Wagyu Opportunities for Tropical Breeds

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Introduction

In the tropics of the world, beef cattle producers face a complex set of challenges in order to achieve sustainable and profitable production levels. Among the main challenges are the environmental influences (comprised of ecological and socioeconomic factors), genetic resources, global infrastructure and support from national institutions.

There is no simple solution to overcome these problems in a cost-effective manner. However, there is increased evidence that purebred and commercial beef cattle producers need to be concerned about the genetic merit of the cattle they produce in order to survive economically. Furthermore, producers need to identify superior individuals within breeds in order to engineer the type of cowherd and progeny that fit their market and overall goals of the modern beef cattle industry more quickly.

Today the beef cattle industry is oriented toward branded beef marketing programs that are based on the production of high quality (highly palatable) cattle meeting certain live animal and carcass specifications. In addition, major packers in the world are entering into programs of buying cattle and selling meat products based on carcass specifications to supply domestic and international niche markets. Excess of fat production and inconsistency in predicting and thus providing tenderness of meat have been identified as major concerns to the beef industry of today. Therefore, in order to compete with some other sources of food protein, the beef industry must produce specified beef products in a predictable and cost effective manner.

Beef cattle production in the tropics is generally based on crossbreeding programs for several reasons, the most important of which are to produce more pounds of red meat per hectare. This is based on the fact that crossbreeding increases fertility in some cases by as much as 15%. *Bos indicus* breeds are used frequently to maximize heterosis and provide additional advantages for heat and disease resistance. In addition, hybrid vigor stimulates growth and feed efficiency of the calf, as well as maternal ability of the cow, increasing weaning weight up to 25%. In the southern United States, heterosis between Zebu and *Bos taurus* breeds has been found to be greater than between *Bos taurus* breeds, and with a crossbred cow of the former type weaning weight can increase by up to 50%.

However, many researchers have reported that as percentage of *Bos indicus* increases the level of tenderness decreases and the variability in tenderness increases. Research has also shown that when meat from cattle with some percentage of *Bos indicus* is compared to meat from other breeds, the *Bos indicus* influence (when greater than ¼) typically results in less tender, and more variable meat. This is confirmed by other studies that show that the percentage of *Bos indicus* influence accounts for more of the variation in tenderness than any other factor.

Germ plasm resources must be matched with other production resources, environmental factors and consumer demands to produce profitable cattle. Therefore, in addition to sire selection, tropical breeders must breed for adaptability and functional efficiency in order to produce offspring that are profitable to all segments of the industry or specific niche markets. An alternative to this is to carefully select breeds that complement each other in economically important characteristics and cross them systematically.

A new breed in the Western Hemisphere is Japanese Red Wagyu. These cattle were introduced into the United States in 1976 for their genetic ability to produce highly palatable beef containing extremely high amounts of intramuscular fat or marbling. The amount of marbling is the most important element in determining beef quality grade in several international meat grading systems and is associated with both palatability and product consistency. These cattle could be beneficial to domestic and foreign markets for the production of palatable beef containing minimal external fat in a predictable and cost efficient manner. In addition, infusion of these genetics in a crossbreeding program will maximize heterosis and breed complementarity responses. Therefore, Red Wagyu genetics may be the final ingredient to create a type of animal that will perform efficiently, improve consistency, maintain uniformity, and maximize the gap between loss and profit.

The main objective of this presentation is to evaluate the role of Red Wagyu genetics in tropical ecosystems and its contribution for the production of more consistent, uniform and palatable beef while maintaining maximum overall efficiency.

Productivity in the Tropics

Tropical ecosystems will play a critical role in the future of the global economy by allowing cattle producers to use natural environments not suitable to some other species for the production of animal protein. Approximately 71% of the world's cattle population (1284 million) are located in developing regions of Africa, Asia, Latin America and the Middle East. In addition, developing countries of the world have 74% of the world's manpower and 58% of the world's arable land. Therefore, from the natural resources point of view, they are in a favorable position to produce an abundance of food to feed the hungry world. However, the level of production in the tropics is low and only some communities, developing countries and regions are making positive changes.

It is estimated that 21% of the world's milk production and 34% of the world's red meat is produced by developing countries. The amount of milk produced per 100 ha is only 14% of that produced by developed countries and meat production is 1,140 kg as compared with 2, 747 kg per 100 ha for the developed countries.

