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SHORT COMMUNICATIONS

A comparison of milk production from Holstein Friesian and Jersey cattle breeds under hot climate of Oman

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Abstract

Data of milk production and performance under Oman climatic conditions are limited. The current study presents a 9-year analysis of daily milk performance of Holstein and Jersey cattle breeds born and raised in Oman and fed similar diets of concentrate and Rhodes grass hay. Data on the daily cow's milk production, during the entire lactation period for nine consecutive milking years between 2009 and 2018, were collected. The data was introduced to a linear mixed model and was analyzed to evaluate the breed variations in milk production across lactations and across years. Holstein Friesian (HF) cows had significantly ($P < 0.001$) higher daily milk production of 17.6 ± 0.4 kg/cow/day compared to 11.7 ± 0.8 kg/cow/day for Jersey cows. Across years, we observed a gradual annual improvement in total milk production in both HF and Jersey breeds of 5% and 6%, respectively. The highest daily milk production was in the third and fourth lactations for HF cows and in the second and third lactations for Jersey cows. In a region where much of the expected demand in milk will be met by exotic breeds and importation, our results provide an insight into the performance of temperate breeds in hot and arid climatic conditions. As such, our results shall be useful for dairy producers seeking to maximize milk production under such conditions.

Keywords Milk production · Cows · Breed · Hot climate

Introduction

According to the Omani national statistics (NCSI 2018), Oman's annual milk production is estimated at 90,000 tons of milk and its production grows by 5.4% annually. The national dairy milk herd population is estimated at 179,000 cows (NCSI 2018) with an estimated production of 0.5 ton/cow/year. The national milk production in Oman is derived from both local and exotic dairy breeds. However, local breeds are known for their low milk production (Shaat and Al-Habsi 2017) ranging between 3.9 and 6.9 kg/cow/day. This is attributed to the harsh environmental conditions and the low-quality pasture feed. Exotic breeds such as Holstein Frisian and Jersey are present in Oman mostly in commercial farms. However, information about their milk production and performance under Omani weather conditions is limited.

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Due to the high year-round temperatures, it is speculated that performance of exotic breeds is lower under hot environments than in their native environments (Nigm et al. 2015) as they are less adapted to higher temperatures compared to native cattle breeds (Gantner et al. 2011; Pragna et al. 2017). The lactating *Bos taurus* cows are articulately sensitive to heat stress due to metabolic heat load as a result of milk synthesis (Cowley et al. 2015). There is limited data on performance of exotic dairy cow breeds under the arid climatic conditions of Oman. In an earlier study in Oman (Srikandakumar and Johnson 2004), it was observed that Holstein cows produced significantly more milk during cooler months compared to hotter months whereas milk production was not affected significantly by heat stress in Australian Milking Zebu breed. The effect is more profound when cows are fed low-quality roughages, such as Rhodess grass hay, which is the dominant roughage source in Omani dairy farming and can be partially reversed by fat supplementation as observed in similar environmental conditions (Moallem et al. 2010). The objective of this study was to compare milk production between HF and Jersey lactating cows fed a similar diet of concentrate and Rhodess grass over nine consecutive milking years.

Materials and methods

Data collection

The data source for our analysis was collected from the research dairy farm milking parlor. The farm is located at the Sultan Qaboos University campus (23°35′54.9″N, 58°09′45.7″E), Muscat city in Oman. The farm contains a dairy herd of lactating HF and Jersey cows, heifers, and calves. The following data was collected: year, morning and evening milking amounts in kg per cow, breed type, and lactation number. Accordingly, a total number of 79,920 daily milking record were collected from a total number of 296 lactations (number of animals were 101 HF and 24 Jersey cows) between the years 2009 and 2018, with each daily milking record representing the sum of morning and evening milking per cow per day. An SQL procedure was performed to extract data from the milking parlor software in Excel format. The data presented here will be useful for dairy producers, dairy genetics, and dairy processors in arid and semi-arid climate countries. It will provide producers information about variability and milking potential of two cattle breeds reared under similar management and environmental systems.

Dairy production system

The cows are artificially inseminated using imported semen from international commercial suppliers. Cows deliver during September through November of each year, and born calves are separated from dams at their first day of age and fed on colostrum. Milking is recorded starting with the third day in milk to allow colostrum collection and administration to calves. Total number of parities varied between 1 and 6, while the lactation period starts in September through May/June each year.

Cows were attached with sensor reader to register tag number and animal information in the milking parlor of 2 × 8 cows' capacity (Fullwood Limited, UK) of each milking time, in the morning around 7:00 and evening around 16:00. The milking parlor was connected with software that stores data.

Before each milking, the cow's udders were tested against mastitis visually, and using California mastitis test. Weather temperatures in 2018 varied between minimum of 12 °C in January up and 47 °C in July month. The cows were usually culled or auctioned when they had serious health or reproductive problems (i.e., conception failure) and auctioned after their sixth lactation.

