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Research article

Myanmar dairy production system and feasibility of establishing a genetic evaluation program

Khin Su Hlaing[a,b], Skorn Koonawootrittriron[a,*], Thanathip Suwanasopee[a], Mauricio A. Elzo[c]

[a] *Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand*

[b] *Livestock Breeding and Veterinary Department, Ministry of Agriculture, Livestock and Irrigation, Nay Pyi Taw, Myanmar*

[c] *Department of Animal Sciences, University of Florida, Gainesville, FL 32611-0910, USA*

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Abstract

This study aimed to characterize the current dairy production system in Myanmar and assess the feasibility of establishing a genetic evaluation program using information collected by dairy producers. Phenotypic and pedigree data from 728 individual animals were provided by eight dairy herds located in the Mandalay Region, the Yangon Region, and the Shan State of Myanmar. Data were assessed for correctness, completeness and genetic links among herds. Means and standard deviations (SD) values were computed for milk yield per day (AD), total lactation yield (TY) and lactation length (LL). Most cows had their sire (63.0%), dam (66.2%) or both parents (57.6%) identified. Cows with records were 12.0% for AD, 47.8% for TY and 13.6% for LL. Cows in the complete dataset produced 10.91 ± 3.23 kg/d for AD, 2,319.10 ± 1,221.93 kg for TY and 273.02 ± 90.71 d for LL. At farm level, mean and SD values ranged from 9.75 ± 5.12 kg/d to 12.75 ± 5.97 kg/d for AD, from 2,165.18 ± 1,556.94 kg to 3,367.85 ± 183.92 kg for TY and from 224.88 ± 155.42 d to 345.50 ± 78.03 d for LL. Although insufficient for a genetic evaluation, the information provided by dairy producers indicated that the basic infrastructure already existed. Thus, to develop a national genetic evaluation program, Myanmar needs to increase the number of participating dairy producers, herds and recorded cows, to improve the completeness and accuracy of individual animal phenotypic and pedigree records and to enhance the genetic connections among herds and contemporary groups through the use of common sires.

Introduction

Genetic evaluation program is an important practice for dairy cattle genetic improvement for economically important traits in many countries. This program provides more unbiased and accurate information, which supports efficient genetic selection and appropriate mating schemes, which both affect genetic progress within the population (Weigel et al., 2017; Konkruea et al., 2017). However, each genetic evaluation program depends on the considered genetic and non-genetic factors that might influence on the traits of individual animals in the population, as same as quantity and quality of the data that collected from individual cattle in the population. With different limitation and condition, especially farm size, usage of dairy sires, connection among contemporary groups (e.g., farm-year-season), and management style, genetic evaluation program of each population could be differed (Van Vleck, 1987; Kennedy and Trus, 1993; Koonawootrittriron and Elzo, 2010; Weigel et al., 2017).

* Corresponding author.
E-mail address: agrskk@ku.ac.th (S. Koonawootrittriron)

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Myanmar is a tropical country in Southeast Asia that has approximately 53.7 million people of whom 31.4% live in urban areas (Worldometer, 2020). Traditionally, people in this country drink tea or coffee with sweetened condensed milk early in the morning before breakfast. Commercial dairy farming and milk production have been promoted in Myanmar since 1990 (Win, 2013). Fresh milk has been advocated to improve growth and overall health; however, consumption has been limited primarily to infants and elderly people (Hinrichs, 2014). Conversely, the demand for processed dairy products (yogurt, cheese, butter, and puddings) among adults has increased, requiring increasingly larger amounts of raw milk for processing within the country (Lee et al., 2014).

The Myanmar government and the Myanmar Livestock Federation (private organization) play a major role in the promotion of commercial dairy cattle production and the dairy industry. According to the Livestock Breeding and Veterinary Department (LBVD), the total number of cattle in Myanmar was approximately 9.7 million in 2018. Most cattle (9.62 million) were used for draught, and only 1% (129,882 cattle, 31,850 holdings) was engaged in dairy production (Livestock Breeding and Veterinary Department, 2018). Local cattle in Myanmar originated from Zebu (*Bos indicus*) that are well adapted to tropical environmental conditions and are resistant to tropical diseases and external parasites, but their milk production is low. To increase the efficiency of milk production, local cattle have been crossed with genetically improved dairy breeds such as Holstein and Jersey. Upgrading local cattle to *Bos taurus* improved dairy breeds through artificial insemination has been supported throughout the country (National Consultative Committee, 2002).