Some of the main causes affecting actual production levels in the tropics have been reported for several countries and in general can be summarized as in Table 1.

Table 1
Average of Estimated Present Production Levels in Tropical Ecosystems

Character	Production level
Birth rate	35-65 %
Death loss to breeding age	10-25 %
Weaning weight at 7 months	120-150 kg.
Age at first calf	3-4 years
Slaughter age, males	3.5-5 years
Slaughter weight	350-450 kg.

Tropical producers within the most economically advanced communities have made numerous attempts to overcome some of these problems by basically importing both genetics and breeding strategies from developed countries, modified to some extent to fit local needs and resources.

However, most attempts at genetic improvement have centered on production and not adaptation. Unfortunately, when the focus is mainly on increased growth and size, the basic concept of functional efficiency is completely overlooked. Cattle in the tropics face climatic stress, disease, parasites and other endemic elements of the natural environment. Therefore, it is evident that to breed livestock which are adaptable to unfavorable environments it is essential to have a deep understanding of the interaction between the whole environment and the total genetic make-up of the animals for any particular environment. Thus, once we have animals that are adapted, we can concentrate on functional efficiency.

An animal is considered to be adapted to any particular environment when it is capable of maintaining a thermal equilibrium in a hot or cold climate. In hot and humid environments, an adapted animal will maintain its internal temperature at atmospheric temperatures of 29°C and higher. In areas where the average annual isotherm is above 28°C, all British breeds of cattle will suffer from tropical degeneration. Animals suffering from this condition are characterized by poor growth and poor condition as well as marked low fertility. Animals not tropically adapted become hyperthermic and their body temperature rises as high as 41°C. Optimum thermal equilibrium allows the animal to utilize the natural resources efficiently, grow faster, reproduce early and regularly and have a low mortality rate without causing any deterioration to the ecosystem in general.

Opportunities for Genetic Improvement

It is time for a new breeding concept in the tropics. A new philosophy based on a deep understanding about the use of natural resources, cattle and their role in human societies in tropical ecosystems. The need is not for new genetic theory or more sophisticated breeding programs. It is about the integration of all small-scale producers that own the majority of the cattle and still live with very poor levels of production. The new successful concept for genetic improvement of cattle in the tropics requires creativity and the desire to understand and value the real needs of people in tropical regions.

In the tropics, cattle populations are different genetically and structurally from those in temperate areas. Although there are many more cattle in these regions, most native breeds are limited to their original areas of introduction, and population sizes are relatively small. For example, in Latin America, few and phenotypically different populations of pure Criollo cattle prevail in different parts. Attempts to improve Criollo cattle (Criollo de Salta in Argentina; Caracu, Mocho Nacional in Brazil; Romosinuano in Colombia) have been practiced for numerous years by the infusion of *Bos indicus* genetics. Representation of tropical breeds in more than one country is relatively limited; examples of breeds in several countries are the Boran, Ongole (Nellore), Gir, Guzerá (Kankrej), Red Sindhi, American Brahman and Santa Gertrudis.

Genetic evolution in tropical breeds (i.e., the Brahman type of India and Pakistan) shows that some of them were never selected for economical characteristics or more precisely, as we define today, for functional efficiency. Unfortunately, the early breed standards of some of these breeds placed too much emphasis on non-economical traits, such as a rising chine, ear length, long twisted horns, a roman nosed forehead, etc. Also, it is well documented that during the selection process of the *Bos indicus* type cattle in Africa, animals were not improved to produce more meat or milk. Instead, South African pioneers selected Afrikaner type cattle for drought purposes. It was not until the beginning of the twentieth century that selection for increased beef production started.

On the other hand, the British and European breeds of cattle were evolved and improved in the Northern Hemisphere where all metabolic functions can be more efficiently performed. This resulted in cattle with better efficiency of food utilization, fertility, milking ability and growth rates among others.

Infusion of *Bos taurus* genetics in tropical cattle populations requires special attention to several very important evolutionary and ecological factors before designing large scale crossbreeding programs. An understanding of those critical factors will position the Red Wagyu breed as an alternative source of genetics to engineer a type of beef production system that will bring maximum net return.

