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Changing Faces of Swamp Buffaloes in an Industrializing Asia

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ABSTRACT

Swamp buffaloes are mainly found in East and South Asia and represents 20.51% of the world's buffalo population. For centuries, swamp buffalo has played a major role in smallholder mixed farming system, however, the intensification of crop farming coupled with the increased farm mechanization in the past decade diminished the swamp buffaloes' role as source of draft in small farms. Despite this development, their value as source of livelihood and food among rural farming families remains high, and thus, undoubtedly, the direction for its development can be shifted towards improving for meat and milk production. Genetic transformation is pursued thru cross breeding and backcrossing with riverine buffalo breeds. For a wide-scale crossbreeding program to be sustained there are necessary elements that need to be institutionalized, one important item is the establishment of Gene Pool of elite riverine buffaloes coupled with organized selection and testing from where genetic materials for wide-scale crossbreeding will be derived. This has to be complimented with a responsive AI and bull loan systems to ensure proper utilization of superior genetic materials and a scheme to stimulate sustained growth of village buffalo-based entrepreneurship.

Keywords: buffalo-based enterprise development, buffalo meat and milk production, Philippine carabao, swamp and riverine buffalo crossbreeding

INTRODUCTION

Economic growth in East and Southeast Asia in recent years in characterized by increasing industrialization and declining share of agriculture in the total economy. This is accompanied by rise in human population, increasing urbanization, increasing income and changes in food preferences. Demand for animal-derived products, such as meat and milk, has been noted to grow in this region at a rate faster than observed in more developed economies (Delgado et al., 1999). These livestock sector major change drivers are observed in countries where the world's swamp buffalo population are mainly found.

To date, there are 32.75M swamp buffaloes and represent 20.51% of the world's buffalo population (FAO, 2012). The history of swamp buffalo is basically a history of smallhold land-based agriculture, since for centuries, the swamp buffaloes have played a major role in draft animal-dependent farming systems, mainly in the production of major agricultural crops, such as rice, corn, sugarcane and coconut. In recent years, however, developments in land-based agriculture in East and Southeast Asia, such as the expansion of irrigation facilities and farm mechanization, have significant impact on the use of draft buffaloes. Intensified rice production became more pronounced in irrigated areas and this has led to increased utilization of small

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farm machineries, significantly displacing the draft buffaloes. The introduction of tractors for land preparation and transport of produce in corn, sugarcane and other crop production areas has had similar effects.

The interest in developing the already existing huge population of swamp buffaloes beyond being a draft animal, to improving the genetic potentials for meat and milk through crossing with riverine-type buffaloes is becoming profound. This lends more meaning in the light of the need to address the growing issue of low income among smallholder farming families amidst the rising cost of farm inputs, thereby creating significant impact on the net income derived from the traditional crop-dominant farming system. The technical aspect of such crossbreeding has been a subject of research interest for several years in view of the known differences in their chromosome numbers, swamp buffalo has 2n=48 while the riverine type has 2n=50. Today, there are enough evidences that this effort is feasible.

ASIAN SOCIO-ECONOMIC SETTING

Human population, landholdings and income

China and Southeast Asian countries with substantial swamp buffalo population has about 1.96 billion people as of 2012, representing 27.76% of the world's population (Table 1). Of interest is the fact that large percent of these people depend on agriculture, and among the people in land-based agriculture, the size of landholding has become smaller over the years. This trend happens in countries with slow industrial growth amidst the fast increase in human population. In this case, the generation of job opportunities outside of traditional agriculture cannot cope with increases in available labor and thus the relatively large number of people in the farming communities have to source livelihood from static, albeit decreasing cultivable land area.

Additionally, the rise in cost of farm inputs, such as fuel and fertilizer led to considerable increase in the cost of production. These simply imply that smallholders’ income from traditional crop remains low, as in the case of rice farmers. In the Philippines for example, while net income from rice production increase by an average of 12.11% per year from 2004 – 2010 mainly due to 8.16% annual increase in buying price of paddy rice (PhilRice, 2012), their net income at $363.97 per ha per cropping is considerably low. At two croppings per year, this is translated to only $722.95 a year and given an average farm size of 1.3 ha per household, it would be difficult to support the basic needs of a family with five members. Additionally, due to inflationary effects, rural farming families are caught in a tight situation of declining purchasing power, and thus, measures to generate sources of additional income for the millions of farming families are for priority consideration.

Changing swamp buffalo population

Impact of industrialization: The changes in swamp buffalo population in East Asia and South East Asia over the last 50 years are shown in Table 1. There are five countries with sustained growth in buffalo population, namely, China, Cambodia, Lao PDR, Myanmar, and Vietnam, while other countries have registered negative growth, namely, Indonesia, Malaysia, Taiwan, Thailand, and the Philippines.

