論文題目　DEVELOPING SMALLHOLDER DAIRY BUFFALO FARM PRODUCTIVITY THROUGH IMPROVEMENT OF NUTRITION, BODY CONDITION, AND MILK PRODUCTION IN SOUTH LUZON, PHILIPPINES

氏　　名　SALUDES, Thelma Almendral

主論文の要約

The Philippine annual per capita milk consumption was 22 kg in 2017 and the national dairy consumption reached 2,486 MMT (LME) however, the domestic milk production was only at 22.76 MMT (LME). This huge demand compared to local supply presents a massive potential for local dairy sector development. Engaging smallholder farming families in small-scale milk production will make use of their existing livestock resources, address malnutrition, improve food security, provide additional sources of income, and eventually lead to poverty alleviation. The majority of this marginalized farming sector, having an average daily family income of less than US$7, lives in rural areas and commonly owns livestock such as carabaos. The Philippine carabao (*Bubalus bubalis*) is a large ruminant, mostly suited in rice cultivation and muddling, and classified as swamp-type, Asian water buffalo. Carabaos are mainly used for draught purposes and have low genetic potential for milk production but can be upgraded using the dairy buffalo germplasm. A crossbred buffalo provides premium milk averaging 5 kilograms daily for 10 months. Genetic development of dairy buffaloes is long and tedious. Alongside this, it is critical to determine multitudes of factors influencing farm and milk productivity. Understanding these vital determinants will help the government design appropriate strategies and programs for dairy buffalo farmers.

Chapter 2, entitled Bayesian analysis of factors influencing productivity of smallholder dairy buffalo farmers in south Luzon, Philippines, is the first local study to apply the Bayesian approach and analyzed the socio-economic, farm, and technology characteristics influencing milk productivity of smallholder dairy buffalo farmers. Cross-sectional data from individual household level interview using pre-tested, semi-structured questionnaire. The respondents were dairy buffalo farmers from General Trias, Cavite and Rosario, Batangas, having at least

one lactating cow, selling the milk to dairy processing plants, and belong to organized groups assisted by the PCC. Secondary data were gathered from routinely submitted reports from the dairy processing plants where all the farmers sell their milk. Data from 58 farmers, socio-economic information, farm information, and adopted technology information were collected. The empirical results revealed that among the socio-economic, farm, and technology characteristics investigated, the household size has a positive effect, the number of lactating dairy buffaloes, a negative effect, and the technology adoption of data recording a positive effect on milk productivity of dairy buffalo farmers rendering these factors critical in the analysis of milk productivity. To address these critical factors, it is recommended to regularly conduct training for smallholder farmers on dairy buffalo production and enterprise development, conduct further studies on technology adoption, and the development, and use of a dairy handbook or manual to serve as a guide and reference for better productivity.

The Philippine dairy industry is characterized by reproductive inefficiencies and low milk production mainly due to poor nutrition and management practices, compounded with high production costs. One of the basic technologies transferred by the Philippine Carabao Center to smallholder farmers is dairy buffalo nutrition and feeding management. A lactating cow requires a diet that supplies the nutrients to meet the demand of milk production. The commonly used subjective but effective technique for evaluating nutritional management is body condition scoring (BCS) system. Body condition changes as it moves through the stages of gestation, calving, and lactation. In many herds, the average is 1 point of body condition loss by 30 days in milk. It is critical that cows do not exceed this to prevent irregular heats, longer time to first ovulation, low conception rate, and less persistence in milk production. Rapid changes in body condition affects milk production, growth, animal health, and reproductive performance. A good nutrition program minimizes the variations between high and low body condition scores, ensuring that dairy cows have the appropriate body condition throughout the lactation cycle and make the necessary nutritional correction for apparent deficiencies.

