Feature Article

Beef cattle production system capacity considerations for improved food security: A case study in Myanmar

Andy D. Herring,[†] Ai Thanda Kyaw,[‡] and Thet Khaing[‡]

[†]Department of Animal Science, Texas A&M University, College Station, TX 77843
[‡]USAID-funded Asia Farmer-to-Farmer Program, Winrock International, Kyee Myin Daing Township, Yangon 11101, Myanmar

Implications

- Natural resources and value-added opportunities exist in Myanmar for improved food security and beef industry development.
- Nutrition currently limits animal reproduction and growth; reassessment of Myanmar land use policy and development of grazing opportunities are needed for reduced feed and labor costs, and dietary improvement.
- Standardized cattle trait recording along with live animal and carcass classification would improve value-added marketing and management opportunities throughout the supply chain.
- Education of cattle farmers and farm youth is needed for fundamental animal and business management principles; technical information should be delivered through "Train-the-Trainer" type programs.

Key words: beef value chains, cow fertility, developing countries, farmer education, grazing land use policy

Introduction

Myanmar is one of the most underdeveloped nations of the world. The economy is heavily based on agriculture, and cattle are used throughout the country for draft, particularly by farmers. Among 4,000 rural Myanmar households, 71% reported some months of the preceding 12 when their households did not have enough food (LIFT, 2012). Immediate export demand of Myanmar live cattle to China, Malaysia, and Thailand markets is currently a large priority for many local economies, but new domestic markets for value-added beef products are developing. Myanmar's national economy is also rapidly developing, and there is great potential to increase food security and food quality in cattle and other livestock industries. Education of farmers and livestock officials is needed for improvements in production and marketing efficiency, and economic empowerment. In this case report, we discuss several scenarios and observations regarding the Myanmar cattle industry in combination with broad-scale beef cattle production systems considerations that can be applied for long-term sustainability in developing nations, regions, or individual operations. Most of the concepts discussed here are also important for sustainable beef cattle production systems globally.

doi: 10.1093/af/vfy010

Systems (Holistic) Concepts for Beef Value Chains

An objective resulting from a multination assessment of Myanmar is to increase livestock production for both consumption and sale to support food security and income (LIFT, 2012). Livestock production systems are more suitable socially, economically, and culturally when considering the welfare of local communities (FAO, 2017) and can improve food security within those communities. Approximately 1 billion people worldwide rely on smallholder livestock production in developing countries (FAO, 2017), and smallholder cattle farmers are prevalent in Myanmar (Figure 1). Livestock production increases have been associated with science and technology as well as increased animal numbers (Thornton, 2010). Emphasis on output-type traits has historically driven production increases in all food animal species. The foundation for both short-term and long-term success for sustainable cattle production must be considered (Figure 2). If these priorities get out of order, production costs increase and production efficiency decreases.

Animal numbers drive supplies and production capacity. Increased numbers of market animals can result from larger herds, or, more efficient herds (Table 1) and dictates economic potential for individual farmers, and well as the overall industry. A sustained supply of animals is important to farmer income and customer business throughout all value chains.

Another important realization for sustained improvement is the interrelationships and potential interactions among animal

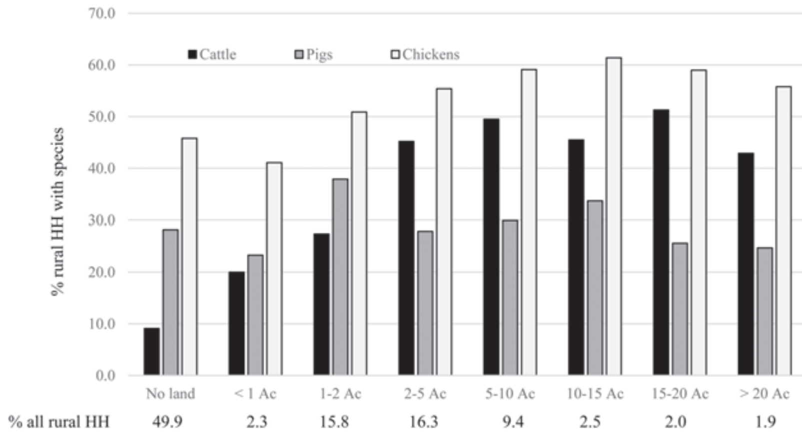

Figure 1. Distribution of Myanmar rural households (HH) with cattle, pigs, and chickens across land holding size categories. Small ruminants and horses are found in 1% to 3%; buffalo and duck incidences increase when landholdings are ≥5 acres (LIFT, 2012).