Nearly all Myanmar dairy producers are small holders and the number of dairy cattle varies by geographic location. According to Livestock Breeding and Veterinary Department (2018), the three largest dairy production areas are the Mandalay Region (47,924 cattle, 16,665 holdings in the central dry zone), the Yangon Region (24,824 cattle, 2,181 holdings in the delta and coastal zone) and the Shan State (11,526 cattle, 2,036 holdings in the upland zone). Under the Köppen climate classification system (Beck et al., 2018), the Mandalay Region has a hot semi-arid climate in the central area and a tropical savanna climate in the northern and southern areas, the Yangon Region has a tropical monsoon climate and the Shan State has a temperate climate with dry winters and a hot summers. To identify the most suitable cattle for Myanmar production and environmental conditions, imported and local germplasm should be genetically evaluated under local conditions at the farm, regional and national levels. Thus, the objectives of this study were to characterize the current dairy production system in Myanmar and to assess the feasibility of establishing a genetic evaluation program for dairy traits using information from three traits collected by dairy producers.

Materials and Methods

Dairy production areas, farms and data

Information was utilized from individual cattle kept by dairy producers in the Mandalay Region, the Yangon Region and the Shan State, the three largest dairy production areas in Myanmar. In total, 15 dairy cattle farms (7, 6 and 2 in the Mandalay Region, the Yangon Region and the Shan State, respectively) were contacted because of their level of recognition and participation in activities of the LBVD. Unfortunately, only eight dairy farms (53%) agreed to participate and contribute with individual animal data, with three farms in the Mandalay Region (Patheingyi, Metila and Pyin Oo Lwin townships), four farms in the Yangon Region (Hmawbi and Mingalardon townships), and one farm in the Shan State (Naung Cho township).

The government and their foreign collaborators (Food and Agricultural Organization of the United Nations, New Zealand, Thailand) suggested data recording in Myanmar. Small farmers maintain data in record books, but commercial farmers prefer to store the data in Microsoft Excel spreadsheets. The number and type of data recorded varied by farm. Only two farms in the Mandalay Region and one farm in the Yangon Region provided data in the Microsoft Excel format. The remaining farms (five farms, 62.5%) sent photocopies of hand-written data form record books as attachments in emails. Subsequently, data from the photocopies were entered into Microsoft Excel spreadsheets. The data received from the eight participating dairy farms were combined into a single dataset containing information on 1,504 cows. Of these data, information on 776 cows (52% of the raw dataset) needed to be discarded because of missing, incorrect or unclear information, such as calving date earlier than conception date, calving at less than age 1 yr and incorrect or incomplete lactation records. Thus, the edited dataset contained phenotypic and pedigree information for 728 cows (48% of the raw dataset) from 8 dairy farms on 328 cows from 3 farms in the Mandalay Region, 235 cows from 4 farms in the Yangon Region and 165 cows from 1 farm in the Shan State that were used to characterize dairy traits and to assess the possibility of establishing a genetic evaluation program in Myanmar.

The edited dataset contained pedigree, performance and farm information. The pedigree information consisted of identification number (ID) of the cow, breed fraction of the cow, ID of the sire, breed fraction of the sire, ID of the dam, breed fraction of the dam, country of origin of the sire and birth date of the cow. Performance information contained calving date, lactation number of the cow, last artificial insemination (AI) date, ID of the last AI sire, number of AI after calving until conception, average milk yield per day (AD), total lactation yield (TY) and lactation length (LL). Farm information consisted of the farm ID and the names of the owner, township and region or state.

Calving years in the edited dataset spanned from 2005 to 2019, and lactation numbers ranged from 1 to 10. Seasons were classified as winter (November to February), summer (March to May), and rainy (June to October). Countries of origin of sires were Germany, Myanmar, New Zealand, Thailand, and the USA. Most cows had no information of breed fractions (84%). However, supplied phenotypic data for AD, TY and LL suggested that although most cows appeared to be crossbreds between the local breed used for dairy (Pyar Sein) and Holstein (H), there were some purebred cows of the parental breeds

(Pyar Sein and Holstein). Some cows had no identification of the sire (n = 269; 37%), dam (n = 246; 34%), or both sire and dam (n = 206; 28%). Only 419 cows (58%) had both the sire and the dam identified.