The majority of *Bos taurus* types of cattle had their origin and evolution in the Northern Hemisphere, mainly between the 45^0 and 60^0 north parallel. In those areas of the world the nutritional value of their native grasses is higher than in most other areas. As a result, animal thermoregulatory functions are performed very efficiently and cattle express their maximum genetic potential. In addition, from the topographical point of view, the Northern Hemisphere is four-fifths land and one-fifth water. The specific morphological adaptations that occurred in the animals of these areas were caused by certain environmental, climatological and nutritional factors during the process of evolution and development of temperate breeds.

In contrast, *Bos indicus* breeds of cattle evolved near the Equator where temperature fluctuations between winter and summer are not as great as in the Northern Hemisphere. In many of these areas the fluctuation between the summer and winter isotherm is seldom over 20^0C due to the fact that the Southern Hemisphere is four-fifths water and one-fifth land. In addition, the difference between summer and winter daylight hours (photoperiod) is smaller than in the areas where *Bos taurus* breeds had their origin and evolution. These climatological conditions are important from the morphological point of view since the difference between the winter and summer photoperiod is the greatest stimulus to hair growth. Therefore, all the breeds developed near the Equator have short hair, which is considered a dominant genetic trait.

Origin and Development of Red Wagyu

Red Wagyu (*Akaushi*), a *Bos taurus* type of cattle had their origin and evolution in Kumamoto, Japan. Kumamoto is located in the middle of Kyūshū island at a latitude of 32^0 48' North and 130^0 42' East, in the northwest part of the Kumamoto Prefecture. Kyūshū is one of the four (Honshu, Hokkaido, Shikoku) major islands of Japan with an inland-basin climate. The elevation of Kyūshū Island is 37.7 meters above sea level with an annual average temperature of 16.8^0C and an annual average precipitation of 1,593 mm. During the winter season, temperature fluctuates between 5 and 12^0C.

The rainy season, called *baiu,* occurs from mid-June to July, just before the beginning of midsummer. Summers are typically hot and humid with temperatures reaching 34^0C in some years. In addition, an important physiographical feature of Kyūshū Island is its mountainous topography and its character as a volcanic country. Some volcanoes such as Unzendake in the Nagazaki Prefecture, Mt. Aso in the Kumamoto Prefecture, and Sakurajima in the Kagoshima Prefecture are still active. Grassland covered with old volcanic ash and pumice called *shirasu* is the predominant soil in southern Kyūshū. Crop production on the *shirasu* uplands is difficult because this type of soil does not retain moisture, which creates a drought condition, resulting in unstable crop yields. Therefore, Red Wagyu cattle were developed to meet the quality demand by consumers and the productivity required by this challenging environment to achieve profitable production levels. Today, southern Kyūshū is Japan's leading producer of beef cattle as well as swine and chicken.

Cattle breeds are divided into two kinds in Japan. One of them comprises dairy cattle, including mainly Holsteins, grade Holsteins and Jerseys. The other type is beef cattle, nearly all of which are called Wagyu. The word Wagyu refers to all Japanese cattle by its direct translation of its two grammatical parts, "wa" and "gyu" meaning Japanese and cattle, respectively. The Wagyu cattle are the Japanese indigenous breeds, which have been subjected to genetic improvement over the last 90 years. Today, there are four breeds of Wagyu cattle, the Japanese Red (Red Wagyu), the Japanese Black (Black Wagyu), the Japanese Polled, and the Japanese Shorthorn. It is estimated at the present time that a population of 58,263 breeding age females represents the Red Wagyu breed. A small number of Aberdeen Angus, Hereford and Charolais have been integrated into the beef breeds of Japan as well.

Native Wagyu cattle of the 1800's were small in size and mainly used for draft proposes. These original cattle populations were the result of the first bovine migrations to the western half of Japan around the second century from Northern China via the Korean peninsula. Thus, cattle from South Korea migrated to southern Kyūshū at the same time and were blended with local types. Hip height measurement for adult females were about 112 cm and 123 cm for adult males. In contrast, these sizes are comparable to 8 and 11 month-old modern Red Wagyu calves, respectively (Table 2). Apart from the meat quality, native Wagyu had poor milking ability, low growth rates and were poor food converters. Breed history records show that a great variation in red coat color was common on native types cattle of the Kyūshū district.