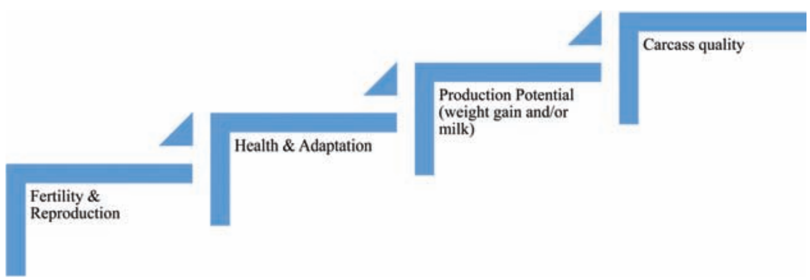

Figure 2. Recommended sequential steps in developing a profitable and sustainable beef production system. It could be argued that health and adaptation is the first level of emphasis in the most harsh environments.

traits, as well as the potential for genetic–environment interactions. This systems style of thinking also extends beyond the animal traits for consideration of optimal genetic-management-market combinations. Some specific observations and considerations for these cattle production traits that will influence production capacity and sustainability for a developing beef industry in Myanmar are described here.

Reproduction Considerations

Cow herd fertility drives profit potential; length of reproductive lifespan is economically important (Hudson and Van Vleck, 1981; Tanida et al., 1988; Snelling et al., 1995), and increased reproductive longevity from crossbred cows has been widely documented (Bailey, 1991; Núñez-Dominguez et al., 1991; Riley et al., 2001). With higher reproductive rates, there is greater potential for genetic improvement as well as profit potential.

Because typical Myanmar heifers first calve at 36 to 48 mo of age, and then produce a calf every other year (24-mo calving interval), female reproductive efficiency needs to be a priority for improvement. An index was evaluated by Siller (2017) as a standard benchmark useful for the tropics where I = 2 − (cow age in years − 2)/number of calves born. This approach calculates a value of 1.00 for cows calving first at 3 yr age, with annual subsequent calving (a cow that is 5 yr old, and has produced two calves would have calculated index value of 2 − (5 − 2)/2 = 0.50, etc.). Table 2 shows example index values across cow ages and calf numbers.

Both reproductive performance (male and female) and nutritional management are key points in dictating economic potential for farmers as well as development potential of a beef cattle supply chain. Table 3 shows projected costs associated with cow reproductive performance regarding the age of first calving and time between calves born. Identification and tracking of individual animal performance are important to identify the most productive and least productive individuals. However, to make full use of these individual differences, pedigree information (sire and dam) needs to be accurately recorded to identify and propagate desirable family lines and de-emphasize undesirable family lines.

Genetic Resources

Reproduction is influenced by favorable combinations of nutrition, health, and genetics. The local type of Myanmar cattle are Asian Zebu (*Bos indicus*) and are predominantly gray (Pyer Sein) or red in color (referred to as Shwe Ni). Cattle have been traditionally bred and managed for draft. These animals are well-adapted to the local environment regarding heat and parasite tolerance, which are very important considerations for a sustained beef industry. However, local cattle traditionally used for draft lack degree of muscularity required by most beef carcass buyers and processors.

Table 1. Potential surplus animals for marketing or herd expansion relative to reproduction and survival in cow herds

Number (or %) of breeding age females—cow herd base	Rate of breeding cow herd used for next calf crop	Calf crop born rate	Calf survival rate from birth to weaning	Calf crop weaned rate	Survival rate weaning to breeding & market	Rate for female calves kept as replacements	Surplus male progeny	Surplus female progeny	Total surplus progeny	Scenario description
100	0.94	0.91	0.96	0.87	0.96	0.15	42	37	79	High fertility and survival rates allows for more surplus animals to be produced
100	0.88	0.87	0.93	0.81	0.95	0.30	38	28	66	Adequate fertility, good survival rates
100	0.85	0.85	0.92	0.78	0.98	0.38	38	24	62	Adequate fertility, negligible fetal losses, and good survival rates
100	0.78	0.75	0.90	0.68	0.94	0.70	32	10	42	Marginal fertility, adequate survival rates
100	0.76	0.74	0.80	0.59	0.80	1.00	24	0	24	High calf losses from birth to weaning (20%) and weaning to breeding age (20%)

Scenarios that allow for maintaining a set, constant number of breeding females. Assumptions: 1) 50:50 sex ratio of calves born, 2) mature cows are removed from herd when found to be nonpregnant. Within each scenario, lower levels of performance will reduce breeding herd size; however, increased performance levels within each scenario allow potential for increased herd size, and/or generation of additional surplus animals.