Dairy farm management

Farm visits and farmer interviews indicated that farm size, management and feeding regimes differed among participating producers in the Mandalay Region, the Yangon Region and the Shan State. Dairy farms in the Yangon Region were run by small operations with limited land area compared to dairy farms in the Mandalay Region and the Shan State. Dairy producers in the Yangon Region generally provided ready-made concentrate and roughage to their cattle twice a day. Limitations of land prevented most the Yangon Region dairy producers growing sufficient forage on their own farms. Thus, they cut roadside-grasses such as Napier (*Pennisetum purpureum*) and Para grass (*Brachiaria mutica*) on other communal lands and carried the freshly cut grass back to feed their cattle. Cotton seed cake, sesame seed cake, rice powder, bean powder, rice bran and brewer grain were provided as feed supplements. Some commercial dairy farms in the Yangon Region fed cows with premixes formulated by foreign projects, whereas other dairy producers in the Yangon Region preferred to purchase brewer grain from beer factories to feed their cattle.

Dairy farms in the Mandalay Region were larger than those in the Yangon Region. They normally used a free grazing system. Some commercial producers in the Mandalay Region kept their cows in barns with a ventilation system to reduce heat stress. Napier grass (*Pennisetum purpureum*) was commonly planted in small plots close to the farms. Legumes such as *Stylosanthes hamata* cv. Verano (Verano stylo), *Stylasanthes guianensis* (Thapra stylo) and *Leucaena leucocephala* (leucaena) were grown in combination with grasses. Other commercial farms in the Mandalay Region planted corn to make their own corn silage. Small producers in the Mandalay Region cut roadside-grasses from local trade areas and carried the fodder to their farms. There are three sugarcane factories in the Mandalay Region. Consequently, many dairy producers in that region bought sugarcane by-products to feed their cows.

Dairy producers on the Shan State farms utilized large areas of grassland and energy-rich and protein-rich by-products from agricultural factories within the state as feed resources for their cattle. In addition, these farmers planted corn and Guinea or Mombasa grass (*Megathyrsus maximus*). They also provided cattle with ready-made concentrates whose main ingredients were corn, wheat flour, bean flour and cotton seed cake.

Producers in all areas fed concentrate to cows at half the amount of milk produced per day. Roughages and water were provided *ad libitum*. During the dry season (winter and summer), when not enough grass was available, cows were supplemented with corn silage and rice straw. The main breeding goal was to increase the efficiency of milk production, with Holstein (H) being the breed of choice for crossbreeding purposes. Cows were artificially inseminated with either nationally produced semen from purebred and crossbred H sires (produced mainly by the LBVD) or with purebred semen imported from other countries (Germany, New Zealand, Thailand and the USA). Artificial insemination sires were chosen based on producers' experience and suggestions from LBVD officers. Mating was done primarily (90%) via artificial insemination performed by LBVD officers and secondarily (10%) via natural service sires depending on the decision of individual producers. Milking was conducted twice a day. Commercial dairy operations milked cows using milking machines, whereas smallholders milked their cows by hand. Vaccinations and disease prevention in all dairy farms were controlled by the LBVD. Every animal was dewormed twice a year.

Dairy producers separately recorded information for pedigree, calves born, feeding practices, mating, milk production, vaccinations, health care, income and expenditure. Producers recorded individual cattle information predominantly by entering it into forms or record books. Only three of the eight dairy producers entered their records into an electronic database (Microsoft Excel). Milk yield in Myanmar was measured in viss units and these were converted to kilograms (1 viss = 1.6 kg) for this study.

Traits and data analysis

The three traits investigated were average milk yield per day (AD), total lactation milk yield (TY) and lactation length (LL). Dairy producers supplied TY and LL records, while AD was computed by dividing TY by LL only for cows with known TY and LL.