Cows were kept under open-sided barns equipped with feeders and drinkers. The barn ground is made of cement concrete towards the feeder's side, while the setting litter is a mixture of cow's manure and straw and was cleaned every week and sold as a fertilizer. During the dry period between June and September, cows were fed approximately 4 kg of concentrate and ad libitum Rhodes grass hay.

An automatic concentrate feeder was connected with the milking parlor to feed the cows according to their milk production, during the milking process and immediately upon arrival to the milking parlor in the morning and in the evening. The feeding system is based on commercial concentrate feed and Rhodes grass hay only. Concentrate feed was offered to cows in the milking parlor during the morning and evening milking sessions at around 7:00 a.m. and 16:00 p.m., respectively.

The Rhodes grass hay chemical composition was as follows: dry matter (DM) of 89.2%, metabolizable energy (ME) of 8.1 MJ/kg DM, digestible organic matter (dOM) of 54.1%, crude protein (CP) of 7.89%, neutral detergent fiber (NDF) of 70.9%, acid detergent fiber (ADF) of 41.8%, crude lipid (CL) of 0.85%, ash of 8.27, calcium (Ca) of 0.7%, and phosphorus (P) of 1.4%. The composition of concentrate feed was as follows: DM of 88.2%, ME of 10.5 MJ/kg DM, dOM of 71.4%, CP of 17.8%, NDF of 18.8%, ADF of 6.1%, CL of 1.8% ash of 7.7%, Ca of 0.9%, and P of 0.72%.

Statistical analysis

Data on the daily morning and evening milking in kg per cow, cows year, breed and lactations representing the entire lactation period for nine consecutive milking years from 2009 through 2018 were analyzed using a linear mixed model in R (R core team 2018) to evaluate the breed variations in milk production across lactations and across years. The model's dependent variable was daily milk production in kg/cow/day, while the independent variables were the breed type of HF and Jersey, lactation numbers (from 1 to 6), year (from 2009 to 2018), and their interactions at confidence interval of 0.95. Cows fitted as random variables. Results presented as least squares means (LSM) using the analysis of deviance method (type II Wald chi-square tests).

Results and discussions

Table 1 summarizes herd data between 2009 and 2018 used in the current study. On average, the 9 years milk production of HF breed was significantly ($p < 0.001$) and 34% greater than in Jersey breed (i.e., 17.6 vs 11.7 kg of milk/day in HF and Jersey breeds, respectively).

Table 2 illustrates the effect of year, breed, lactation, and their interactions on daily milk yield in HF and Jersey cows. Milk production was significantly affected by year ($p < 0.001$); however, year and breed interaction did not affect milk production significantly. Our results further show that LSM of daily milk production has improved over years and in both breeds. For instance, the average year over year (YoY) improvement in milk production was 5% and 6% in the HF and Jersey breeds, respectively. Lactation has

Table 1 Summary of dairy herd data used between 2009 and 2018

	Breed	
	Holstein Friesian	Jersey
Number of lactations	236	60
Milking years	9	9
Lactations	1 to 6	1 to 6
Total number of milking records	63,720	16,200
Daily milk production kg/day	17.6^{A}	11.7^{B}

Milk production presented in least square means (LSM). Different lowercase letters indicate significant differences ($P \leq 0.05$) between Holstein Friesian and Jersey cattle breeds

affected milk production significantly ($p < 0.001$), with highest HF milk production being during the third and fourth lactations. Highest milk production in Jersey cows was achieved during their second and third lactations. Across lactations, milk production varied between 15.3 and 18.7 kg/cow/day for the HF cows and between 11.3 and 13.9 kg/cow/day for Jersey cows.

In the year 2018, the average daily temperature varied between a high of 47 °C in July and a low of 12 °C in January; this range of temperatures in the study location is overall representative for previous years. Our results agree with a previous study (Srikandakumar and Johnson 2004) conducted under the Omani conditions. In that study, milk production of HF cows was 18.3 kg/cow/day, compared to 12.1 kg/cow/day for the Jersey cows. Furthermore, HF milk yield in the current study is similar to that reported by Cowley et al. (2015) who evaluated cows' performance under heat stress conditions in Australia in which daily milk yield was 17 kg/cow/day. High ambient temperatures above the cow's comfort zone reduce the levels of dry matter intake, which is a primary reason for reduced milk yield (West 2003). The YoY growth in milk production could be attributed to the genetic improvement of the dairy populations in both breeds as semen was purchased commercially from international suppliers (primarily from Australia). Compared to cow's milk production in India, Jersey milk production reported in our study is greater than that reported by Dinesh et al. (2014), who found the life time Jersey milk production of 4.77 kg/cow/day.