Light-colored gray cattle seem to be preferred among the farmers that use cattle for draft. However, Myanmar cattle traders that sell to Chinese export markets have indicated that the darker color animals are preferred. Chinese export buyers also prefer solid-colored cattle (such as black, brown, red, etc.), but discount cattle that are two-colored (such as have white spotting).

For the long-term success of an industry, providing farmers access to several breeds enables opportunities for producing many different crosses to tailor breeding programs to local regions, and also helps prevent inbreeding in the future. Keeping track of pedigree information is also needed to help prevent inbreeding. Hybrid vigor also is highly beneficial for both fertility and health, and crossbreeding programs offer commercial (non-seedstock) producers large advantages over purebred (non-crossbred) animals; increased weight of calves weaned per cow exposed to breeding may be increased by 40% or more when *Bos indicus–Bos taurus* crosses are properly utilized. Genetic improvement is one factor that can be equally shared across all sizes of operations.

Animal Health and Management Considerations

Diseases have not been thought to be the most important livestock production constraints in southeast Asian countries; however, poor veterinary inputs and services have been important limitations for improvements (Devendra et al., 1997). Common cattle diseases found in Myanmar include Foot and Mouth Disease, hemorrhagic septicemia, anthrax, and blackleg (*Clostridium chauvoei*). Common parasite concerns for Myanmar cattle include ticks carrying babesiosis and liver flukes. It is common that Myanmar calves are first vaccinated at 2 to 3 mo of age for hemorrhagic septicemia and anthrax, 6 mo of age for FMD, and 12 mo of age for blackleg. As production increases and animal values rise, continual and regularly scheduled reassessment of health and vaccination programs is recommended. Myanmar livestock vaccination and health management is overseen by the Livestock Breeding and Veterinary Department, with one veterinarian responsible for each township.

Use of locally adapted genetic resources is critical for adaptation and animal health. For instance, Jonsson et al. (2008) reported cases caused by *Babesia bovis* in northern Australia to be 5% in *B. indicus*, 9% in *B. indicus* crossbreds, and 48% in *B. taurus*. Thus, conservation of Myanmar cattle genetics should be considered for future breeding programs. It is recommended that a portion of the Myanmar local cattle be evaluated with genomic tools and compared to other populations before large-scale breeding objectives are established. New composite breed development should consider the merits of local breeds as well.

Nutritional Inputs

Valuable feedstuffs are available for cattle feeding in Myanmar, however most cattle feedstuffs are low-nutrient crop

Table 2. Cow reproductive productivity index example values relative to age and number of calves

Cow age	No. calves	Index	Cow age	No. calves	Index	Cow age	No. calves	Index
Tier 1 fertility level—high								
2	1	2.00	2	0		2	1	2.00
3	2	1.50	3	1	1.00	3	1	1.00
4	3	1.33	4	2	1.00	4	2	1.00
5	4	1.25	5	3	1.00	5	3	1.00
6	5	1.20	6	4	1.00	6	4	1.00
7	6	1.17	7	5	1.00	7	5	1.00
8	7	1.14	8	6	1.00	8	6	1.00
9	8	1.13	9	7	1.00	9	7	1.00
10	9	1.11	10	8	1.00	10	8	1.00
11	10	1.10	11	9	1.00	11	9	1.00
12	11	1.09	12	10	1.00	12	10	1.00
13	12	1.08	13	11	1.00	13	11	1.00
Cows that first calved at 2 yr and had a calf every year			Cows that first calved at 3 yr and had a calf every year since			Cows that calve at 2 yr, but do not breed back to calve at 3 yr, then calve each year		
Tier 2 fertility level—adequate								
3	1	1.00	3	1	1.00	3	0	.
4	2	1.00	4	1	0.00	4	1	0.00
5	3	1.00	5	2	0.50	5	2	0.50
6	3	0.67	6	3	0.67	6	3	0.67
7	4	0.75	7	4	0.75	7	4	0.75
8	5	0.80	8	5	0.80	8	5	0.80
9	6	0.83	9	6	0.83	9	6	0.83
10	7	0.86	10	7	0.86	10	7	0.86
11	7	0.71	11	8	0.88	11	8	0.88
12	8	0.75	12	9	0.89	12	9	0.89
13	9	0.78	13	10	0.90	13	10	0.90
Cows that first calve at 3 yr and then skip one more calf			Cows calve at 3 yr, skip at 4 yr, and then breed back each year			Cows that first calve at 4 yr and have a calf each year afterward		
Tier 3 fertility level—substandard								
3	0		3	1	1.00	3	1	1.00
4	0		4	2	1.00	4	1	0.00
5	1	−1.00	5	2	0.50	5	2	0.50
6	2	0.00	6	3	0.67	6	2	0.00
7	3	0.33	7	3	0.33	7	3	0.33
8	4	0.50	8	4	0.50	8	3	0.00
9	5	0.60	9	4	0.25	9	4	0.25
10	6	0.67	10	5	0.40	10	4	0.00
11	7	0.71	11	5	0.20	11	5	0.20
12	8	0.75	12	6	0.33	12	5	0.00
13	9	0.78	13	6	0.17	13	6	0.17
Cows that first calve at 5 yr and have a calf every year afterward			Cows that first calve at 2 yr and have a calf every other year			Cows that calve at 3 yr, and then have a calf every other year		