Numbers of records, means, standard deviations, minimum values and maximum values were used to describe AD, TY and LL by dairy farm (numbered 1 to 8), dairy production area (Mandalay Region, Yangon Region and Shan State) for the complete dataset. Means for AD, TY and LL were used to compute differences between farms and between dairy production areas. Associations between AD, TY and LL were evaluated using Pearson's correlation coefficients. All data analyses were performed using the Statistical Analysis Software (SAS, 2002).

Farm visits, farmer interviews and pedigree and performance information from the eight participating dairy producers were used to assess the feasibility of establishing a genetic evaluation system in Myanmar.

Results and discussion

Numbers of animals and records

Table 1 presents the numbers and percentage of animals, pedigree records, cows with phenotypic records for all traits (AD, TY and LL) and cows with both phenotypic records for all traits and complete pedigree information (known sire and dam) in the eight dairy farms within the three dairy production areas and for all farms. The percentages of cows with one or both parents identified varied widely across farms. The percentages of cows with the sire identified fluctuated between 3.6% (farm 2) and 94.4% (farm 3) in the Mandalay Region and between 0% (farm 5) and 94.7% (farm 4) in the Yangon

Region, whereas 69.1% of cows had their sire identified in farm 8 from the Shan State. The percentage of cows with known dams was higher than the percentage of cows with known sires in most farms. Percentages of cows with known dams ranged from 87.2% (farm 1) to 97.2% (farm 3) in the Mandalay Region and from 0.1% (farm 5) to 97.1% (farm 6) in the Yangon Region and 53.3% of cows in farm 8 from the Shan State had their dam identified. Lastly, the percentage of cows with both parents identified ranged from 3.6% (farm 2) to 92.4% (farm 3) in the Mandalay Region and from 0% (farm 5) to 94.7% (farm 4) in the Yangon Region and 52.8% of cows had both parents identified in farm 8 from the Shan State.

The percentages of cows with phenotypic records for all traits (AD, TY and LL) also showed a wide variation among farms (Table 1). Percentages of cows with records for all three traits ranged from 0% (farm 3) to 14.5% (farm 2) in the Mandalay Region and from 0% (farm 7) to 93.9% (farm 5) in the Yangon Region. None of the cows on farm 8 from the Shan State had records for all traits. The three farms in the Mandalay Region and farm 8 from the Shan State had neither complete pedigree nor performance records and only 50% of the farms in the Yangon Region (68.6% of cows in farm 4 and 1.9% of cows in farm 6) had cows with complete pedigree and phenotypic information. Interestingly, none of the three farms with high percentages of sires and dams of cows identified (farms 3, 7 and 8) had phenotypic records for all traits. Conversely, farm 5 had 93.9% of cows with records for all traits (AD, YT and LL), although none of the cows had their sire identified and only 0.1% had the dam identified.

Although the number of farms in this study was small, these percentages indicated that some dairy producers in these areas were more interested in pedigree than in production information (farms 3, 7 and 8), whereas other producer were more focused on production than on pedigree data (farm 5), with the remaining producer considering both pedigree and performance data to be important for dairy operations (farm 4).

Breed composition

Improved dairy breeds such as Holstein (H), Jersey (J) and Kiwi (New Zealand H-J crossbreds) have been used to increase milk production in Myanmar through crossbreeding and upgrading programs with local cattle (Pyar Sein). Purebred and high percentage H crossbred cows (> 87.5% H) seemed to be preferred by Myanmar dairy producers. Dairy producers in the five farms in the Yangon Region and the Shan State recorded breed fractions for a small number of cows (n = 115; 15.8%), sires of cows (n = 36; 4.9%) and dams of cows (n = 48; 6.6%). Conversely, the three dairy producers in the Mandalay Region recorded no breed composition data on either cows or their parents. Cows in farm 8 from the Shan State had higher H fractions (88–99%) than cows from the four farms in the Yangon Region (50–75%). These H breed fractions suggested that cows on farm 8 were being upgraded to H and that dairy producers in farms 4, 5, 6 and 7 appeared to either prefer cows of the lower H fraction (75% H or less) or perhaps they were only in the second generation of the upgrading process. Dairy producers imported H semen from five countries for their upgrading programs (Germany, Myanmar, New Zealand, Thailand and the USA). If producers in the Yangon Region were interested in utilizing cows with intermediate to medium high H fractions for their dairy operations, then Thailand would be an excellent source of proven sires for a wide range of H fractions (50–98%; Dairy Farming Promotion Organization of Thailand, 2020). A major advantage of the Thai dairy sires is that their genomic estimated breeding values are based on the daughters of multiple H fractions performing under tropical conditions, which are similar to the tropical/subtropical conditions in Myanmar.

