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RESEARCH PAPER

Genetic and environmental factors affecting 305-day mature equivalent milk yield of Holstein Friesian cows in the United Arab Emirates

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العوامل الوراثية والبيئية التي تؤثر على إنتاجية الحليب من أبقار الهولستاين فريزيان في دولة الإمارات العربية المتحدة

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ABSTRACT. The main objective of this research was determining the effect of sire of cow, year and season of freshening, lactation number, and their different interactions on 305-day mature equivalent *(ME)* milk yield of *Holstein Friesian* cows in the United Arab Emirates (UAE). It also aimed to estimate sire and error variance and heritability of 305-day *ME* milk yield. The data was collected from AL Salamat Dairy Farm in Al Ain. The average size of the herd was 1000 animals during the experimental period. *The Dairy Comp 305* computer program was used for compiling the data. The data under the study covered the years 2004 to 2007. The climatic temperature during the summer (April to September) varied from moderate to very hot. The winter (October to March) had lower temperature and higher relative humidity than the summer. All the effects were fixed except for random sire and residual error term. The overall least-square mean of the 305-day *ME* milk yield was 11060±355 kg/305 days. The data showed a significant effect of sire of cow ($p\leq0.001$), year of freshening ($p\leq0.001$), lactation number ($p\leq0.01$), year x season of freshening ($p\leq0.01$), and year of freshening x lactation number ($p\leq0.001$) on milk yield. However, the effect of season of freshening showed non significant effect. No significant seasonal differences were found in 2004. However, in the year 2005 and 2006, the summer fresheners had significantly higher yield than those of the winter season. The 305-day *ME* pertaining to summer *vs.* winter were 11691±400 kg *vs.* 11483±410 kg and 11522±369 kg *vs.* 11041±374 kg for the year 2005 and 2006, respectively. However, the reverse was true in 2007 with the fresheners during summer that have lower 305-day *ME* (10286±372kg) than those freshening during winter (10672±388 kg). The differences among the three lactations were relatively high in 2004 (9837 to 12116 kg), compared to 2005 - 2006 (11267 to 11747 kg) and 2007 (9853 to 11355 kg). The heritability of 305-day *ME* was 0.31 indicating that a significant response to selection would be achieved through a well-designed progeny testing and cow evaluation program.

