Environment (Year and Season of Birth) Effects on First-Lactation Milk Yield of Dairy Cows

IOP Conf. Series: Earth and Environmental Science **372** (2019) 012010 doi:10.1088/1755-1315/372/1/012010

Environment (Year and Season of Birth) Effects on First-Lactation Milk Yield of Dairy Cows

A Susanto[1,3], L Hakim[2], Suyadi[2] and V M A Nurgiartiningsih[2]

[1)] Graduate Program, Faculty of Animal Science, Brawijaya University (UB), Malang, Indonesia
[2)] Faculty of Animal Science, Brawijaya University (UB), Malang, Indonesia
[3)] Faculty of Animal Science, University of Jenderal Soedirman (UNSOED), Purwokerto, Indonesia

E-mail: lhakimgs@ub.ac.id

Abstract. Nutritional status (protein and energy) during early life has important effect on milk yield of dairy cows. Feed quantity and quality is often influenced by season representing the fluctuation of water supply which is essential for plants including forage. The aim of the present study was to analyse the effect of year and season of birth on first-lactation milk yield of Holstein Friesian cows. The data included 1005 records of first-lactation daily recorded milk yield available in National Breeding Centre for Dairy Cows and Forages of Baturraden (the so-called BBPTUHPT Baturraden) database. The milk yield was recorded within the years of 2004 to 2014. Milk yield data were adjusted to 305 standard days of milking using multiplicative-local correction factor. Animals' date of birth was grouped divided into years and months of birth. Months of birth were assigned into: (1) traditional-two season categorization (wet and dry), (2) extended-categorization of three seasons (wet, wet-dry and dry), (3) extended-categorization of four seasons (wet, wet-dry, dry and dry-wet). The effect of date of birth factor on first-lactation milk yield was tested using likelihood ratio test of full and reduced model. The result showed that both years and months of birth have significant effect on first-lactation milk yield, regardless of the season categorization. It is therefore concluded that season plays important role to consider in dairy cattle management and has to be included in genetic analysis to remove non-genetic effect which regards to first-lactation milk yield.

Keywords: birth, cows, non-genetic, Holstein, Indonesia

1. Introduction

Milk production is the most attracting trait of dairy cows and continues to receive significant attention from researchers around the globe. It is well understood that milk production of dairy cows not only is affected by their genetic make up and direct environmental effects those animals live on but also is determined by the genetic constitution and non-genetic factors of the dam the so-called maternal effects. Environmental factors affecting animals during prenatal dan early postnatal period play important role for the animals to express their performance during adult age [1]. Maternal factors that might affect the milk production capacity of cows could be for instance the dam's age [2] and energy status of the dam

[3]. For the later, factors affecting forage availability such as amount of rain fall is important to consider in dairy management.

Genetic analysis requires that all significant factors to be included in the model of analysis so that the ultimate genetic component of animals can be separated from non-genetic factors. In addition, in dairy cattle management, information about which factors have significant effect on the main trait of interest (milk yield) is crucial thus management decision can be properly executed to maintain milk production at the optimum level. Therefore, it is important to evaluate environmental factors that effect animals' performance. This study aimed to analyse the effect of year and month of birth on the first-lactation milk yield of Holstein dairy cows.

2. Methodology

The study was conducted at National Breeding Centre for Dairy Cows and Forages of Baturraden (the so-called BBPTUHPT) Baturraden. Data were retrieved from its database stored in spreadsheet file format. Milk yield were recorded from twice daily milking for each cow and therefore the data were combined and converted into milk yield per lactation. Since the number of days in milk of cows were varied, animal's milk yield were then standardized into 305 days in milk using local correction factor of [4]. Correction factors for different number of days in milk of [4] are presented in **Table 1**. As many as 1005 milk yield per lactation records were analysed in the study and only cows that have records of days in milk of more than 120 days were included.

In the present study, month of birth was assigned into different "season categorization" namely: (i) 12 categorization, (ii) 2 categorization, (iii) 3 categorization, (iv) 4 categorization. When 12 categorization of season was used, the assignment was based on month of birth. Wet and dry season were used when season assignment was into 2 categories. When month of birth was assigned into 3 categorization, the grouping was dry, semi wet and wet season. Month of birth was grouped into dry, semi dry, semi wet and wet season when 4 categorization was used. The significant effect of birth year and season and its interaction were tested individually for each season categorization.