After the Meiji restoration in 1868 the new Japanese government sought to improve the indigenous Wagyu cattle for the first time and by the 1900's Simmentals and Devons were imported from Switzerland and England to cross with the native cattle raised over the years in the Kumamoto prefecture. Accordingly, from 1900 to 1912, the upgrading process by European breeds was popular in the breeding of the native Wagyu cattle. The results of these crossbreeding programs, however, were not always successful. The first and second generations were improved mainly as a result of heterosis responses resulting in rapid growth and increased milking performance. However, this new type of animal was very inefficient in performing the rice field cultivation practices, had poor meat attributes, and poor dressing percentages. Therefore, Japanese farmers began to prefer the small and indigenous type of cattle again. Meanwhile (since 1912), the lifestyle of the Japanese society was improving gradually and the demand for meat was increasing. Since the most desirable type of cattle in those days were too small and inefficient in the production of good red meat, the improvement of cattle was recommended again by the Government. Thus, the crossbreeding process continued until 1925.

After this selective crossbreeding stage, two distinct strains of Red Wagyu were defined, the Kumamoto and the Kochi types. The Kumamoto Red Wagyu were strongly influenced by Simmentals and Devons with a very small influence of South Korean cattle. On the other hand, a high proportion of Korean genetics was maintained to develop the Kochi type. Therefore, these two strains of Red Wagyu differ greatly in their breed characteristics. The Kochi Red Wagyu has a profound resemblance to the original native Korean cattle characterized by their small size, refined bone structure and lack of muscle development. In addition, the Kochi type is black pigmented around the nose, feet and legs. The Kumamoto Red Wagyu cattle more closely resemble modern American beef cattle.

In order to identify and fix specific conformation and quality traits from the various breed types resulting from the crossbreeding, a registered association was established in 1923. Then, in 1944, it was officially recognized as a breed, and given the name Japanese Red because of its distinctive red color. After 22 years of practicing this selective registration system, Red Wagyu cattle were fairly uniform. The use of Red Wagyu as draft cattle gradually shifted to beef production, due to the mechanization of agriculture and increasing demand on beef. Accordingly, in 1957, draft performance was the primary objective for improvement, while meat performance was secondary. Later on, in 1966, draft performance was completely omitted from the breeding objectives. In 1974, a central performance and progeny testing system was established to produce superior sires by embryo transfer. In addition, a unique dam evaluation system was implemented for the first time with the idea to speed up the rate of genetic improvement.

It should be pointed out that 82% of Red Wagyu registered females (47,655) and all of the primary sires (56), have been raised in the Kumamoto Prefecture. Therefore, the Kumamoto Prefecture plays an important role as a nucleus population for the breed. In 1994, new genetic lines of Red Wagyu cattle were imported into the state of Texas, United States and they represent the largest Red Wagyu breeding nucleus outside of Kumamoto, Japan.

Breeding for Reproductive Performance

As producers continue to focus on growth and not functional efficiency, the productivity of their breeding cow herd decreases considerably as a result of the reduction in number and weight of calves weaned each year. A functional and efficient female has the ability to produce a calf every year without calving difficulty, wean a calf (which is a high percentage of the dam's live weight between 7 to 8 months of age), and conceive shortly after calving. In the case of a male, functional efficiency is the ability of a bull to settle at least 25 cows in a three-month service period. Therefore, the bull must have libido and produce a sufficient amount of good-quality semen.

The ability of a tropical-adapted cow to produce a calf every year depends greatly on its capability to conceive, maintain its pregnancy during the first trimester and give birth with no calving difficulty (dystocia). Data collected from various parts of the world have indicated that dystocia not only represents a major loss of production potential due to calf deaths but is also associated with increased cow mortality, delayed return to estrus and lower conception rates. Among the numerous factors affecting dystocia, such as those attributed to the dam (pre-calving weight, pelvic area, gestation length, age at parity of dam, dam's breed or size, dam's sire, nutritional status and condition of dam and hormonal status), pre-calving weight and pelvic area are the most important. On the other hand, calf sex and particularly calf birth weight are the most important calf factors affecting calving difficulty. Recent studies have concluded that birth weight is the single most important source of variation for dystocia. Among the factors determining calf birth weight, genetics and breed of sire play the most important role.