المستخلص: كان الهدف الأول من هذا البحث هو دراسة تأثير الأب وسنة الإنتاج وموسم الإنتاج ورقم الولادة والعلاقة فيما بين هذه العوامل على الإنتاجية السنوية للحليب (إنتاج الحليب المعدل لتر٣٠٥ يوم) في أبقار الهولستاين فريزيان بدولة الإمارات العربية المتحدة. أما الهدف الثاني فكان حساب معامل التوريث بعد تحديد مقدار التباين للأب وللخطأ العشوائي. تم جمع بيانات هذا البحث من مزرعة سيح السلامات في مدينة العين بدولة الإمارات العربية المتحدة. كان متوسط حجم القطيع خلال سنوات الدراسة (٢٠٠٤-٢٠٠٧م) هو ١٠٠٠ رأس من الأبقار. تم إستخدام برنامج الديري كومب (٢٠٠٠) لتجميع هذه البيانات وتحريرها. تباينت درجات الحرارة خلال فترة الصيف (أبريل إلى سبتمبر) من متوسطة إلى عالية مع درجات رطوبة عالية أيضاً. وفي فترة الشتاء (أكتوبر إلى مارس) تنخفض درجات الحرارة وتزيد الرطوبة النسبية بدرجة كبيرة مقارنة بفصل الصيف. تم إستخدام برنامج هارفي للمربعات الصغرى والإحتمالات الكبري للتحليل الإحصائي. حوت المعادلة الإحصائية لتحليل إنتاجية الحليب على أب البقرة ورقم الولادة وسنة الإنتاج وموسم الإنتاج والتفاعل بين سنة الإنتاج وموسم الإنتاج كان بين سنة الإنتاج ورقم الولادة بالإضافة إلى الخطأ العشوائي. كان تأثير جميع العوامل ثابتاً ما عدا تأثير الأب والخطأ العشوائي فان تأثيرهما عشوائياً. كان المتوسط العام لإنتاجية الحليب ١١٠٦٠±٣٥٥كجم. كان تأثير الأب (p<٠٠١) وسنة الإنتاج (p<٠٠١) ورقم الولادة (p<٠٠١) والتفاعل بين سنة الإنتاج وموسم الإنتاج (p<٠,٠١), وكذلك سنة الإنتاج ورقم الولادة (P<٠,٠١) دالّا معنوياً على إنتاجية الحليب السنوية للبقرة بينما كان تأثير موسم الإنتاج غير دال معنويًا على تلك الصفة الإنتاجية الهامة. لم يكن هناك تأثير لموسم الإنتاج في سنة ٢٠٠٤. ولكن عند دراسة السنوات ٢٠٠٥ و ٢٠٠٦ وجد أن إنتاجية البقرة في فصل الصيف كانت أعلى منها في فصل الشتاء. وبناءاً على ذلك وجد أن متوسط إنتاجية البقرة في هذين الموسمين (الصيف مقابل الشتاء) هو ١١٦٩١±٤٠٠ كجم مقابل ١١٤٨٣±٤١٠ كجم و١١٥٢٢±٣٦٩ كجم مقابل ١١٠٤١±٣٧٤ كجم للسنوات ٢٠٠٥ و ٢٠٠٦ على التوالي. ولكن العكس كان صحيحاً في عام ٢٠٠٧ حيث وجد أن الأبقار التي بدأت موسم إنتاجها في فصل الصيف لديها أقل إنتاجية (١٠٢٨٦±٣٧٢كجم) من مثيلاتها التي بدأت موسمها في فصل الشتاء (١٠٦٧٢±٣٨٨ كجم). كانت الفروقات بين الولادات كبيرة نوعاً ما في عام ٢٠٠٤ (تراوحت من ٩٨٣٧ إلى ١٢١١٦كجم), وصغيرة في عامي ٢٠٠٥ و ٢٠٠٦ (تراوحت من ١١٢٦٧ إلى ١٢٧٤٧كجم) ومتوسطة في عام ٢٠٠٧ (تراوحت من ٩٨٥٣ إلى ١١٣٥٥كجم). كان معامل التوريث هو ٠,٣١ مما يدل على أن هنالك فرصة كبيرة للتحسين الوراثي من خلال برنامج إختبار النسل الذائع الصيت.

الكلمات المفتاحية: دولة الإمارات العربية المتحدة ، أبقار حليب ، هولستاين فريزيان، انتاج الحليب ، البيئة

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Introduction

There is an increasing demand of animal products in all countries around the world. However these demands exert more pressure on the countries in the arid zone to increase the animal production (Philip, 2010). It is well-known that the indigenous cattle are low-producing animals. Thus, almost all the countries in the tropics and sub-tropics have imported high milk producing cattle from temperate zone. The dairy cattle such as *Friesian* and *Holstein-Friesian* are the most commonly imported cattle. AL Ain Dairy Farm is a leading dairy company in UAE. Several problems have been encountered in raising these animals in the tropics. Heat stress was one of the most important problem (Yousef, 1985). Furthermore, Yousef (1985) defined heat stress as the magnitude of forces external to the body system which tend to displace its system from their resting or ground state. Climate is a combination of elements that include temperature, humidity, rainfall, air movement, radiation, barometric pressure, and ionization (Johnson, 1987). The relationship between the animal and environment determines the degree to which the animal remains in thermal equilibrium with its environment (Finch, 1976). Effects of heat stress are more severe in hot humid climates, but dairy cattle raised in areas with relatively moderate climates are also exposed to periods of heat burden. So the thermal environment is a major factor that affects milk production and reproductive performance of dairy cows especially in animals with high genetic merit (Koppock et al,1982).