The third chapter having the following title, the relationship of body condition scores to milk production in dairy buffaloes in PCC at UPLB is a retrospective study of body condition scores, milk yield, and lactation stage records of purebred and crossbred Murrah buffaloes raised under Philippine condition. This study aimed to determine the correlation between the body condition scores

of lactating dairy buffaloes and daily milk yield, effect of the month of observation, breed (purebred and crossbred), stage of lactation, and climatic parameters (temperature, relative humidity, and rainfall) to body condition score and daily milk yield. The visual assessments developed for Murrah buffalo were used in BCS determination by a PCC trained researcher. To come up with a body condition score, each animal was visually assessed by a using the eight skeletal checkpoints. Based on the amount of body fat reserves on these anatomical features, body condition scores were determined using a 5-point scale with 0.5 increments. A BCS of 1 indicates emaciation, BCS 2 indicates thin, BCS 3 indicates average, BCS 4 indicates fat, and BCS 5 indicates an obese condition. Body condition scoring of each cow was done weekly every Mondays and Wednesdays before milking in the afternoon. Records of body condition scores and milk production of 34 apparently healthy lactating dairy buffaloes, 21 purebred Murrah, and 13 crossbreds (Murrrah x Carabao) for 12 months were used and analyzed in the study. The crossbreds have the following blood compositions and number of heads: 93.75% x 6.25% (1), 87.5% x 12.5% (5), 75% x 25%C (1), and 50% x 50% (6) aged 3 to 6 years old and having 2nd to 4th parities, respectively. The animals were also classified according to their lactation stage, i.e., early (0 to 100 days), mid (101 to 200 days), late (more than 200 days), and their breed (purebred and crossbred). Significant correlations ($P<0.01$) between all parameters except for rainfall were found. BCS was negatively correlated ($r = -0.2305$) to milk yield and affected milk yield by 0.8583 kg/day per unit change in BCS. Milk yield was affected by early lactation positively ($r = 0.3962$) while BCS negatively ($r = -0.2627$). In the early lactation stage, the estimated rate (b=slope) of the increase and decrease for milk yield was 1.5194 kg/day and 0.2667 units in BCS, respectively. The relationship of the breed to BCS and milk yield were significant. The milk yield was positively affected in purebred ($r= 0.1160$) and negatively in BCS ($r= -0.1444$). The purebred produced significantly ($P<0.01$) more milk (5.44 kg/day) than crossbred (4.98 kg/day) in the overall period. The highest milk yield was observed both in March for purebred (6.40 kg/day) and crossbred (5.99 kg/day) while the lowest in August (4.82) and October (4.23) for purebred and crossbred, respectively. BCS and milk yield were positively correlated ($P<0.01$) with temperature while negatively for relative humidity. The amount of rainfall was found not to affect BCS and milk yield. In conclusion,the body condition scores, stages of lactation, breed, temperature, and relative humidity affect milk production. A practical recommendation would be to look at BCS during specific periods such as breeding, calving, 60- and 90-days post-

calving, and drying-off. The information obtained would benefit the dairy buffalo farmers to improve animal management and milk productivity.

Synonymous to excellent animal nutrition program is high quality forages. Forages are the cheapest feed source providing significant nutrients needed for milk production. Producing milk is one of the most energy demanding biological processes, and the best way of improving the quantity and quality of milk, live weight, health, and fertility, is to provide dairy cows with the highest quality, well-balanced and palatable feeds. A stable daily supply of high-quality fodder is crucial in maximizing the potential of dairy animals for higher milk productivity. Though local forage is abundant in the tropics like the Philippines, feeding a dairy herd is dependent on the seasonality of forage production. Forages are abundant in the rainy seasons but inadequate in dry months. Improved pasture management, high soil fertility, and forage nurseries are required to achieve a continuous and ample supply of good-quality forages for better livestock nutrition. Dairy farmers must be intentional in growing their own fodder to ensure the daily availability of feeds for their stocks all year round. Sweet Sorghum and Mombasa were chosen in our quest for tropical forages with outstanding performance because they are both highly suitable under the Philippine condition. Moreover, Sweet Sorghum has outstanding characteristics and performance and is often referred to as a smart crop because of its multitude uses from being human and animal food source to construction material, ethanol, biofuel, and bioenergy crops (Sweet Sorghum, 2019). Its adaptation to limiting growth conditions, drought, and limiting nitrogen, allows sorghum to grow in extensive cropping conditions. On the other hand, Mombasa has a vigorous upright growth habit similar to the hybrid Napier grass but leafier and very suitable for grazing, cut-and-carry, and silage and has high palatability when used as animal feed It is defined to have high nutritive value with crude protein levels of 8-14% and dry matter yield of 17-28%. Aside from resilience to drought, it is also shade and cold tolerant. In addition to the good innate traits of these forage grasses, there is still enormous potential for improvement by increasing dry matter yield and nutritional content. One of the ways to improve forage production is through fertilization. Commercial chemical fertilizers like urea are costly, while buffalo manure is a daily farm organic waste that may be explored as a substitute. Waste management allows the recycling of animal manure to replace, partly or in whole, chemical fertilizers without decreasing crop production and sustainability. High quality forages translate into greater dry matter intake, increased digestibility, higher diet inclusion rate, more outstanding nutrient contribution to the diet, and improve milk yield and

composition to produce premium buffalo milk.