residues, namely rice straw and corn stover, and cut-and-carry forage from along roadways. Protein-supplement feeds such as sesame cake, peanut cake, and cottonseed meal are available regionally. The biggest animal nutritional challenge seems to be lack of access to grazing lands and no or very limited grains or forage crops grown for cattle feed sources. It is now widely recognized in human health that proper nutrition during the first 1,000 d of life (starting at conception) is critical for proper long-term physical development and health. Recent research has also shown that gestational influences (fetal programming) are very important for growth, development, and fertility later in life in cattle and small ruminants.

An educational need in Myanmar is delivery of accurate information about basic nutritional and feeding management for cattle. Protection of feeds from spoilage to maintain high quality without nutrient losses is needed for smallholders and commercial farmers to maintain adequate animal diets across dry seasons to provide consistency of performance, with adequate forage protection during monsoon seasons as well. Development of a livestock feeding–allied industry that offers feed choices, as well as processing and storage options, could also help strengthen rural economies as new industry components. Many cattle farmers and buyers in Myanmar desire cattle with greater growth rates and BW for increased production, but they must also address the increased accompanying nutritional demands.

Animal Physical Size and Body Condition

The mature size and body composition affect multiple facets of the beef value chain. The Chinese export buyers of Myanmar cattle prefer animals that will produce at least 100 Viss (160 kg) carcass weight (1 Viss = 1.64 kg). These buyers also prefer bulls to steers and do not expect or desire females (due to smaller size, leanness, and less muscle). Regarding the carcass weights of these animals, the physical conformation is not that important at present (250 kg carcass from taller, less muscular animal is valued the same as a 250 kg carcass from smaller, more muscular animal). The typical dressing percentage for Myanmar cattle at harvest is not known but appears to be 50% to 53% with 3 to 5 mm of 12th-rib fat thickness, based on our field observations. We observed several cattle farmers who obtained acceptable growth rates and carcass traits when utilizing knowledge-based feeding programs for value-added markets.

Carcass weight can be increased in three ways: 1) have bigger cattle, 2) have more muscular cattle, and 3) have fatter cattle. Table 4 shows typical expected live weights from various carcass weights and dressing percentages. It may be more economically and environmentally viable to have fewer animals that are well-fed and managed than simply having more animals for increased beef production. Cattle that have ability to deposit and maintain body condition can have less required time to market and improved beef carcass quality without jeopardizing female fertility and longevity. Simply having larger mature size cattle in an attempt to increase overall production without consideration of fertility, adaptation, and production costs is highly discouraged. Example target weights for cattle are described in Table 5.

Low BCS is the main limitation for beef female reproductive efficiency among all genetic backgrounds (Herd and Sprott, 1986; Rae et al., 1993; Funston, 2014) and is a function of reduced nutritional inputs. Improved body condition of animals during growth and development would have beneficial effects on both reproductive performance and a reduced time to produce acceptable animals to market as young live animals and as carcasses. Systematic documentation of animal weight and body condition, in combination with individual animal identification, is recommended among breeding females.