Unfortunately, the emphasis by beef producers on size and growth rate in recent years has resulted in many British and *Bos indicus* sires producing large birth weight calves. It is estimated than more than 3.5 million calf deaths are recorded annually in the United States and that 45% of those are related to dystocia, but only 16% of them are related to mature cows. Therefore, 84% or 1,575 million calf deaths on a yearly basis can be associated to first-calf heifers that experience various degrees of calving difficulty.

Traditionally, beef cattle producers have predominantly used British breed sires on first-calf heifers in temperate ecosystems and *Bos indicus* type breeds in tropical regions in order to minimize calving difficulty. In the southern parts of the United States it is a common practice to use Longhorn bulls on first-calf heifers. This practice has resulted in decreased value of calves due to a reduction in performance traits and beef type. Tropical beef cattle producers have been using Brahman bulls for decades on first-calf heifers in order to avoid dystocia problems because Brahman and Brahman crossed calves are relatively small in size at birth. However, there is one problem, well recognized by Brahman breeders around the world, related to the size of calves at birth in purebred Brahman cattle populations. This problem is known as the "dummy calf syndrome". Calves carrying this genetic defect are not only very small in size at birth but apparently have no inclination to suckle their dams. This highly heritable defect is one of the principal causes of the high mortality rate among newborn Brahman calves in many Brahman nucleuses.

Among all the modern beef cattle breeds, Red and Black Wagyu are well known for their genetic ability to produce calves with low birth weight. Several studies involving British x Wagyu and Continental x Wagyu crosses show an average birth weight of 33.5 kg. Several crossbreeding projects in process at the present time involving Brahman x Red Wagyu and Bradford x Red Wagyu crosses show a similar average birth weight than those from the mentioned *Bos taurus* crosses. This birth weight indicates that it is probably safe to breed first-calf heifers to Wagyu sires and thus, alleviate many existing calving problems within herds.

Impact of Mature Size on Reproductive Parameters

Another antagonism as a result of selection on growth is increased cow mature weight. Larger framed cows require higher maintenance requirements in order to reach and maintain optimum reproductive levels. Hence, all physiological activities, such as puberty, are delayed until older ages. Numerous studies show that weight at puberty is a function of mature size and that large framed cattle are generally late-maturing cattle. The key for sustainable growth levels in a desired crossbreeding program, without increasing age at puberty, is to maintain tight culling cow levels and to place emphasis on earlier maturing breeds.

It is important to point out that in the wet tropical ecosystems, the soil pH is generally low as a result of high temperature and relative humidity. Native grasses in these ecosystems grow very rapidly, mature fast, and consequently, are higher in crude fiber content and lower in protein value. In addition, they are very deficient in macro and microelements, especially phosphorus. Phosphorous deficiency is associated with low fertility and has a profound impact on growth rates. Therefore, to achieve maximum efficiency in these areas, only medium framed cattle of the *Bos taurus* type should be used in crossbreeding programs. In addition, some *Bos Indicus* breeds (i.e., Brahman and Afrikaner) are known to have fertility problems mainly associated to hereditary causes and improper nutritional management. Several reproductive studies on Brahman and Afrikaner cattle show that low calving percentages are associated with lactation anoestrus.

Red Wagyu cattle, based on the Kumamoto, Prefectural Beef Improvement System, have been developed by using a multiple trait approach with special emphasis on fertility traits. In the case of the Kumamoto females, they must produce their first calf at 24 months of age without calving difficulty and conceive shortly after calving. The males have to reach puberty at young ages and produce good quality semen in order to speed up genetic progress. In addition, special emphasis is place on testicular development and size. It has been documented that Red Wagyu females and males reach puberty at a very young age.

Since 90% of the genetic improvement in a cowherd is related to sire selection it is important to evaluate the reproductive potential of sires within breeds before using them in crossbreeding programs. Increased scrotal circumference and thus onset of puberty are two of the most crucial factors in selecting sires. Puberty in young bulls has been defined in a variety of ways (i.e., first ability to serve, first sperm production, first ejaculation of motile sperm, etc.). Various studies on male reproduction show that puberty occurs when a scrotal circumference of 28 cm is achieved, regardless of large differences in body weight and age at puberty and within different breeds of bulls. In addition, other researchers have shown that the major characteristics of semen quality improve linearly during the first 12 to 16 weeks after reaching this criterion of puberty. Numerous studies show a high correlation between these improvements in semen quality ($r = .44$ to $.75$) with the steady linear increase in scrotal circumference that occurs during this post-pubertal period in *Bos taurus* breeds.