Table 1. Correction factors for different number of days in milk

No	Class of DIM	Correction Factors
1	120 - 169	1.93
2	170 - 219	1.43
3	220 - 269	1.15
4	270 - 319	1.00
5	320 - 369	0.89
6	370 - 419	0.80
7	420 - 469	0.74
8	470 - 519	0.70
9	520 - 569	0.67
10	570 - 619	0.58

Source: [4]

The goodness-of-fit between two models was evaluated using likelihood ratio test (LRT) applying lmtest package [5] conducted with Rstudio program [6]. Likelihood ratio test was initiated by constructing the simpler model (reduced model; *Eq*. 1) to analysis and the additional factor was added into the model to form a more complicated model (full model; *Eq.* 2). The reduced and full models were as the followings:

$$MY_{i,j} = \mu + YOB_i + e_j \qquad \text{(Equation 1)}$$

$$MY_{i,j,k} = \mu + YOB_i + SOB_j + e_k \qquad \text{(Equation 2)}$$

where:
MY : milk yield per lactation (kg)
μ : general mean
YOB : year of birth
SOB : season of birth
e : residual
The likelihood ratio test is then conducted by computing the likelihood score which is the different between *log* likelihood of reduced and full models:

$$LRT = 2x(logL_1 - logL_2)$$

where log L_1 and log L_2 are the log likelihood of full and reduced model, respectively. The statistic test of *LRT* will approximately follow chi-square distribution.

3. Result and Discussion

Distribution of milk yield of first parity and data disperson of 2, 3 and 4 season categorization are depicted in Error! Reference source not found., Error! Reference source not found., Error! Reference source not found. and Error! Reference source not found., respectively. It shows that the first-lactation milk yield data was distributed normally and there was tendency of increasing milk production as season changed from dry to wet. Milk yield adjustment into standard 305 DIM was able to reduce data variation (coefficient of variation) of 35.20 % (from 40.94 to 26.53 %). Basic statistics of 305 DIM corrected and uncorrected milk yield are as presented in **Table 2**. This 305 DIM milk yield was much lower that those reported by [7] and [8] who reported that milk production of Holstein–Friesian breed were 6557 ± 1140.1 kg and 7480.06 ± 1592.12 kg, respectively. This difference could be due the climate as well as management factors applied to the population. Different selection pressure imposed by the breeder to the population could also result in different milk production. Compared to milk yield reported from a study of Holstein Friesian population in Thailand (4170.43 ± 249.77 kg) published by [9], result of the present study was slightly lower. Since the climate of Indonesia and Thailand are similar, this discrepancy of those milk yield could be due to management factors as well as the selection program imposed to the two populations

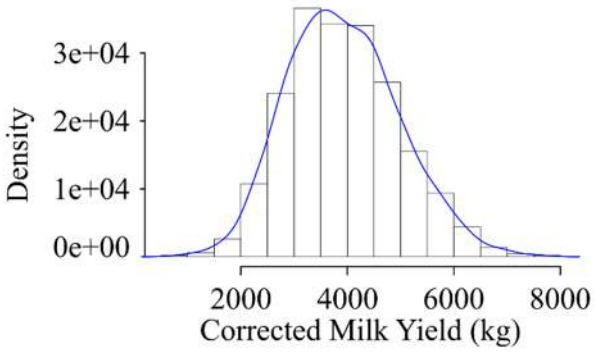

Figure 1. Histogram of milk yield of first parity

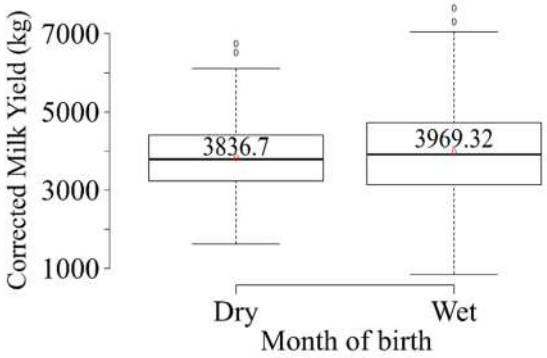

Figure 2. Boxplot of 2-categorisation season

From the factor analysis of year and season of birth on first parity milk yield using likelihood ratio test, it revealed that year and season were significant except for 12 categorization of season (**Table 3**). Result of the present agrees with the study of [10] that year of birth has significant effect on first-lactation milk yield. The effect of year of birth on first-lactation milk yield could come from different ways such as inbreeding level and genetic composition of the animals born on each different year and management decision applied to the population on each particular year. Since the population under study was dynamic where selection program is in operation, cows born in each year could have different genetic average and this could result in different milk yield.