Dairy cattle research tended to concentrate on genetic improvements in order to increase milk production. Little attention had been paid to the thermoregulatory ability of the modern cow, as her capacity to produce milk (Murphy et al. 1983). Tao and Dah (2013) reported that cows which were heat stressed during late gestation have impaired mammary growth before parturition and decreased milk production in the subsequent lactation. Ray (1992) found that milk production was depressed for cows calving in summer and fall. Heat stress threatens the normal metabolic balance and usually produces positive feedback, which affects the performance of the animal when the heat exceeds the upper critical temperature (UCT).

High producing cows are affected more than low producing and dry cows as the thermonuteral zone (TNZ) shifted down as milk production, feed intake, and heat production increased (Koppock et al, 1982). Johnson et al. (1963) showed that cows consumed less feed as ambient temperature and combined ambient temperature and percent relative humidity (RH) were increased. Berman et al. (1985) suggested that the upper limit of ambient temperatures at which *Holstein* cattle may maintain a stable body temperature was 25 to 26°C, and that above 26°C, practices should be instituted to minimize the rise in body temperature. However, in the humid area, one of the major challenges is the combined effects of high RH with high ambient temperature. When the temperature reaches 29°C with 40% RH the milk yield of *Holstein, Jersey* and *Brown Swiss* cows was 97%, 93%, and 98% of the normal yield, respectively. But when the RH was increased to 90%, the yields of these breeds decreased to 69%, 75%, and 83% of the normal values, respectively (Binaca, 1965).

Knowledge of other non-genetic factors that influence production is important for better assessment of genetic ability of dairy farm. Knowledge of the interaction between genetics and environment is also very important for successful selection and progeny testing programs. Moreover increased milk production can be achieved by implementation of environmental modification such as installation of cooling facilities through shades, water spray, and fans (Armstrong 1994). Furthermore, Armstrong (1994) stated that the economic benefit should be determined before installing these equipments to reduce heat stress. A point to mention is that environmental modifications can not only be used to protect the animals, but they can also be used to protect dairy products from deterioration of their quality. Intawiwat et al. (2013) developed green polyethylene film for protection of dairy products to reduce degradation of photosensitizers. Beede and Collier (1986) and Chase (2005) identified three management strategies to minimize the effects of heat stress: physical modification of the environment (shading and cooling), genetic development of heat-tolerant breeds and improved nutritional management practices.

For accurate selection of bull and better evaluation of dairy farms, 305-day *ME* milk yield was used. The 305-day *ME* milk yield is the standardized milk yield according to some factors. The most important factors in this standardization are lactation length, calving age and milking frequency (Suleyman, 2006). Standardizing records according to these factors will raise accuracy in selection as they reflect the genetic structure of animals. This method is also important for proper evaluation of strength of the cow in milk production as well as estimation of the excepted of subsequent lactations yield (Suleyman, 2006). While superior bulls or cows are being selected for breeding, their ability to transfer this genetic merit to their progeny should be considered by breeders. In simple terms *heritability (h2)* measures the degree to which the phenotypic value of an individual reflects the actual genetic merits of that individual.

This study focuses on the performance of the *Holstein Friesian* cows in the United Arab Emirates with the following specific objectives:

1-To determine the effect of sire of cow, lactation number, year of freshening, season of freshening, and year X season of freshening, and year of freshening *X* lactation interaction on 305-day *ME* milk yield of the *Holstein Friesian* cows in UAE.

2-To estimate heritability of 305-day *ME* milk yield using sire and residual variance components for *Holstein Friesian* in UAE.

Materials and methods

Area of study and climate

This study was conducted in Sei'h AL Salamat Dairy Farm which is one of AL Ain Farms for Livestock and Animal Production. It is located in Al Ain city, found in the eastern part of UAE. This farm was initially established in 1987 with 300 milking cows. Now the farm has 1000 milking cows and 750 rearing heifers for replacement.

