIM) مرتفع بشكل ملحوظ في الأبقار التي يقل عمرها عند الولادة الأولى عن 30 شهرًا مقارنة بتلك التي تلد في أعمار أكبر. وفي المجمل، يلعب موسم الولادة والعوامل المتعلقة بالحيوان، بما في ذلك ترتيب مواسم الولادات والفترة المفتوحة والعمر عند اول ولادة وموسم الولادة وفترة الجفاف، دورًا كبيرًا في التأثير على صفات إنتاج اللبن في أبقار الهولشتاين فريزيان الحلابة. لذلك، فإن التأكيد على ممارسات الإدارة الجيدة لتلك الابقار من هذه السلالة أمر بالغ الأهمية لتحسين الأداء الإنتاجي لها السلالة في ظل الظروف المصرية شبه الاستوائية.