Sire representation and genetic connectedness across herds and years

There were 135 sires represented in the edited dataset; of these 68 (50.4%) had one daughter, 41 (30.3%) had 2–4 daughters, 19 (14.1%) had 5–10 daughters, 5 (3.7%) had 11–20 daughters and 2 (1.5%) had 35 daughters. In total, 190 cows (26.1%) from farms 2, 3, 4 and 8 had information on the country of origin of their sires: Germany (3 cows; 0.4%), New Zealand (44 cows; 6.0%), Thailand (124 cows; 17.0%), the USA (10 cows; 1.4%), and Myanmar (9 cows; 1.2%). Unfortunately, the performance of the daughters of these sires could not be assessed because their phenotypic records were either incomplete or non-existent.

Table 1 Numbers and percentages of cows, pedigree records, cows with phenotypes for all traits, cows with phenotypes for all traits and known sire and dam by dairy farm within and across production areas

Dairy Production Area	Farm	Number of cows	Cows with known			Cows with records for all traits (AD, TY, and LL)	Cows with records for all traits and known sire and dam
			Sire	Dam	Sire and dam		
Mandalay	1	156	20 (12.8%)	40 (87.2%)	20 (12.8%)	7 (4.5%)	0 (0%)
Region	2	28	1 (3.6%)	22 (96.4%)	1 (3.6%)	4 (14.5%)	0 (0%)
	3	144	136 (94.4%)	140 (97.2%)	133 (92.4%)	0 (0%)	0 (0%)
Yangon	4	57	54 (94.7%)	57 (100%)	54 (94.7%)	41 (71.9%)	39 (68.4%)
Region	5	33	0 (0%)	3 (0.1%)	0 (0%)	31 (93.9%)	0 (0%)
	6	104	93 (83.4%)	101 (97.1%)	93 (83.4%)	4 (3.9%)	2 (1.9%)
	7	41	41 (100%)	31 (75.6%)	31 (75.6%)	0 (0%)	0 (0%)
Shan State	8	165	114 (69.1%)	88 (53.3%)	87 (52.7%)	0 (0%)	0 (0%)
All	All	728	459 (63.0%)	482 (66.2%)	419 (57.6%)	87 (12.0%)	41 (5.6%)

AD = average milk yield per day; TY = total lactation milk yield (TY); LL = lactation length

Mating information of sires used in each of the eight farms in this study showed that no sire (purebred or crossbred H) was used across herds. Thus, there was no connectedness through sires among any of the farms in any of the three dairy production areas, as a desirable mating structure for genetic evaluation in populations composed of multiple subunits such as herds. However, there was some degree of connectedness across years. Although most of the sires had no calving year information for their daughters (n = 37; 27.4%) or they had daughters in one year only (n = 73; 54.1%), the remaining sires had daughters in two years (n = 22; 16.3%), three years (n = 2; 1.5%), and 5 years (n = 1; 0.6%). Genetic connectedness across herds through the use of sires in multiple herds and over several years is needed to make fair comparisons of their daughters across contemporary groups (usually defined as herd-year-season in dairy cattle populations, Van Vleck, 1987; Kennedy and Trus, 1993). However, this aspect can be quickly resolved in this population by using a few artificial insemination sires across multiple herds across dairy production areas in future years. The genetic connections created by these sires would link all animals in the population across herds and years.