The latitude at Sei'h AL Salamat Dairy Farm area is 24°12'N and the longitude is 55°46' E. The ambient temperature, relative humidity and rainfall were taken from AL Ain Weather Station, located in the same farm area. Climatic condition in the UAE is generally hot and humid during April to September and warm to cool from October to March. The RH throughout the year is high in the coastal area and decreases gradually toward the interior region. Al Ain city is about 200 km away from the costal area, so it is less humid than the costal area. The maximum temperature during the period of study gradually increased from 26.6° C in January and reached the peak of approximately 44.0° C during the period from June to August and then declined gradually to reach 27.2° C in December. On the other hand the maximum RH started with a peak of 93% in January and declined to the lowest value; of approximately 62%; during May to August, then gradually increased to reach 91% in December. These results indicated that the months with high maximum temperature has low RH and this was very important and helpful in the use of *evaporative cooling system*. Similar tendency were observed with the minimum monthly temperature and RH months.

Management system

According to the routine management based on personal communication with the farm managers, the breed of cattle studied was *Holstein Friesian*. The sheds were free-stall and each was 72x63 meters in dimension and accommodated 125 cows. The shaded area was 15.5% of the total area of the shed. The space between adjacent sheds was 4.5 meters wide and it was roofed and used as feeding area. All the cows' standing and feeding area were covered with concrete. The sheds were equipped with fans, sprinkles and *Korral Kool system* (American Cooling System using sprinkles and fans controlled by a computer). During the years of the study (2004-2007), all the different groups of cows were covered with the cooling system. Cow shower was fixed at the exit of milking parlor.

The cows were fed total mixed ration (TMR) which was formulated in the farm according to the need of the different cow groups. The cows were milked four times a day. The daily milk yield per cow was measured two times a month. Drinking water was available on a 24-hour basis, providing eight inch as water space per cow. Intensive management practices were implemented in order to counteract the heat stress. *Dairy Comp 305 program* (Valley Agricultural Software, 2000) was used for cow management. The program monitored milk production, conception rate, pregnancy rate, culling rate and *ME* milk yield calculation.

Animal health and vaccination

Based on the personal communication with the veterinarian in charge, the program of treatment and vaccination against infectious disease *(e.g. Foot and Mouth Disease, Rinder Pest, Clostridium, Brucela, Rota Virus, Corona Virus and E coli)* was designed and applied by qualified staff. Sick animals were isolated and treated. The application of preventive measurement was started at the gate of the farm by good bio-security and foot and wheel bath. The cow sheds were cleaned three to four times daily. The flies and insects were controlled by AL Ain Municipality. Samples specimens were sent to the laboratory for investigation when necessary. The farm received feedback report from the milk factory showing the composition analysis and microbiology counting of total Bacteria and Coli-form for the farm raw milk on daily basis. Corrective action was taken if necessary.

Data collection

The data for the current study were collected from Se'h Al Salmat Dairy Farm, during the years 2004 to 2007 inclusive. Cow milk record consisted of cow identification

Table 1. Distribution of *ME* yield records by year *x* season of freshening subclass[1].

Year of Freshening	Season of Freshening		Total
	Summer	Winter	
2004	47	57	104
2005	110	107	217
2006	227	166	393
2007	323	114	437
Total Records	707	444	1151

[1]*ME*: 305-days mature equivalent

Table 2. Analysis of variance for 305-day ME milk yield[1].

Source	d.f.	Sum of Square	Mean squares	P-value
Sire of cow	49	331659687	6768565	***
Year of freshening	3	112576245	37525415	***
Season of freshening	1	800652	800652	NS
Lactation number	2	25277098	12638549	**
Year X Season	3	32795915	10931972	**
Year X Lactation	6	116558474	19426412	***
Residual error	1086	2968086550	2733045	

[1]*P ≤ 0.05, **P≤ 0.01 ***P≤ 0001, NS=Not significant

number (ID), sire ID, dam ID, cow date of birth, cow date of calving, cow lactation number, days open, ME milk yield and days in milk. The data were thoroughly edited and records with missing information were discarded. The total numbers of cow records which were used to determine the genetic and environmental factors affecting 305-day *ME* milk yield as well as to estimate heritability for this economically important trait were 1151 record distributed by year and season of freshening (Table 1).