Chapter 4 is entitled Effect of Fertilization on Dry Matter Content, Nutrient Composition, and *In Sacco* Degradation of Sweet Sorghum (*Sorghum bicolor* (L.) Moench) and Mombasa Guinea Grass (*Panicum maximum* Jacq. cv. 'Mombasa'). This study evaluated the performance of Sweet Sorghum and Mombasa forage grasses fertilized with urea and raw buffalo manure by comparing the dry matter content per hectare, nutrient composition (crude protein, crude fiber, neutral detergent fiber, and acid detergent fiber), and rumen digestibility using *in sacco* degradation. The split-plot design was used for this study. The size of each plot was 4 meters x 3 meters (12 m2). The distance between plots was 1 meter. The distance between replicates was 2 meters. The lay-out is shown in figure 1 where the vertical factors are the 2 forages (Mombasa and Sweet Sorghum), and the horizontal factors are the different fertilizer treatments with 4 replications. Sweet Sorghum attained higher ($P < 0.05$) dry matter yield per hectare in the main and first ratoon crop. Forage crops fertilized with urea alone and a combination of urea and buffalo manure attained the highest ($P < 0.05$) dry matter yield in the first and second ratoon crop. Nutrient composition (crude protein and crude fiber), including detergent fibers of Mombasa and Sweet Sorghum with fertilizer treatments, were affected ($P< 0.05$) by fertilizer applications in the main and ratoon crops. However, acid detergent fiber was unaffected ($P < 0.05$) in all harvest periods. There were no significant differences in the means of dry matter (%) digestibility, crude protein (%) digestibility, neutral detergent (%) digestibility, and effective digestibility ($P < 0.05$) observed between Mombasa and Sweet Sorghum. Mombasa is a highly recommended forage crop because it is cheaper to establish and very stable with minimal management. Sweet Sorghum can be used as a substitute for feeding when Mombasa is not available. Recommendations for further studies include evaluation of other high-value forage grasses and fertilizer sources and rates to find more efficient forage crops for animal production.

To further investigate Sweet Sorghum and Mombasa, the final chapter entitled, Comparative Effects of Sweet Sorghum (*Sorghum bicolor* L. Moench) and Mombasa Guinea Grass (*Panicum maximum* Jacq. cv. 'Mombasa') to Milk Yield and Milk Composition of Dairy Buffaloes in the Philippines, compared the effects of feeding Sweet Sorghum and Mombasa to lactating buffalo milk yield, composition, and property. A total of 20 lactating dairy buffaloes were kept in individual research pens and grouped into three. Each group was fed separately with Treatment 1 (Sweet Sorghum), Treatment 2 (Mombasa), and Control (Napier) 45

days. Milk was collected individually, twice a day in the morning and afternoon. Milk samples were analyzed for fat, lactose, protein, milk solids-not-fat, total solids, and freezing point. The time of milk collection significantly affected dairy buffalo milk fat. Milk collected in the morning contained less fat (p-value < 0.0001) than milk collected in the afternoon. Morning milk from Mombasa-fed buffaloes has a higher fat content. Morning milk has significantly (p-value = 0.0007) higher protein compared to afternoon collection. There is a larger (p-value = 0.0005) percentage of SNF in morning milk compared to afternoon collection. Morning milk contained less (p-value < 0.0001) total solids than collected milk in the afternoon. There is no evidence to support that the treatments or time of collection significantly affected lactose. The freezing point of dairy buffalo milk collected in the morning is lower than afternoon milk. It is highly recommended for dairy buffalo farmers to perform twice a day milk collection to maximize the premium quality of buffalo milk. Future prospects would include investigating other kinds of forages and also legumes and longer feeding trial in order to increase the chance of observing evident effect on milk production and composition.