Cow phenotypic performance within farms, dairy production areas and complete dataset

Table 2 presents the numbers and percentage of records, means, standard deviation, minimum and maximum values of AD, TY and LL for individual farms within dairy production areas and for the complete dataset. Only two out of three farms in the Mandalay Region and three out of four farms in the Yangon Region had phenotypic records for AD, TY and LL. Farm 8 from the Shan State reported only a small number of LL records, likely for a selected sample of cows; thus it was not considered further. Farm 1 in the Mandalay Region and farm 6 in the Yangon Region kept much higher percentages of TY records (96.8–100%) than records for AD (3.8–4.5%) and LL (3.8–5.1%). Farm 2 from the Mandalay Region kept twice as many TY records (32.1%) than AD (14.3%) and LL (17.9%) records. Farms 4 and 5 from the Yangon Region had the highest percentages of record keeping for AD, TY and LL (farm 4: 71.9%, 89.5%, 75.4% and farm 5: 93.9%, 100.0%, 93.9% for AD, TY and LL, respectively).

Table 2 Number and percentage of cows with trait records, mean, SD, minimum and maximum values for average milk yield per day (AD), total lactation milk yield (TY) and lactation length (LL) for each farm within region and the complete dataset

Dairy Production Area	Farm	Trait	Number and percentage of cows[1]	Mean ± SD	Minimum	Maximum
Mandalay Region	1	AD (kg/d)	7 (4.5%)	11.13 ± 4.40	7	19.9
		TY (kg)	151 (96.8%)	2,165.18 ± 1,556.94	34	6,518
		LL (day)	8 (5.1%)	224.88 ± 155.42	71	482
	2	AD (kg/d)	4 (14.3%)	9.75 ± 5.12	5.4	16.9
		TY (kg)	9 (32.1%)	2,741.78 ± 1,159.74	1,260	4,455
		LL (d)	5 (17.9%)	245.20 ± 36.13	198	277
	3	AD (kg/d)	0	-	-	-
		TY (kg)	0	-	-	-
		LL (d)	0	-	-	-
Yangon Region	4	AD (kg/d)	41 (71.9%)	10.12 ± 3.53	3.5	20.54
		TY (kg)	51 (89.5%)	2,298.25 ± 434.20	1,630	3,154
		LL (d)	43 (75.4%)	255.58 ± 102.21	150	584
	5	AD (kg/d)	31 (93.9%)	11.81 ± 0.91	9.5	13.4
		TY (kg)	33 (100.0%)	3,367.85 ± 183.92	2,983	3,777
		LL (d)	31 (93.9%)	286.19 ± 17.78	251	339
	6	AD (kg/d)	4 (3.8%)	12.75 ± 5.97	7	18
		TY (kg)	104 (100.0%)	2,183.46 ± 934.82	170	5,799
		LL (d)	4 (3.8%)	326.50 ± 109.38	211	463
	7	AD (kg/d)	0	-	-	-
		TY (kg)	0	-	-	-
		LL (d)	0	-	-	-
Shan State	8	AD (kg/d)	0	-	-	-
		TY (kg)	0	-	-	-
		LL (d)	8 (4.8%)	345.50 ± 78.03	296	535
All	All	AD (kg/d)	87 (12.0%)	10.91 ± 3.23	3.5	20.5
		TY (kg)	348 (47.8%)	2,319.10 ± 1,221.93	34	6,548
		LL (d)	99 (13.6%)	273.02 ± 90.71	71	584

[1]Percentages with respect to the number of cows on each farm

The AD was similar among farms (from 9.75 ± 5.12 kg/d for farm 2 from the Mandalay Region to 12.75 ± 5.97 kg/d for farm 6 in the Yangon Region). Conversely, the LL differed substantially among farms (from 224.88 ± 155.42 d for farm 1 in the Mandalay Region to 326.50 ± 109.38 d for farm 6 in the Yangon Region). Similarly, there was a wide range of TY across farms (from 2,165.18 ± 1,556.94 kg for farm 1 in the Mandalay Region to 3,367.85 ± 183.92 kg for farm 5 in the Yangon Region). Noticeably, the mean TY for farm 5 in the Yangon Region, was 1,184.39 kg higher than the mean TY for farm 6 also in the Yangon Region, although its mean LL was 40.31 d shorter than that of farm 6. The minimum values that were extremely low for TY (34 kg) and LL (71 d) of farm 1 in the Mandalay Region, and for TY (170 kg) of farm 6 in the Yangon Region (Table 2), were likely from Pyar Sein cows.