Beef Quality Assurance Concepts (Best Management Practices)

The U.S. National Cattlemen's Association introduced its Beef Quality Assurance (**BQA**) program in 1982 to address concerns of avoiding residues in beef (Bredahl et al., 2001). When

Table 3. Cow input costs relative to age at first calving and subsequent calving interval lengths required to produce five calves

Age at first calving: 3 yr (1,095 d)		Age at first calving: 4 yr (1,460 d)	
Calving interval (d)	Total cost per cow ($)	Calving interval (d)	Total cost per cow ($)
375	1,739	375	1,983
400	1,806	400	2,050
425	1,873	425	2,117
450	1,940	450	2,184
475	2,007	475	2,251
500	2,074	500	2,318
525	2,141	525	2,385
550	2,208	550	2,452
575	2,275	575	2,519
600	2,342	600	2,586
625	2,409	625	2,653
650	2,476	650	2,720
675	2,543	675	2,787
700	2,610	700	2,854
725	2,677	725	2,921

Assumptions: $0.67 (1,000 Myanmar Ks) per day ($245 per year) for costs through cow lifespan.

Table 4. Expected cattle live weights based on target carcass weights and different dressing percentages

Carcass weight (kg)	Live weight (kg) with 50% DR	Live weight (kg) with 55% DR	Live weight (kg) with 60% DR
160	320	290.9	266.7
200	400	363.6	333.3
250	500	454.5	416.7
300	600	545.5	500.0

better-quality carcass beef and associated by-products reach their target customers, buyers are more confident in the products they purchase. In turn, market acceptance increases, along with potential for market growth, and these value-added improvements can occur throughout the production process (from the cow herd through the processing plant). Polkinghorne and Thompson (2010) reviewed data from Australia, Korea, Ireland, United States, Japan, and South Africa and showed that consumers across diverse cultures and nationalities had similar views of beef eating quality. These authors also found that consumers will pay higher prices for better eating quality and that this trend was consistent across demographic levels and meat preferences. Additionally, international consumers have increasingly demanded traceability of meat products (Pendell et al., 2010). The growing Myanmar tourist industry is currently providing economic incentives for traceability and quality (Figure 3). The concept of value-added does not only apply to the final product but also to the intermediate process and animals throughout the system.

Infrastructure Considerations

Table 6 provides some comparative values of Myanmar to North American countries for some societal, economic, and agricultural data. As typical in developing countries, a much higher percentage of the population is involved in agriculture, and a much higher percentage of GDP is agriculture-based than developed countries.

Potential ways to incentivize the entire industry are likely the most economically sustainable (a rising tide lifts all boats). One of the drastic differences in comparing Myanmar to these North American countries is the low amount of permanent pastureland nationally. The natural resources of Myanmar are very valuable and conducive to a prosperous beef cattle industry. Adequate rainfall and land areas exist for row crops and well as forage crops. However, many areas that appear to be useful for cattle grazing without altering the environment are not accessible due to national land use policy. Sixty-eight percent of Myanmar rural households have less than 1 ha of land (LIFT, 2012).

Land use is highly regulated in Myanmar. Regarding MNLUP (2016) basic principles, Part (I) Chapter III section 8 (l) "To permit freedom of crop selection and adoption of cultivation technologies in a way that will not negatively affect the environment"; 8 (n) "To decentralize decision making related to land"; and 8 (p) "To address the impacts of climate change and natural disasters". The improved use of

Figure 3. Meat shop at a food market in Yangon. These markets are open 6:30 to 10:00 5 or 6 days a week. Many people buy their food daily because they have little storage area in their homes or the have little to no refrigeration for perishable foods. The gentleman is Zayar Chit Sein, and his meat market purchases and fabricates three beef sides per day. He supplies some restaurants and hotels in Yangon.

Table 5. Example target cattle weights (kg) for Myanmar at developmental ages

	Weaning (6–7 mo)	12 mo	18 mo	24 mo	30 mo	First calving (36 mo)
Male weights expected to be 5–10% higher than females.	80	146	216	292	360	438
	100	166	236	312	380	458
	120	186	256	332	400	478

To meet weight expectations, animals will need to gain approximately 0.4 kg per day until 3 yr of age. Growing animals should not be managed to where they lose weight; in good times they will experience compensatory gain as long as the amount of time that they do not gain weight is 6 mo or shorter. Pregnant cows need to gain a minimum of 0.4 kg per day during the last 3 mo of gestation for reproductive efficiency and fetal development. Management for weights such as these would allow production of market animals at 3 yr of age.