Statistical analysis

The statistical model which was used to analyze the 305-day *ME* milk yield data is presented as follows:

$$Y_{ijklm} = \mu + s_i + a_j + b_k + c_l + ab_{jK} + ac_{jl} + e_{ijklm}$$

Where Y_{ijklm} = $_{ijklm}{}^{th}$ *ME* milk yield/cow.

μ = fixed mean constant to all observation.

s_i = effect of i^{th} sire of cow for i =1 to 50 (random)

a_j = effect of j^{th} year of freshening group for j = 2004 to 2007 (fixed)

b_k = effect of k^{th} season of freshening group for k = 1 for summer and 2 for winter (fixed)

c_l = effect of l^{th} lactation number for l = 1 to 3 (fixed)

ab_{jk} = effect of jk^{th} year X season of freshening interaction (fixed)

ac_{jl} = effect of jl^{th} year of freshening X lactation number interaction (fixed)

e_{ijklm} = effect of $ijklm^{th}$ residual error term (random).

First, conventional analysis of variance was carried out with all the factors assumed to be fixed except for the random residual error term. Then, *Harvey Least square and Maximum Likelihood Computer Program* (1988) was used to fit this model (model 2) and also to estimate the sire (σ_s^2) and error (σ_e^2) variance components. For the variance component estimation, the sire of cow and residual error variance term were assumed to be random and have the following distribution N~ (0, σ_s^2) and N~ (0, σ_e^2), respectively. The sires were un-related and errors un-correlated.

The heritability (h^2) of 305-day *ME* milk yield was estimated as follows:

$$h^2 = 4\,\sigma_s^2 / (\sigma_s^2 + \sigma_e^2)$$

Table 3. Estimation of variance components and heritability of 305d *ME* milk yield[1].

Source	Value
Sire Variance (σ_s^2)	230137
Residual Variance (σ_e^2)	2733045
Heritability (h^2)	0.31

[1]$h^2 = (4\,\sigma s^2 / \sigma s^2 + \sigma e^2)$

Results

Factors affecting 305-day *ME* milking yield

Results in Table 2 show that the effects of sire of cow (P ≤ 0.001), year of production (P ≤ 0.001) and lactation number (P ≤ 0.01) were significantly affecting *ME* milk yield. Furthermore, the effects year X season of freshening (P ≤ 0.01) and year of freshening X lactation number (P ≤ 0.001) interactions were also highly significant. However, the effect of season of freshening had non significant (P > 0.05) effect. Since the interactions had significant effect on *ME* mild yield, then the main effect of the individual factors has little value and will not receive any further discussion. The least-square means for the effect of year X season of freshening and year of freshening x lactation number interactions were also depicted on figures 1 and 2 respectively.

Heritability of 305-day *ME* Milk Yield

The heritability of milk yield measures the portion of the genetic merit that is transferred from the parent to their progeny. In the present study, a sire model was used and maximum likelihood method was utilized to estimate sire and error variance components. The result in Table 3 shows that the heritability for *ME* Mature Equivalent milk yield was 0.31.

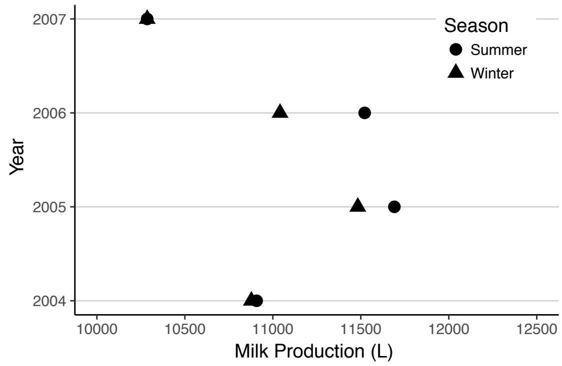

Figure 1. Effect of year and season of freshening on 305-day *ME* milk yield.