Thus, scrotal circumference is not only associated with puberty and good quality semen but is directly related to semen production in beef bulls due to the fact that 80% of the testicles are composed of seminiferous epithelial cells, the cells that produce sperm cells. It is common for 12-month-old Red Wagyu bulls to reach scrotal circumferences of 32 cm with an average body weight of 420 kg. Reproductively sound yearling bulls should have a scrotal circumference of at least 30 cm. In addition, scrotal circumference is the most highly heritable ($h^2 = .34$ to $.50$) reproductive trait and is positively correlated to age at puberty of the bull's daughters. Studies have shown that with an increment of 4.0 cm above the breed average on a particular individual, we can expect a 1.0-centimeter increase in the scrotal circumference of male offspring and an earlier puberty of approximately 15.4 days in their female offspring. In contrast, there is evidence that suggests that bulls with small testicles tend to produce a higher percentage of abnormal sperm cells. Therefore, the use of sires with above average testicular size for his age and breed type will improve the productivity of the cowherd by producing female progeny that reach puberty at a younger age and consequently have extended lifetime productivity.

Breeding for Maximum Adaptability

Some of the most important factors that affect the degree of adaptability of animals in tropical areas are the structural properties of the hide (diameter, vascularity, zebum secretion, presence of pigment, etc.) and the coat color. These conformational traits form the animal's natural shield between the external environment and the animal. The hide (skin) is considered the largest organ of the animal's body, and it represents approximately 12% of the animal's live weight. Hence, great emphasis should be place on selecting breeds with desirable color and coat type for crossbreeding programs in tropical areas.

Bos indicus cattle such as the Brahmans of North America and Asia are well known for their distinct desirable skin characteristics. These breeds have sleek coats (very smooth-coats), thick hides and a large surface area per weight unit. In addition, they have a well-developed pliable dewlap with high vascularity and pigmented hides. Several research studies involving tropical adapted breeds show that thicker, and vascular hides have a profuse blood flow, which allows the animal to recover faster from a skin injury. In contrast, animals in tropical conditions with thin and woolly coats with low vascularity need twice the time to recover from a similar type of injury. In addition, these animals usually suffer from heat dissipation and became tropically degenerated. Another important characteristic that is associated with thick and mobile skins is the presence of pigment. Pigmented skins give the animals protection against ultra-violet radiation and are associated with large amounts of zebum (lipid secretions of the sebaceous gland) in the hide. These secretions act in conjunction with the hair to protect the animal from the harmful ultra-violet rays.

During their first stages of development, Red Wagyu cattle were exposed to the tick-born diseases, external parasites and other natural endemic factors present in the hot and humid environment of Kumamoto, Japan. Therefore, they developed smooth coats and thick and mobile skins with more dewlap skin folds than traditional *Bos taurus* breeds. Modern Japanese Red Wagyu cattle are raised in the same areas now declared by the Kumamoto Prefectural Government as "tick free". This is a result of a prefectural tick eradication program initiated in the 1960's.

Coat color is directly related to the animal's capability to reflect infrared and ultraviolet radiation. Studies in tropical ecosystems with large savanna areas where the high ambient temperatures and intensive infrared radiation are severe problems show that red (brown and light), yellow (light and golden), and creamy-white coated cattle with pigmented hides should be bred for maximum adaptability. Other coat color studies performed on different breeds (Black Aberdeen Angus vs. Creamy-white Afrikaner) of cattle show that animals with black hair and hides reflect very little infrared radiation (3% vs. 15%) as compared to the creamy-white type animals. However, black coated animals will be more efficient in screening ultra-violet radiation. Therefore, it is obviously important that tropical breeders give special attention to selection of suitable hair and hide color in order to raise animals that are well adapted to any particular tropical ecosystem.