Table 6. Some comparative metrics among Myanmar and North American countries

Category	Canada	Mexico	Myanmar	USA
Population (mil)[a]	36.3	127.5	52.9	323.1
Land surface area (000 km^{-1})[a]	9,985	1,964	677	9,832
Population density (people per km^{-1} land area)[a]	4.0	65.6	81.0	35.3
Poverty (% of population) at $1.90 per d (2011 PPP)[a]	0.3	3.0	6.5	1.0
Income share held by lowest 20% of population[a]	6.6	5.1	7.3	5.1
Life expectancy at birth (yr)[a]	82	77	66	79
GDP (bil US$)[a]	1,530	1,047	63	18,624
GDP per capita (US$)[a]	42,154	8,209	1,196	57,638
Agriculture, value added % of GDP (US$)[a]	2	4	25	1
Gross Ag output (bil 2004–2006 intl US$)[b]	29.9	40.4	20.1	251.2
Ag land rain-fed crop equiv (mil ha)[b]	53.4	31.8	16.9	211.4
Permanent pasture (mil ha)[b]	14.6	81.0	0.3	251.0
Ag labor force (000 people 15 + yr)[b]	309	7,720	21,122	2,301
Livestock total (cattle equiv, mil)[b]	18.0	61.0	28.4	136.7
Machinery (000 40-CV tractor equiv; CV = metric hp)[b]	784	252	71	4,311
Livestock feeds (crops & residues, 89% DM, mil MT)[b]	21.8	31.4	16.4	191.6
Livestock feed per cattle equiv per annum (kg)[b]	1,210	514	578	1,402
Total cattle (mil)[c]	11.9	16.6	15.0	91.9
Breeding cows (mil females that have calved)[c]	4.7	10.1	?	39.5
Cattle carcass meat produced per annum (mil MT)[c]	1,130	1,879	0.3	11,507

[a]World Bank (2018), or calculated from reported values.

[b]USDA-ERS (2017), or calculated from reported values.

[c]USDA-ERS for year 2014; Myanmar data from ABN (2018) for year 2013.

grazing lands in Myanmar for the beef cattle industry and other grazing livestock can contribute in accomplishing these important policy goals, if appropriate grazing management is utilized.

Development of permanent pastures for grazing gives farmers access to other means of income from cattle and reduces animal feeding costs. Continual heavy-grazing pressure can drastically harm environmental resources (Holechek, 1981); however, appropriate stocking rates and rotational/seasonal grazing management have potential to sustain or even improve environmental resources (Jones et al., 2009; Roche et al., 2013; Freitas et al., 2014)), promote desirable wildlife species (McIlroy et al., 2013), and increase available forage quantity and quality for livestock. Potential success of a future Myanmar beef industry as well as empowerment of its rural population can be greatly influenced by its National Land Use Policy, and development of long-term, sustainable grazing land management.

Currently, Myanmar has no standardized classification system or method to describe cattle for domestic sale, for export buyers, or for local slaughterhouses, and no standardized carcass classification related to yield or consumer acceptance. Regional cattle auctions are common (Figure 4), and most municipalities have cattle processors. It has been policy in Myanmar that only cattle that are 12 yr of age or older can be harvested for domestic beef. This is a carry-over from British colonial rule and was in place to maintain adequate inventory of farm animals for draft. This policy is in the process of being altered and is not being strictly enforced. Recently, the export sale of Myanmar beef has been approved. This will prompt cattle-processing facilities to provide direct economic incentives regarding carcass traits to the cattle sellers, and potentially to the cattle farmers.

Several livestock industry and producer groups such as the Myanmar Livestock Federation already exist and appear to have strong commitments to improving opportunities for cattle (and other livestock) farmer livelihoods through improved production efficiency. Government departments such as the Myanmar Livestock Breeding and Veterinary Department and Rural Development Department are in place and can effectively work with industry organizations. Industry-based funding of research and education based on animal sales (such as Checkoff programs in North America and the Meat and Livestock Australia [**MLA**] approach) are recommended for consideration.

Education and training is needed for cattle farmers. Among Myanmar rural households, only 4% had received any vocational training regarding livestock production within 3 yr, and only 5% had received training regarding crop production; these incidences did not vary widely across income levels or farm size (LIFT, 2012). This training may be conducted in partnership with industry groups, government departments, and should include Myanmar universities. It is recommended that

Figure 4. Cattle auction near Pyawbwe in Mandalay Region. Farmers have their cattle on display, and potential buyers walk around and negotiate prices. All transactions at this market must be completed by noon through a collection office on-site.

