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Full length article

Factors affecting weight at first service of Holstein Friesian heifers born and reared in a tropical environment

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ABSTRACT

The introduction of Holstein Friesian to an environment out of their thermo-comfort zone and to diseases not existing in their original temperate climates, was assumed to affect their reproductive and productive performance. From this assumption came the need to investigate and evaluate the performance of this breed in the hot climate of Northern Sudan, hence the objective of this study. The trait studied was weight at first service under the factors of year and season of birth of heifer, weaning weight class, weaning age class and their interactions. The method of data analysis was the Least Mean Squares. The data were subjected to analysis of variance using the SPSS program version 12.5. A total number of 588 records covering the period from the year 1989 to the year 2002 were retrospectively collected and analyzed. The results showed that the overall mean weight at first service was 337.25 ± 2.76 kg. The effect of the year of birth of heifers on this trait was highly significant (P≤ 0.001). The season of birth of the heifers, age at weaning and weight at weaning exerted no significant effects on the weight of heifers at first service (p ≥ 0.05). The interactions of these factors also showed no significant effect on the trait (p≥ 0.05). The weight at first service revealed by this study was not far from the breed norms in their countries of origin. We can conclude that the Holstein Friesian heifers born and reared under the prevailing environmental and management conditions at the farm of study were able to adapt and perform satisfactorily.

Keywords: First service, Holstein Friesian, Tropical environment, Weight

INTRODUCTION

The Holstein Friesian breed of cattle originated in the northern regions of Holland and Germany. Its name is derived from the Friesland province in Holland and the Holstein province in northern Germany, where the breed was historically concentrated. Renowned as the world's highest milk-producing cattle, Holstein Friesians have spread far beyond Europe and are now widely raised in dairy farms across the world (Anonymous, 2026).

Adult Holstein Friesian cows typically weigh between 690–770 kg and stand 140–165 cm tall. At birth, healthy calves weigh around 40–50 kg. By 14 months of age, when they reach an average weight of 320 kg, they are ready for breeding. Farmers generally plan for heifers to calve for the first time at about 22 months, when they have attained roughly 80% of their mature body weight (Anonymous, 2026).

Although often overlooked in dairy operations, raising heifers is crucial since they represent the future

of the herd. In some countries, commercial production systems that employ advanced technologies in milk production and animal husbandry account for about 10% of total output, particularly where exotic dairy breeds are kept (Hammoud et al., 2010).

Reproductive performance in dairy cows is influenced by multiple factors, including breed, calving, season, environment, and management practices. Key indicators of productive efficiency include milk yield and days in milk, while reproductive indices encompass age at first calving, days open, services per conception, and calving interval (Tadesse, 2010; Amene et al., 2011; Usman et al., 2013; Hoka et al., 2019).

Regular monitoring of body weight (BW) and growth rate provides valuable insights for farmers, enabling better decision-making. Tracking BW in future dairy cows enhances herd productivity and reduces disease incidence (Costa et al., 2021). Genetic and environmental factors—such as calving weight, nutrition, litter size, gestation length, calving year, season, insemination bull, calf gender, type of birth, geographical region, and altitude—can all affect the weight of heifers or cows at first service (Yaylak et al., 2015).

Live weight is considered the most critical factor influencing puberty (Ugarte, 1989). Large breeds typically reach puberty at around 270 kg, while smaller breeds do so at approximately 240 kg. It is therefore more effective to use target live weights rather than age when planning heifer mating. In tropical regions, recommended breeding weights are 200–220 kg for smaller breeds and 290–310 kg for larger breeds (Moran, 2012).

This study was designed to evaluate the impact of year and season of birth, age, and weaning weight on the body weight of Holstein Friesian heifers at first service, under the prevailing farm management practices and tropical environmental conditions of Northern Sudan.

MATERIALS AND METHODS

Farm Location and Establishment

The farm under study belonged to the Arab Company for Agricultural Production and Processing (ACAPP). This company was one of the largest companies established by the Arab Authority for Agricultural Investment and Development (AAAID). This farm is located about 40 Km south of khartoum at Al Bagair area .It lies about 4Km West of khartoum –Medani road .It was established in 1984 ,it started by importing 1000 heifer-in-calf in two batches (500 heads each)in 1984 and 1985 from West Germany .They were pedigree registered Holstein –Friesian heifers.