Breeding for Healthier Beef

The improvement of overall eating quality of cooked beef, the reduction of dietary cholesterol and the contribution of beef in their total intake of saturated fatty acids have become important issues to consumers and the meat industry alike. Therefore, the modern genetic approach to manipulating fatty acid profiles in cattle should be to select for individuals or breed types capable of transmitting to their descendants the ability to accumulate adipose tissue with less palmitic (C16:0) and (or) more oleate (C18:1) and stearate (C18:0) acids because the latter have desirable effects in humans. A desirable beef product must be economically competitive with other products of the same origin, highly tender, juicy and flavorful with an adequate amount of marbling, minimal amount of external fat and a high ratio of monounsaturated to saturated fatty acids.

The degree of intramuscular-lipid deposition in muscles is one of the main factors that influence the organoleptic properties of beef. Therefore, it is important to understand and evaluate the factors affecting the lipid quantity and composition in bovine muscle and adipose tissue. Under normal fattening conditions, the lipid deposition in muscles increases with age or animal growth and it is difficult to modify via dietary manipulation. In addition, it is reported that lipid deposition is affected by the degree of fattening and breed. Thus, modification of fatty acids by selecting breeding may be more effective. Several studies involving cattle from different breeds indicate that Hereford and Brahman cows differed in their fatty acid composition. Fat samples from Brahman cows are less saturated than counterparts from Hereford cows. Hereford cows exhibit a smaller percentage of monounsaturated (MUFA) or polyunsaturated fatty acids and had a lower unsaturated fatty acid to saturated fatty acid (SFA) ratio than Brahman.

Japanese Wagyu cattle are characterized by their ability to produce highly palatable beef containing high amounts of intramuscular fat. Wagyu beef also has significantly higher ratios of monounsaturated to saturated fatty acids than does beef from domestic sources. Several studies conducted by the National Research Council show that consumption of higher levels of MUFA, in conjunction with reduced levels of SFA, is believed to prevent increases in blood cholesterol levels, and in the case of oleate, to possibly lower blood cholesterol. Therefore, efforts should be made to utilize the potential of specific breeds such as Japanese Wagyu to improve the overall quality of meat from the health point of view.

Final Remarks

The complex scenario of beef cattle production in the tropics today clearly shows the need for a new global breeding philosophy in order to reach profitable and sustainable beef production levels. The new breeding approach should take into account not only sources of outside genetics and breeding technology but the integration of germ plasm and environmental resources into crossbreeding programs designed to produce functional and efficient cattle. Thus, successful implementation of this breeding philosophy will yield successive generations of animals that are better suited to the needs of the modern beef cattle industry while maintaining a high degree of adaptation to their environments and maximizing the use of their natural resources.

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Table 2
Development, in Height, of Modern Red Wagyu Calves

Male

Age (mos.)	High (cm)	Low (cm)	Average (cm)
6	116.0	100.6	108.2
8	122.2	107.3	115.1
10	127.4	113.7	120.6
12	131.8	118.7	125.2
14	135.4	122.7	129.0
16	138.4	125.8	132.1
17	139.8	127.2	133.4
18	141.0	128.3	134.6
19	142.1	129.4	135.7
20	143.1	130.3	136.6
21	144.0	131.2	137.5
22	144.9	131.9	138.3
23	145.7	132.6	139.1
24	146.4	133.2	139.7
25	147.0	133.7	140.3
26	147.6	134.2	140.9
27	148.1	134.6	141.4
28	148.7	135.0	141.8
30	149.5	135.6	142.5
36	151.4	136.8	144.1
48	154.0	138.0	146.0

Female

Age (mos.)	High (cm)	Low (cm)	Average (cm)
6	113.9	100.6	107.2
8	118.2	105.8	112.0
10	121.7	110.1	115.9
12	124.5	113.5	119.0
14	126.8	116.3	121.5
16	128.5	118.6	123.5
17	129.3	119.5	124.4
18	130.0	120.4	125.2
19	130.6	121.2	125.9
20	131.1	121.9	126.5
21	131.6	122.6	127.1
22	132.0	123.1	127.6
23	132.4	123.7	128.0
24	132.7	124.1	128.4
25	133.0	124.6	128.8
26	133.3	124.9	129.1
27	133.6	125.3	129.4
28	133.8	125.6	129.7
30	134.1	126.1	130.1
36	135.0	127.1	131.1
48	135.6	128.4	132.0