Figure 5. Cattle-drawn cart in Mandalay Region of Myanmar.

"Train-the-Trainer" programs be conducted first so that technical information and skills be familiar to officials and industry leaders, to help pass along information to farmers. Education and training programs of farm youth should also be developed and implemented.

In Myanmar, it is also important for both livestock officials and farmers to acquire training in basic business management practices to motivate consideration of the economic implications of all their farming and animal husbandry methods collectively. This approach can also stimulate environmental stewardship regarding resource management and foster cooperative types of marketing opportunities and arrangements.

Conclusions

As the national economy of Myanmar grows, its cattle industry is also growing and transitioning from a draft-based use (Figure 5) to a more meat animal–focused market. Natural resources appear poised to support grazing and cropping systems. Marketing incentives exist for value-added production and product improvements. Improved knowledge regarding animal reproduction, health, genetics, and nutrition is needed for farmers and livestock officials. A strong and diverse Myanmar beef industry can help to improve economic opportunities and food security for farmers and strengthen domestic and export markets.

About the Authors

Dr. Andy D. Herring is the John K. Riggs' 41 Beef Cattle Professor in the Department of Animal Science at Texas A&M University where he teaches undergraduate and graduate courses in beef cattle production and conducts research targeting genetic improvements in beef supply chains. He also works with state, national, and international beef cattle producers and industry organizations for improved overall production efficiency, profitability, and consumer satisfaction. He is the author of the textbook *Beef Cattle Production Systems* (CABI). **Corresponding author:** andy.herring@tamu.edu

Dr. Ai Thanda Kyaw is Country Director at Winrock International, Asia Farmer-to-Farmer Program, Myanmar where she manages to support technical assistance to rural Farmers of Myanmar in Livestock, Fisheries, and Agriculture sectors. Previously as a consultant, she conducted Cattle Movement study funded by OIE, National Supply Chain study for Cattle funded by FAO, and took part as a consultant and facilitator on National Livestock Policy Advocacy Paper Development organized by Nathan Associates Inc funded by USAID, Burma Mission.

Dr. Thet Khaing is Technical Officer at Winrock International, Asia Farmer-to-Farmer Program, Myanmar. He is a veterinarian by training and has previously worked as veterinary officer for the Myanmar Livestock Breeding and Veterinary Department. He currently provides educational training and technical information to Myanmar farmers and acts as liaison with livestock and farmer organizations.

Literature Cited

ABN. 2018. Myanmar country profile. Hanoi (Vietnam): Asia Beef Network. [accessed January 6, 2018] http://www.asiabeefnetwork.com/.

Bailey, C. M. 1991. Life span of beef-type *Bos taurus* and *Bos indicus* x *Bos taurus* females in a dry, temperate climate. J. Anim. Sci. 69:2379–2386.

Bredahl, M. E., J. R. Northen, A. Boecker, and M. A. Normile. 2001. Consumer demand sparks the growth of quality assurance schemes in the European food sector. In: A. Regmi, editor. Changing structure of global food consumption and trade. USDA Economic Research Service publication WRS-01-1. p. 90–102

Devendra C., D. Thomas, M. A. Jabbar, and H. Kudo. 1997. Improvement of livestock production in crop–animal systems in rainfed agro-ecological zones of South-East Asia. Nairobi (Kenya): ILRI (International Livestock Research Institute). p. 116.

FAO. 2017. Livestock production in Latin America and the Caribbean. Rome (Italy): Food and Agriculture Organization of the United Nations. [accessed February 8, 2017] http://www.fao.org/americas/perspectivas/produccion-pecuaria/en/.

Freitas, M. R., L. M. Roche, D. Weixelmanand, and K. W. Tate. 2014 Montane meadow plant community response to livestock grazing. Environ. Manage. 54:301–308. doi:10.1007/s00267-014-0294-y

Funston, R. 2014. Importance of early conception and factors influencing it. In: Proceedings of the Nebraska State of Beef Conference. North Platte (Nebraska): University of Nebraska Lincoln. p. 63–79.

Herd, D. B., and L. R. Sprott. 1986. Body condition, nutrition, and reproduction of beef cows. Texas Agric. Extension Service, B-1526. College Station (TX): Texas A&M University System.