Environmental Conditions in the farm Area:

Meteorological data showed that the average annual rainfall in the farm area was 167mm.There was a wet season from July to September with 70% of the total annual rainfall falling within this period. Temperatures in the area were high with an annual mean average of 30.7°C, and extremes of over 45°C. The hotter months were June and July with a mean average of about 35.5 °C. The lowest temperatures were recorded in January with a mean average of 24.6 °C. Relative humidity recorded at 6: 00 GMT was 13% and was 40% at 12: 00 GMT. It was 52% at 18: OO GMT. Relative humidity was lowest in March and April and highest in August. The mean wind speed varied between 3.10 m./sec. In October and 4.40 m./sec. in several months during the year.

The Management System in the Farm

Housing

Each 500 cows were kept in a cow sub-unit. The sub-unit comprised a single steel-frame building of 6900 m2. The building contained 10 cow pens, milking parlour, holding areas and storage and cooling facilities. The building was essentially open with the southern side being provided with low walls and shutters to give protection from dust storms. Adequate ventilation was ensured through the open gables and an open ridge. Each group of 48 cows was having a shaded resting and feeding area of 7.7 m2 per cow and free access to an open exercise yard of 4.3o m2/cow. Free access to drinking water was ensured in the shaded area the floor of the covered and open areas was concrete.

The Feeding System

The animals were fed on green or dry roughage (mainly sorghum hybrid) and a concentrate mix. The concentrate mix generally consisted of oil seed cakes, wheat bran, sorghum grain, molasses, sorghum gluten, salts and lime. There were fluctuations in the quantity and quality of both roughage and concentrate rations from year to year and from season to season. The roughage was offered once a day while the concentrate mix was given twice daily after milking.

Milking Practice

Machine milking was adopted in the farm. Each 500 cow sub-unit was supplied with a- 16 x 2(units) milking parlour with milk storage and cooling facilities. Cows were milked twice daily as a routine, but in some years, when good levels of nutrition were secured, three-times –milking per day was practiced.

The Breeding Program

Artificial insemination (A.I.) was the main method adopted for breeding females in the farm. High quality frozen semen from proven Holstein-Friesian sires was imported every year. Cows that return to A.I. were referred to natural service by a bull from the herd. The farm kept pure Holstein-Friesian animals since its

establishment. Neither cross-bred animals were introduced nor cross-breeding was practiced in the farm.

Animal Health and Disease Control

Vaccination against the major prevailing epidemic diseases in the Sudan was a regular practice in the farm. The main diseases vaccinated against were Rinderpest, Anthrax, Black Quarter, Hemorrhagic Septicemia, Contagious Bovine Bleuro-pneumonia and Foot and Mouth Disease. Female calves at the age of four to eight months were vaccinated against Brucellosis using stain 19. Cows were vaccinated against Brucellosis using K 49/vaccine and diluted strain 19. Tick control was practiced by regular spraying of all animals with acaricides Spraying was done once – weekly in the first year of importing the animals, then twice-monthly afterwards.

Source and collection of data

This study was conducted retrospectively using 558 Holstein Friesian heifers' records for documenting their weight at first service and associated factors under the prevailing farm management practices and tropical environmental conditions from 1989 to 2002 at the Arab Company for Agricultural Production and Processing (ACAPP), Northern Sudan.

Statistical analysis:

The data were analyzed by the method of Least Mean Squares (Steel, Torrie and Dickey, 1997). They were subjected to analysis of variance using SPSS program version 12.5.
Fixed model:

$$Yijkl=\mu+Yi+Sj+AWK+WWI+(Y\times S)+(Y\times AW)+(Y\times WW)+(S\times AW)(S\times WW)+ E ijKL$$

Where:
Yijkl = The trait studied
μ = Overall mean
Yi= effect of year of birth
Sj= effect of Season of birth
AWK= effect of Class of Age at Weaning
WWI= effect of Class of Weight at Weaning
(Y×S),(Y×AW),(Y×WW),(S×AW), (S×WW)= interactions
Eijkl = Standard error.