In early 40's, the phenomenon of declining swamp buffalo population, though relatively small, in an industrializing environment was noted in the southernmost island of Japan, as a result of the massive farm mechanization. The same trend was noted in Taiwan in the early 60's. From the population of about 324,516 hd in 1960, the number declined steadily with power tillers increased at the rate of 3,500 units per year (Lin, 1975). To date, swamp buffalo in Taiwan is a zoo animal.

Substitution of buffalo with tractors also occurred as early as 1957 in the central plain of Thailand where swamp buffaloes were most densed (Na Puket, 1975), and this trend continued in the subsequent years due to aggressive government mechanization program. During the period 1960-2010, the reduction in swamp buffalo population is estimated to be 67.3%. Similar trend in swamp buffalo population was noted in Malaysia (Table 2). In these countries, the phase of industrialization has overtaken agriculture development as clearly manifested in the significant decline in the contribution of agriculture in the entire economy, ranging from only 12.0% in Malaysia to as low as 1.6% in Taiwan. In Indonesia and the Philippines, while there are recorded reductions in buffalo population, the rate of decline was not as drastic. In fact, there were recorded recovery peaks between 1990-2000, and increase in buffalo population is sustained in the Philippines until 2010 (Table 2). The recovery in population in the Philippines between 1990 and 2000 can be related with the entry of buffalo meat from India that started in 1994. Translated in live animal equivalent, the volume of annual import is equal to about 400,000 hd per year.

What is interesting is the case of China, a country wheree agriculture contributes only 9.7% to the total economy and yet, registered the highest growth rate in swamp buffalo population in the last 20 years. Elsewhere in South East Asia, countries with positive growth in buffalo population are those with greater contributions of agriculture to their total economy, and ranged from 20% in Vietnam to as high as 43% in Myanmar.

Other contributory factors: Some factors why farmers shy away from raising buffaloes is also interesting to be understood**.** The more apparent reasons are as follows:

Aging farmers: Majority of farmers directly engaged in small-holder mixed farming system in Asia are above 50 years old. They are ageing. In 10-15 years they will retire from working in the farm and they expect younger generation as replacement. However, the younger generation, if given opportunity, are moving out of their farming environment and seek out off-farm employment. This is particularly true for those who have gone through college education. Other than the fact that farm work is less attractive to them, the low level of income generated from small landholding is a major reason.

Farming convenience: Older farmers, just like the younger generation who may opt to stay in the farming setting due to lack of education and other off-farm employment option also embrace convenience. Tending their small land holdings, they find means how to carry out farming tasks more conveniently.

Mechanization is very attractive to them, and given access, such as government support for mechanization program, they readily adopt it.

Market price of buffalo-derived product: When swamp buffalo is raised purely for meat, one consideration in countries with slaughter ban, such as the Philippines, is the depressed price of buffalo meat vs cattle. This is related with the policy of promoting availability and usage of draft buffaloes during the early 60's, the period when farming was largely dependent on draft animals. The ban allowed slaughter of male only after age of 7 years old, and of female only after 11 years old, the objective was to allow females to reproduce and be used for farm work, and males to be used for draft during their productive life.

Such policy created the impression that buffalo meat is very tough, essentially because what were legally available in the market come from retired and old work buffaloes. Up until this time, the consuming public has considered buffalo meat second class to beef, and thus is priced much less. For this reason, in the Philippines, raising buffalo purposely for meat is less attractive than cattle. It may take some time to change consumer's negative perception of buffalo meat, even long after the removal of the slaughter ban. Some farmers sell their buffaloes and buy beef cattle for raising purposely for meat.

GROWING DEMAND FOR ANIMAL-DERIVED PRODUCTS

Many Asian countries have registered sustained economic growth in recent years and this has also resulted in increased establishment of urbanized areas. The rise in income among urban population has also brought about a corresponding shift in food preferences as demonstrated in greater demand for beef and milk. With the reduced land area for grazing and forage production, the only immediate option to meet the growing requirements is increase in imports of milk and beef in recent years.

It is easy to understand that sudden rise in meat demand in the fast-growing population of Asia can be met by intensive production of chicken and pork. This has taken place in China and Southeast Asian countries in significant magnitude, of course, with corresponding increases in imports of feed grains. Requirements for beef in these countries are met by massive imports of buffalo meat from India, with Malaysia and the Philippines leading. Indonesia imports about 16.0% of its beef requirements whereas China is nearly self-sufficient with only about 2.5% of its requirements coming from imports.