Table 2. Basic statistics of first-lactation milk yield

Statistics	Milk Yield	
	Uncorrected	305 DIM corrected
Mean (kg)	4067.10	3925.25
Standard deviation (kg)	1665.22	1041.41
Coefficient of variation (%)	40.94	26.53

This indicated that between class variation caused by season categorization into 12 groups was not big enough in comparison with the residual variation. In contrast, the other season grouping of month of birth was able to capture more between group variation and thus its effect on first parity milk yield was highly significant ($P < 0.001$). Adult performance including milk production is determined by genetic merit of an individual inherited from its parents. In addition, permanent changes in the metabolism due to prenatal and postnatal environment may also affect the adult performance of animals [1]. Not only milk yield of the first lactation, animals body weight at first calving has also been shown to be influenced by postnatal environment during rearing [11]. Though the mechanism on how the early life affects the adult performance is shown to be ambiguous and thus deeper research needs to be conducted [12]. The effect of season of birth on milk yield of first parity probably is indirectly through season (amount of rain fall) and forage quality relation. Nutritional value of forage is significantly affected by harvest date and other factors such as farming management and rates of N fertilization [13]. It has been pointed out by [11] about the importance of early life period of cows especially dealing with body weight accretion. Animal's pre-weaning body weight is positively associated with milk yield on first lactation [14]. Even though [15] has reported opposite result that accelerated growth program will result in decreased milk yield of first parity. It is suggested that the decreased milk yield in an accelerated growth program could be due to the failure development of mammary [16]. Factors related the calf born such as its gender [17] which initiates lactation of the cow has also been shown to affect milk yield. The exact underlying mechanism of several effects such as photo period, temperature and nutritional status on milk yield is still elusive even though multiple hypotheses have been proposed [12]. Regardless of how season of birth affects milk yield of first parity, farm management during early life of animals are crucial and it cannot be overlooked.

Table 3. Significant level of the likelihood ratio test

Factors	Significance (*P*-value)
Year of birth	***
Season of birth	
12 categorization	ns
2 categorization	***
3 categorization	***
4 categorization	***

*** : $P < 0.001$
ns : not significant ($P > 0.05$)

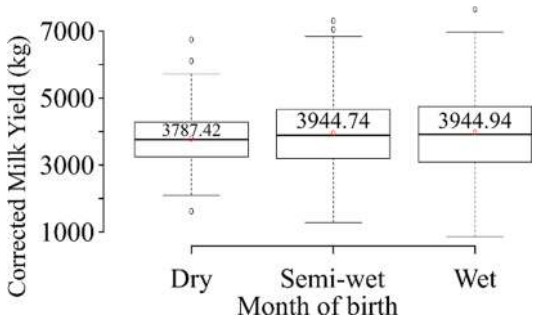

Figure 3. Boxplot of 3-categorisation season

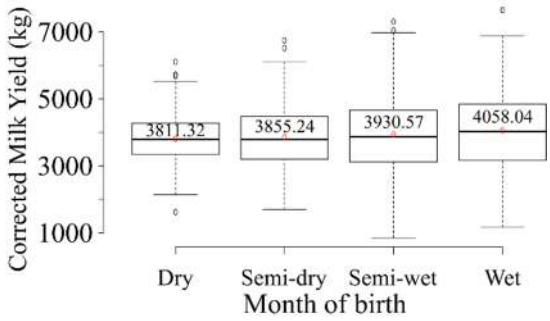

Figure 4. Boxplot of 4-categorisation season

4. Conclusion

Results of the present study indicated that year and season of birth (and its interaction) have important effect on first-lactation milk yield except for 12-season categorization. It is recommended that year and season of birth effect (2, 3 or 4 season categorization) should be put in the model of first-lactation milk yield analysis so that the trait would not be biased by these factors. Farm management during pre and postnatal are crucial and attention should be given so that optimum milk production can be achieved.