However, HF and Jersey cows in our study produced less than in their usual production in native environment which averages approximately 29 and 21 kg/cow/day, for HF and Jersey cows of respectively (Capper and Cady 2012). Improvement of resilience to heat stress can be achieved in two different paths. First, genetic/genomic selection can be practiced and can potentially (over generations) improve the overall resilience of cattle herds to heat stress by focusing on cattle. For example, genetic variation already exists in cattle

Table 2 Least square means (LSM) of year, breed, lactation effects and their interaction on milk yield in Holstein Friesian and Jersey cows

Main effect and interactions	Holstein Friesian	SE	Jersey	SE	*P*value
Year effect					<0.001
Breed effect					<0.001
Lactation effect					<0.001
Year by Breed effect					0.315
2009/2010	14.9	0.73	9.2	1.39	
2010/2011	15.6	0.73	9.3	1.43	
2011/2012	15.9	0.74	9.3	1.08	
2012/2013	15.0	0.82	12.5	1.54	
2013/2014	17.4	0.62	11.6	1.23	
2014/2015	19.3	0.59	14.1	1.15	
2015/2016	18.3	0.59	15.3	1.83	
2016/2017	20.0	0.73	11.3	1.89	
2017/2018	21.7	0.81	12.9	1.60	
Breed by Lactation effect					0.1067
Lactation 1	15.3	0.4	11.8	0.89	
Lactation 2	17.2	0.4	13.0	0.77	
Lactation 3	18.2	0.4	13.9	0.99	
Lactation 4	18.7	0.6	11.3	1.22	
Lactation 5	17.8	0.8	11.8	1.53	
Lactation 6	18.2	2.0	8.6	3.13	

hair characteristics and is linked to resilience to heat stress (Sarlo Davila et al. 2019). This can be exploited to improve their adaptation to heat stress. Additionally, improvement in diet and management practices and housing can be introduced such that production levels can be increased during the otherwise low production periods.

Conclusion

In our study, HF and Jersey breeds share attributes of lower milk production compared to their native environments (i.e., in the USA). This could be in part attributed to the differences in ambient temperatures, feeding systems, and genetic improvement plans.

A low productivity of exotic breeds under the study conditions could reflect a decreased feed efficiency due to the reduced dry matter feed intake during the hot weather. Therefore, improving roughage quality, alternatively, replacing Rhodes grass with a high-quality roughage sources (i.e., Alfalfa hay), and increasing dietary energy concentration could improve feed efficiency. Further management strategies related to housing system and animal health would be associated with improving cow's well-being and productivity and reducing the heat load on animals.

Further research is needed to evaluate milk performance, feed efficiency, and reproductive efficiency of exotic breeds in Oman.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Capper, J.L., Cady, R.A., 2012. A comparison of the environmental impact of Jersey compared with Holstein milk for cheese production. Journal of Dairy Science, 95, pp. 165–176.

Cowley, F.C., Barber, D.G., Houlihan, A.V., Poppi, D.P., 2015. Immediate and residual effects of heat stress and restricted intake on milk protein and casein composition and energy metabolism. Journal of Dairy Science, 98, pp. 2356–2368.

Dinesh, K., Thakur, Y P., Katcho, S., Sankhyan, V. 2014. Lifetime milk production efficiency of Jersey cows under sub-temperate conditions. Indian Journal of Animal Research. 48 (3):286–289.

Gantner, V., Mijic, P., Kuterovac, K., Solic, D., and Gantner, R. 2011. Temperature-humidity index values and their significance on the daily production of dairy cattle. Mljekarstvo, 61: 56–63.

Moallem U., Altmark, G., Lehrer, H., Arieli, A. 2010. Performance of high-yielding dairy cows supplemented with fat or concentrate under hot and humid climates. Journal of Dairy Science, 93(7):3192–202

National Center for Statistical Information of Oman (NCSI). 2018 Statistical Yearbook.

Nigm, A., Sadek, R., Sherien A. Yassien, Ibrahim, M., El-Wardani, M A. 2015. Effect of climate change on test-day milk yield of Holstein cows maintained in the Nile Delta of Egypt, Egyptian Journal of Animal Production, 52(2):113–121

Pragna P., Archana, P.R., Aleena, J., Sejian, V., Krishnan, G., Bagath, M., Manimaran, A., Beena, V., Kurien, EK, Varma, G., Bhatta, R. 2017. Heat stress and dairy cow: impact on both milk yield and composition, International Journal of Dairy Science 12:1–11

R Core Team, 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.

Sarlo Davila, K., Hamblen, H.,Hansen, P., Dikmen, S., Oltenacu, P., Mateescu, R. 2019. Genetic parameters for hair characteristics and core body temperature in a multibreed Brahman–Angus herd, Journal of Animal Science, Volume 97, Issue 8, August 2019, Pages 3246–3252, https://doi.org/10.1093/jas/skz188

Shaat, I., and Al-Habsi, R., 2017. Status of Animal Genetic Resources in Oman Journal of Agricultural Sciences and Food Technology, Vol. 2 (9), pp.139–146.

Srikandakumar, A. and Johnson, E.H. 2004. Effect of heat stress on milk production, rectal temperature, respiratory rate and blood chemistry in Holstein, Jersey and Australian Milking Zebu cows. Tropical Animal Health and Production, 36(7): 685–692.

West, J.W., 2003. Effects of heat stress on production in dairy cattle, Journal of Dairy Science, 86, 2131–2144.