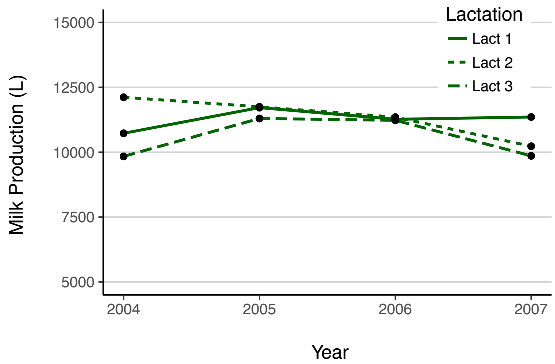

Figure 2. Effect of year and season of lactation number on 305-day *ME* milk yield.

Discussion

Results indicated that the effects of year of freshening ($P \leq 0.001$) and lactation number($P \leq 0.01$) on 305-day *ME* milk yield were highly significant. This finding is close to that of Suleyman (2009) who used the same *Least-square method* to analyze milk yield of *Holstein cows* in Turkey. The interaction of year X season of freshening on 305 day-*ME* milk yield was highly significant ($P \leq 0.01$). Similar results were also reported by Ray et.al. (1992). The results in Figure 1 show that during the years 2004 the difference between 305-day *ME* milk yield of summer and winter calving was insignificant. However, during the years 2005 (11691±400 kg *vs.* 11483±410 kg) and 2006 (11522±369 kg *vs.*11041±374 kg) cow freshening during the summer season gave significantly higher average *ME* milk yield than those freshening during the winter season.

However, in the year 2007 those freshening during the summer season gave significantly lower 305-day *ME* milk yield (10286±372 kg) than their winter counterparts (10672 ±388 kg). The superiority of the summer freshening over the winter freshening during the years 2005 and 2006, occurred as a result of provision of the efficient cow cooling system. On the other hand the inferiority of the summer freshening in the year 2007 was due to the increase of the numbers of cows without a parallel increase in the cow cooling system a fact that rendered the cooling system inefficient. These results are in agreement with Ray et al. (1992) who reported that in the absence of efficient cooling system, the summer season had significantly lowered 305-days *ME* milk yield (7387± 193 kg) than the winter season (7765± 193 kg) in Arizona.

As it was mentioned above, the effect of year of freshening x lactation number interaction on 305-days *ME* milk yield was highly significant ($P \leq 0.001$). This interaction is evident in Fig. 2 where the difference among lactation fluctuated with years of freshening. The largest difference observed among lactations in the year 2004, 2005, 2006 and 2007 was 2279, 449, 122 and 1502 kg, respectively. The change of differences among lactations, with increasing years might indicate unavoidable management differences from one year to another. Another reason of year of freshening x lactation number interaction was the change in ranking of the lactations with years of freshening. A point to mention is that the second-parity cows had the highest 305-days *ME* milk yield in the year 2004 (12116±453 kg) while the first lactation cows had the highest 305 day *ME* milk yield in the years 2007 (11355±407 kg). Another point to mention is that the third-parity cows had the lowest 305-day *ME* yield throughout the years 2004 to 2007.

The heritability of 305-day *ME* milk yield was 0.31. This result is close to the value of 0.29 which was reported by Ojango and Pollott (2001) in Kenya. Estimates of heritability for milk yield from European breeds kept in the tropics were lower than those from similar breeds kept in temperate countries (Lobo et al., 2000). The farm under study imports semen of high quality progeny tested breeding bulls. But a heritability of this magnitude suggests that a successful sire evaluation program could be established.

Conclusion and recommendations

The least-square mean of 305-day *ME* milk yield for *Holstein Friesian* cows was 11060 ±355 kg /305 days/ cow. The effect of genetic (sire of cow) and non genetic interacting factors (year and season of production and lactation number) had significantly affected *ME* milk yield. The heritability of *ME* milk yield was 0.31 indicating that improvement programs would be effective. Reproductive performance of *Holstein Friesian* cattle should be investigated in future studies.

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