The very high maximum values of TY for farm 1 in the Mandalay Region (6,518 kg) and for farm 6 in the Yangon Region (5,799 kg), as well as the very long maximum values of LL for farm 1 in the Mandalay Region (482 d) and for farms 4 (584 d) and 6 (463 d) in the Yangon Region, were likely due to the well-fed and managed high percentage or purebred H cows. Assuming roughly similar H cow percentages and distribution of lactation years and seasons in these two herds, in the absence of specific information on farm feeding and management strategies, it could be speculated that the differences in intensity of management and feeding regimes likely determined the observed mean values for TY and LL in these two herds. The wide range of values for the three traits (AD, TY and LL) in all farms with phenotypic data (farms 1 and 2 in the Mandalay Region and farms 4, 5 and 6 in the Yangon Region) indicate that dairy producers in these herds were exploring alternative strategies to increase the level of productivity of their herds, producing H crossbred cows of multiple percentages, while testing suitable management and feeding regimes suitable to their production and economic goals.

The mean values of AD for farms 1, 2, 4, 5 and 6 in the Mandalay Region and Yangon Region (9.75 kg/d to 12.75 kg/d) were within the range of mean AD values reported for small, medium and large farms in Central Thailand composed of groups of multibreed cows (from low to high H percentages) of multiple ages and years of lactation (9.43 kg/d to 16.01 kg/d; Rhone et al., 2008; Yeamkong et al., 2010). Furthermore, the average AD found in the Mandalay Region was consistent Aung et al. (2015) who surveyed the dairy production system of 180 smallholders in the central dry zone of Myanmar. The reported average milk yield per day was in the range 8.3–9.9 kg in Amarapura township, and 10.7–15.7 kg in Tatar U township. The average dairy cattle per household was 4.4 head including milking cows, heifer and calves, while the percentages of cows were in the range 45.14–48.91 % in Amarapura township and 49.28–64.00 % in Tatar U township.

Table 3 shows numbers and percentages of cows with records for one or more traits (AD, TY and LL), and their corresponding values for the mean, SD, minimum and maximum by dairy production area and for the complete dataset. Dairy producers in the Mandalay Region recorded substantially larger percentages of AD (32.3%), TY (80.0%) and LL (33.2%) than dairy producers in the Yangon Region (AD, 3.4%; TY, 48.8%; and LL, 4.0%), indicating a higher level of commitment to increase the level of dairy production in the Mandalay Region. The overall percentages of cows with phenotypes in the complete dataset were substantially lower for AD (12.0%) and LL (13.6%) than for TY (47.8%), indicating that TY was the primary trait of interest for dairy producers across the three dairy producing areas. The sizeable standard deviations for all traits were likely a reflection of the small numbers of records and the variety of cow genetic backgrounds, lactation years and seasons, management and feeding conditions provided by the farmers participating in this study.

The mean and SD values of AD, TY and LL in the Mandalay Region (10.62 ± 4.50 kg/d, 2,197.60 ± 1,540.20 kg and 232.69 ± 120.96 d, respectively) were 3.0%, 9.3% and 16.6% lower than the corresponding values in the Yangon Region. Assuming roughly similar cow H percentages and distribution of lactations across years and seasons in the Mandalay and Yangon Regions, it can be surmised that on average, farms in the Mandalay Region had a less intensive

Table 3 Number and percentage of cows with trait records, mean, SD, minimum and maximum values for average milk yield per day (AD), total lactation milk yield (TY) and lactation length (LL) for each dairy production area and the complete dataset

Dairy Production Area	Trait	Number and percentage of cows[1]	Mean ± SD	Minimum	Maximum
Mandalay Region	AD (kg/d)	11 (3.4%)	10.62 ± 4.50	5.4	19.9
	TY (kg)	160 (48.8%)	2,197.60 ± 1,540.20	34	6,518
	LL (day)	13 (4.0%)	232.69 ± 120.96	71	482
Yangon Region	AD (kg/d)	76 (32.3%)	10.95 ± 3.04	3.5	20.5
	TY (kg)	188 (80.0%)	2,422.50 ± 854.52	170	5,799
	LL (d)	78 (33.2%)	279.12 ± 84.47	150	584
Shan State	AD (kg/d)	0 (0%)	-	-	-
	TY (kg)	0 (0%)	-	-	-
	LL (d)	8 (4.8%)	345.50 ± 78.03	296	535
All	AD (kg/d)	87 (12.0%)	10.91 ± 3.23	3.5	20.5
	TY (kg)	348 (47.8%)	2,319.10 ± 1,221.93	34	6,548
	LL (d)	99 (13.6%)	273.02 ± 90.71	71	584