Holechek, J. L. 1981. Livestock grazing impacts on public lands: a viewpoint. J. Range Mgmt. 34:251–254.

Hudson, G. F. S., and L. D. Van Vleck. 1981. Relationship between production and stayability in Holstein cattle. J. Dairy Sci. 64:2246–2250.

Jones, B. E., D. F. Lile, and K. W. Tate. 2009. Effect of simulated browsing on aspen regeneration: implications for restoration. Rangeland Ecol. Manag. 62:557–563. doi:10.2111/.1/REM-D-09-00082.1

Jonsson, N. N., R. E. Bock, and W. K. Jorgensen. 2008. Productivity and health effects of *Anaplasmosis* and babesiosis on *Bos indicus* cattle and their crosses, and the effects of differing intensity of tick control in Australia. Vet. Parasitol. 155:1–9. doi:10.1016/j.vetpar.2008.03.022

LIFT. 2012. Baseline survey results, July, 2012. Yangon (Myanmar): Livelihoods and Food Security Trust Fund. [accessed March 28, 2018] http://www.lift-fund.net.

McIlroy, S. K., A. J. Lind, B. H. Allen-Diaz, L. M. Roche, W. E. Frost, R. L. Grasso, and K. W. Tate. 2013. Determining the effects of cattle grazing treatments on Yosemite toads (*Anaxyrus* [=*Bufo*] *canorus*) in Montane meadows. Plos One 8:e79263. doi:10.1371/journal.pone.0079263

MNLUP. 2016. Myanmar National land use policy. Nay Pyi Taw (Myanmar): The Republic of the Union of Myanmar, National Land Resource Management Central Committee.

Núñez-Dominguez, R., L. V. Cundiff, G. E. Dickerson, K. E. Gregory, and R. M. Koch. 1991. Heterosis for survival and dentition in Hereford, Angus, Shorthorn, and crossbred cows. J. Anim. Sci. 69:1885–1898.

Pendell, D.T., G. W. Brester, T. C. Schroeder, K. C. Dhuyvetter, and G. T. Tonsor. 2010. Animal identification and tracing in the United States. Amer. J. Agr. Econ. 92: 927–940. doi:10.1093/ajae/aaq037

Polkinghorne, R. J., and J. M. Thompson. 2010. Meat standards and grading: a world view. Meat Sci. 86:227–235. doi:10.1016/j.meatsci.2010.05.010

Rae, D. O., W. E. Kunkle, P. J. Chenoweth, R. S. Sand, and T. Tran. 1993. Relationship of parity and body condition score to pregnancy rates in Florida beef cattle. Theriogenology 39:1143–1152.

Riley, D. G., J. O. Sanders, R. E. Knutson, and D. K. Lunt. 2001. Comparison of F1 *Bos indicus* x Hereford cows in central Texas: II. Udder, mouth, longevity, and lifetime productivity. J. Anim. Sci. 79:1439–1449.

Roche, L. M., L. Kromschroeder, E. R. Atwill, R. A. Dahlgren, and K. W. Tate. 2013. Water quality conditions associated with cattle grazing and recreation on national forest lands. Plos One 8:e68127. doi:10.1371/journal.pone.0068127

Siller, A. E. 2017. Initial assessment of calf performance and cow reproductive traits in a Dominican Republic beef herd [M.S. thesis]. College Station (TX): Texas A&M University.

Snelling, W. M., B. L. Golden, and R. M. Bourdon. 1995. Within-herd genetic analyses of stayability of beef females. J. Anim. Sci. 73:993–1001.

Tanida, H., W. D. Hohenboken, and S. K. DeNise. 1988. Genetic aspects of longevity in Angus and Hereford cows. J. Anim. Sci. 66:640–647.

Thornton, P. K. 2010. Livestock production: recent trends, future prospects. Phil. Trans. R. Soc. B. 365:2853–2867. doi:10.1098/rstb.2010.0134

USDA-ERS. 2017. Agricultural total factor productivity growth indices for individual countries, 1961–2014. Washington (DC): USDA Economics Research Service Agricultural Productivity Datasets. [accessed April 2, 2018] https://www.ers.usda.gov/data-products/international-agricultural-productivity/.

World Bank. 2018. World Development Indicators database – Country Profiles [accessed April 3, 2018] https://databank.worldbank.org/data/home.aspx.