Acknowledgement

The authors thank the Director of Research and Community Services, Directorate General of Research Enhancement and Development, Ministry of Research, (Technology, and Higher Education and the Director of Research and Community Services Office, University of Jenderal Soedirman UNSOED) (contract document SK no. 059/SP2H/LT/DRPM/2018). The authors also thank the National Breeding Centre for Dairy Cattle and Forage of Indonesia (BBPTUHPT Baturraden) for providing data and the staffs who gave tremendous help in data collection.

References

[1] M. Hanson, K. M. Godfrey, K. A. Lillycrop, G. C. Burdge, and P. D. Gluckman. 2011. Developmental plasticity and developmental origins of non-communicable disease: Theoretical considerations and epigenetic mechanisms. *Prog. Biophys. Mol. Biol*. 106(1):272–280.

[2] S. Astiz, A. Gonzalez-Bulnes, F. Sebastian, O. Fargas, I. Cano, and P. Cuesta. 2014. Maternal aging affects life performance of progeny in a Holstein dairy cow model. *J. Dev. Orig. Health Dis*. 5(5):374–384.

[3] M. M. Kamal, M. Van Eetvelde, H. Bogaert, M. Hostens, L. Vandaele, M. Shamsuddin, and G. Opsomer. 2015. Environmental factors and dam characteristics associated with insulin sensitivity and insulin secretion in newborn Holstein calves. *J. Anim*. 9(9):1490–1499.

[4] S. A. Santosa, A. T. A. Sadewo, and A. Susanto. 2014. Penyusunan faktor koreksi produksi susu sapi perah. *Agripet*. 14(1):1–5.

[5] A. Zeileis and T. Hothorn. 2002. Diagnostic checking in regression relationships. *R News*. 2(3):7–10.

[6] RStudio Team. 2016. *RStudio: Integrated Development for R*. RStudio, Inc, Boston, MA URL http//www.rstudio.com/.

[7] F. Buckley, K. O'Sullivan, J. F. Mee, R. D. Evans, and P. Dillon. 2003. Relationships among milk yield, body condition, cow weight and reproduction in spring-calved Holstein-Friesians. *J. Dairy Sci*. 86(7):2308–19.

[8] T. Pritchard, M. Coffey, R. Mrode, and E. Wall. 2013. Genetic parameters for production, health, fertility and longevity traits in dairy cows. *J. Anim.* 7(01):34–46.

[9] A. Seangjun, S. Koonawootrittriron, and M. A. Elzo. 2009. Characterization of lactation patterns and milk yield in a multibreed dairy cattle population in the Central Thailand. *Kasetsart J. Nat. Sci*. 43(1):74–82.
[10] F. Soberon, E. Raffrenato, R. W. Everett, and M. E. Van Amburgh. 2012. Preweaning milk replacer intake and effects on long-term productivity of dairy calves. *J. Dairy Sci*. 95(2):783–793.
[11] A. Bach and J. Ahedo. 2008. Record keeping and economics of dairy heifers. *Vet. Clin. North Am. Food Anim. Pract*. 24(1):117–138.
[12] M. V. Eetvelde, M. M. Kamal, L. Vandaele, and G. Opsomer. 2017. Season of birth is associated with first-lactation milk yield in Holstein Friesian cattle. *Animal*. 11(12):2252–9.
[13] C. R. Johnson, B. A. Reiling, P. Mislevy, and M. B. Hall. 2001. Effects of nitrogen fertilization and harvest date on yield, digestibility, fiber, and protein fractions of tropical grasses. *J. Anim. Sci*. 79(9):2439–2448.
[14] F. Soberon, E. Raffrenato, R. W. Everett, and M. E. Van Amburgh. 2012. Preweaning milk replacer intake and effects on long-term productivity of dairy calves. *J. Dairy Sci*. 95(2):783–793.
[15] P. C. Hoffman, N. M. Brehm, S. G. Price, and A. Prill-Adams. 1996. Effect of accelerated postpubertal growth and early calving on lactation performance of primiparous Holstein heifers. *J. Dairy Sci*. 79(11):2024–2031.
[16] K. Sejrsen, J. T. Huber, H. A. Tucker, and R. M. Akers. 1982. Influence of nutrition on mammary development in pre- and postpubertal heifers. *J. Dairy Sci*. 65(5):793–800.
[17] K. Hinde, A. J. Carpenter, J. S. Clay, and B. J. Bradford. 2014. Holsteins favor heifers, not bulls: biased milk production programmed during pregnancy as a function of fetal sex. *PLoS ONE*. 9(2):e86169.