[1]Percentages with respect to the number of cows in each dairy production area

system of feeding and management than farms in the Yangon Region. Furthermore, the ranges of AD found in this study were higher than those reported by Hinrichs et al. (2014). The average milk yield per day of a milking cows raised in Mandalay was in the range 3.2–11.2 kg/d, whereas the range of average milk yield of milking cows in Yangon was 3.2–8.96 kg/d.

Correlations between total lactation milk yield and lactation length

The correlation coefficient between TY and LL was 0.79 ($p < 0.01$) in the Mandalay Region, 0.17 ($p = 0.14$) in the Yangon Region and 0.36 ($p < 0.01$) for the complete dataset. The higher correlation estimates between TY and LL in the Mandalay Region (0.79) than in the Yangon Region (0.17) indicated that TY was more closely associated with LL in cows from farms in the Mandalay Region than cows from farms in the Yangon Region. A closer inspection of the mean TY and LL values per farm in Table 2 suggested that the low correlation between TY and LL was likely due to substantially longer LL for cows on farm 6 (71 d longer on average) than those on farm 4, although cows on these two farms had comparable TY values.

Feasibility of establishing a genetic evaluation program

The wide variation in the information supplied by the eight farms included in this study likely provided a reasonable representation of the current status of dairy production in terms of: 1) pedigree and performance data collection (small number of herds collecting data on a fraction of cows in the herd; incomplete pedigree and phenotypic data; mostly on paper rather than in electronic form); 2) breed composition of cows in farms and dairy production areas (mostly unavailable); 3) country of origin and breed composition of sires used on dairy farms (mostly unavailable); 4) genetic connectedness among herds and contemporary groups (non-existent); 5) databases at a farm, regional and national levels (non-existent); 6) dairy producer organizations (none reported); 7) genetic evaluation and selection programs (none); and 8) production, breeding and economic objectives of dairy producers (increase milk production through crossbreeding or upgrading to H; improve livelihood by increasing profitability through sales of milk and dairy products).

The analysis of the dairy information supplied for this study indicated that the current structure of the dairy industry in Myanmar contains the basic infrastructure to pursue a stepwise plan to develop and implement a genetic evaluation in Myanmar using producer-collected dairy information. To develop a national genetic evaluation program, Myanmar would need to: 1) increase the number of participating dairy producers, herds and recorded cows; 2) improve the completeness and accuracy of individual animal pedigree and phenotypic information; 3) enhance the genetic connections among herds and contemporary groups through the use of common sires by artificial insemination; 4) maintain accurate information on feeding, management and health practices at a farm level; 5) collect economic information to assess the impact of genetic improvement at the farm, regional and national levels; 6) develop a database with pedigree, phenotype, feeding, management, and health information, inputs, outputs, costs and returns from all animals in the population; 6) provide periodic training to personnel involved in dairy farm work including tasks related to the genetic evaluation program; and 7) promote an increase in the productivity, profitability, economic viability and sustainability of dairy cattle under an effective genetic evaluation and selection program. These practices will support unbiased comparisons among sires and dams in the Myanmar dairy cattle population, provide more accurate information for both genetic and management improvement and ensure the long-term survival of the Myanmar dairy industry.

The next step would be to develop a national genetic evaluation program, which requires scientific, technical and economic support from relevant universities (University of Veterinary Science and Yezin Agricultural University), government organizations (Livestock Breeding and Veterinary Department) and dairy industry organizations (Myanmar Livestock Federation, and Myanmar Dairy Association). A consortium involving all concerned stakeholders (dairy producers, government organizations, universities, industry organizations) would need to be developed to ensure its long-term success. Information from countries with similar environmental conditions would help decrease risks and speed up the development of the national genetic evaluation program in Myanmar.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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