RESULTS &DISCUSSION

The trait was examined under the factors of year and season of birth, weaning weight class, weaning age class, and their interactions. Statistical analysis revealed that the overall mean body weight at first service for Holstein-Friesian heifers at the study farm was 337.25 ± 2.76 kg (Table 1). These findings are consistent with those reported by Roger et al. (1983), Muller and Botha (2000), Archbold et al. (2012), and Cook (2019). Conversely, they differ from the results presented by Ugrate (1989), Menjo et al. (2009), Duplessis et al. (2015), Bazely et al. (2016), Le Cozler (2019), and Levina et al. (2019). Such discrepancies in body weight may be attributed to evolving standards over time or variations in management practices, including feeding strategies, housing systems, and record-keeping methods, as previously highlighted by Heinrichs and Losinger (1998).

Table 1: Overall mean ± standard Error of heifer's weight (Kg) at first service

Breed	No. of Records	Mean (Kg)	Std. Error
Holstein Friesian	558	337.25	2.76

Table 2: Analysis of variance for the effect of year & season of birth, class of age at weaning, class of weight at weaning & their interactions on weight at first service of heifers

Source of Variation	df	Mean Square	F	Sig.
Years of birth	6	24018.06	13.97	0.00
Season of birth	2	31.09	0.18	0.83
Class of Age at Weaning	3	751.59	0.44	0.74
Class of Weight at Weaning	2	1716.79	1.00	0.37
Years of birth * Seasons of birth	11	1119.56	0.65	0.78
Years of birth * Class of Age at Weaning	14	1098.26	0.64	0.83
Season of birth * Class of Age at Weaning	6	594.96	0.35	0.91
Years of birth * Class of Weight at Weaning	10	634.18	0.37	0.96
Season of birth * Class of Weight at Weaning	4	553.80	0.32	0.86
Class of Age at Weaning * Class of Wt. Weaning	6	2115.68	1.23	0.29

In this study, the year of birth of the heifer had a highly significant effect on body weight at first service ($P < 0.001$) (Table 2). As shown in Table 3, the highest mean weight at first service (375.88 ± 2.76 kg) was recorded during the 1993–1994 period, while the lowest mean weight (288.36 ± 7.70 kg) occurred in 1997–1998. This substantial variation is likely linked to the severe resource shortages the farm experienced in certain years of operation.

Table 3: Means ± standard Errors of weight (Kg) at first service in the different years of birth of heifers.

Years of Birth	Mean (Kg)	Std. Error
1989-1990	325.93	10.37
1991-1992	331.44	5.11
1993-1994	375.88	4.80
1995-1996	299.42	11.49
1997-1998	288.36	7.70
1999-2000	358.21	7.07
2001-2002	360.00	13.33

The influence of environmental factors on heifer body weight across different seasons is presented in Table 4. As shown, heifers born during winter exhibited higher mean body weights (339.11 kg), whereas those born in the dry summer recorded lower weights (333.47 ± 5.19 kg) as presented in Table 4. Statistically, however, the season of birth did not have a significant effect on weight at first service ($p \geq 0.05$), as indicated in Table 2. These findings are consistent with the results of Singh and Gurnani (2002), Elabdein and Makkawi (2006), and Hurst (2021), but differ from those reported by Singh and Gurnani (2002), Uhrincet et al. (2021), and Hurst et al. (2021). The observed variation in mean heifer weight across seasons may be explained by the observations of Fedorovych et al. (2023), who emphasized that seasonal climatic changes and fluctuations in feed availability significantly affect animal growth and are increasingly important considerations in breeding strategies.

Table 4: Means and standard errors of weight (Kg) at first service in the different seasons of birth of heifers

Season of Birth	Mean (Kg)	Std. Error
Winter (Nov.- Feb.)	339.11	4.53
Dry Summer (March – June)	333.74	5.19
Wet Summer (July – Oct.)	338.53	4.66

In this study, the effect of weaning weight on weight at first service was found to be non-significant ($p \geq 0.05$), as shown in Table 5. However, heifer calves weaned at body weights greater than 70 kg tended to reach first service at a higher weight (345.85 kg), as indicated in Table 5. This trend was likely influenced by management practices, particularly nutrition. These findings are consistent with those of Machado et al. (2025), who reported a very weak association between body weight and fertility in heifers. In contrast, Ugrate (1989), Gaafar et al. (2005), documented different outcomes, suggesting that weaning weight did affect weight at first service. Such discrepancies among studies may be attributed to the fact that weaning is a management decision, shaped by the specific conditions prevailing on each farm.

Table 5: Means and standard errors of weight (Kg) at first service at different classes of weight at weaning

Class of Weight at Weaning (Kg)	Mean	Std. Error
40 – 55	335.88	5.39
56 -70	329.21	4.42
> 70	345.85	4.65

Analysis of the effect of age at weaning on body weight at first service revealed no significant differences ($P \geq 0.05$), as shown in Tables 2 & 6. The variations among age classes in relation to weight at first service were relatively minor, likely reflecting management decisions and practices. In contrast, Costigan et al. (2022) and Constantin (2023) reported that age at weaning did have an impact on heifer weight at first service. These discrepancies may be attributed to differences in farm-specific weaning policies, which are often tailored to individual management conditions and resource availability.

Table 6. Means and standard errors of weight (Kg) at first service at different classes of age at weaning of heifers

Class of Age at Weaning (Days)	Mean	Std. Error
42 – 60	342.34	6.75
61 – 75	333.04	3.99
76 -90	340.28	5.65
> 90	336.78	6.99

CONCLUSION

The findings of this study reveal that heifers born and raised in the hot climate of the Northern Gezira were able to achieve body weights at first service comparable to those reported in countries with temperate or similar environments, despite the challenging conditions. This highlights their ability to adapt to prevailing environmental stresses. Moreover, these results provide valuable guidance for farm management practices and support recommendations concerning the introduction and effective management of temperate dairy breeds in Sudan.

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Author contributions

Ismail Mohamed Elfagir, Abdelmoniem M. Abu Nikhaila, Tarig A. A., Mohamed Khair Abdallah, and Adil Mousa Younis Waniss, the 5 authors equally contributed on proposal plan, Data collection, processing, analyzed, interpretation of data, wrote first & final draft of Manuscript. All Authors have approved this version of the manuscript.

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Conflict of interest

The authors have declared no conflict of interest.

Ethical standards

The Faculty of Animal Production, University of Khartoum, Sudan, approved the study.

Data availability

All data generated and analyzed during this study are included in this published article.

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العوامل المؤثرة على وزن عجلات الهولشتاين فريزيان عند أول تلقيح لها والمولودة والمرباة في البيئة الاستوائية

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الملخص

ان إدخال أبقار الهولشتاين فريزيان إلى بيئة خارج نطاق بيئتها، وعرْضها لأمراض غير موجودة في مناخاتها المعتدلة الأصلية، افترض أنه سيؤثر على أدائها الإنتاجي والتناسلي. ومن هذا الافتراض جاءت الحاجة إلى دراسة وتقييم أداء هذا السلالة في المناخ الحار لشمال السودان، كانت الصفة المدروسة في هذه الدراسة الاستعادية هي وزن العجلات عند أول تلقيح لها، والعوامل المؤثرة عليها مثل سنة وموسم الميلاد، وفئة وزن الفطام، وفئة عمر الفطام. تم استخدام طريقة المتوسطات المربعة الصغرى لتحليل البيانات، وأُخضعت البيانات لتحليل التباين باستخدام برنامج SPSS .تم جمع وتحليل ما مجموعه 588 سجلاً تغطي الفترة من عام 1989 إلى عام 2002. أظهرت النتائج أن متوسط الوزن للعجلات عند أول تلقيح كان 2.76± 337.25 كجم. كشف التحليل الاحصائي ان سنة الميلاد كان لها تأثير معنوي ذو دلالة إحصائية (P≤0.001)على وزن العجلات عند اول تلقيح، بينما لم يكن لموسم الميلاد، أو عمر الفطام، أو وزن الفطام أي تأثير معنوي. كما ان كشفت نتائج هذه الدراسة أيضا ان وزن العجلات عند أول تلقيح لم يكن بعيداً عن القياسات والصفات الخاصة بالسلالة في بلدانها الأصلية. خلصت الدراسة الى ان عجلات الهولشتاين فريزيان المولودة والمرباة في مزرعة الهيئة العربية للاستثمار والانماء الزراعي كانت قادرة على التكيف والأداء بشكل مرضٍ تحت الظروف البيئية والإدارية السائدة في منطقة الدراسة.

الكلمات المفتاحية: أول تلقيح، الهولشتاين فريزيان، البيئة الاستوائية، الوزن

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