As a long-term development strategy, however, efforts in fast-growing economies in Asia have also included programs to enhance growth in their respective local dairy industry with massive infusion of stocks of "tropicalized" dairy cattle from Australia and New Zealand. This development approach is becoming more meaningful in most of the Asian countries that remain net importers of milk and dairy products as prices of milk in the international market have surged in view of the policy and regulatory measures in some exporting countries, and also due to unfavorable climatic factors that resulted in reduced production and thus in traded milk in the international market. With the rising demand for same dairy animals for restocking farms in post-BSE Europe and Latin America, however, prices of dairy breeder stocks have also significantly increased lately.

Utilization of the existing population of swamp buffaloes in hot and humid tropics and harnessing the age-tested abilities of the smallhold farmers to rear these animals to provide opportunities to earn additional income, and also to meet the growing domestic demand for milk and meat, against the backdrop of increasing farm mechanization, are good reasons to transform the huge number of draft animals into producers of milk and meat.

Given the abundance of low-cost labor among farming families, the production cost for milk and meat from crossbred buffaloes becomes competitive. With the net income derived from crop-dominant farming system as reference, it has been demonstrated that net income from milk of 1 to 2 crossbreds/backcross is sufficient to double the income of the smallholder family tending a hectare of rice. The added advantage in dairying is the derivation of cash income on a daily basis from the sales of milk while on the seasonal long wait for harvests from crops.

CROSSING SWAMP X RIVER BUFFALOES

Implementation of crossbreeding and backcrossing

The introduction of riverine buffalo genetic materials into distinctly swamp buffalo populated countries of China and South East Asia started as early as 1917 in the form of both live animals and frozen semen (Tables 3 and 4) as cited by Balaine (1988). Most of the breeds infused were Murrah Buffalo from India and Nili-Rav from Pakistan.

The early introduction of riverine breeds resulted in crossbreds, either by way of natural mating between the introduced breed and the indigenous swamp buffaloes or by AI in the late 60’s or early 70’s. In China wide-scale crossbreeding between Murrah and the local breed of swamp buffalo started as early as 1965 through AI. By 1977, the Murrah x swamp crossbreds were mated with Nili Ravi to create a triple cross (Liu et al., 1986). In the Philippines the wide-scale use of AI for crossbreeding of Murrah and swamp buffalo was initiated only in 1984 after the setting up of buffalo semen processing laboratory. Since then, the F_1 crossbreds were continuously inseminated with Murrah semen to produce backcrosses with increasing blood of riverine breed (Cruz, 2007, 2010). This wide-scale AI system is complimented with organized bull loan program. To date, the estimated number of crossbreds and backcrosses is almost 400,000hd with riverine blood line varying from 50% to 93.75%. In other SEA countries, the extent of crossbreeding has been at experimental scale as reported in Thailand (Konanta, 1986; 1994), Vietnam (Thac, 1979; Ly, 1985), and Taiwan (Lin, 1975).

Another interesting account of deliberate crossing between swamp and riverine type buffaloes was in Cuba. In a span of three years, in 1983-1986 Cuban government infused a total of 1,438 swamp buffaloes and 279 riverine types. These animals were crossed to produce F1 and backcrosses. In Australia, crossing were also reported between riverine breed and swamp buffaloes (Lemke, 2004).

To date, China and the Philippines are the only two countries in Asia that are pursuing large-scale crossbreeding and backcrossing of swamp buffaloes with the intent to produce critical population of animals with higher genetic potentials for milk and meat production.

Chromosomal analysis of water buffaloes and their crosses

The interest among scientists in the past has been anchored on the known fact that swamp and riverine buffaloes have different chromosome numbers: the diploid chromosome number of the swamp buffalo is 48 while that of the river buffalo is 50. The reduction in chromosome number in swamp buffalo is seen as the tandem fusion (telomere - centromere) of chromosome pair 4 and 9 of riverine karyotype. The general apprehension was based on other animal species of different chromosomes crossbreeding data indicating fertility problems among resulting offspring.

When crossbreeding between the 2 buffalo types occur, males and females of the F_1 generation are heterozygous for the fusion with chromosome 2n=49. Of these chromosomes, 3 chromosomes included one metacentric, one submetacentric and one telocentric chromosome were not in pair. Through the G-band analysis, it was demonstrated that the metacentric chromosome in the three unpaired chromosomes belonged to the chromosome 1 of swamp buffalo, and the other two chromosomes corresponds to chromosomes I and 9, respectively, from river buffaloes, which may be homologous as they had G-band type (Huang, 2006).

Inter-se mating of F I produces F2 hybrids of three different karyotype categories *(*2n=48, 2n= 49 and 2n=50*)*. Chi-square tests on pooled data indicated that the distribution 1:2:1 ratio is expected if only balanced gametes with 24 and 25 chromosomes are produced by the F I hybrids. Backcrosses (75:25) produced out of mating FI (50:50) with swamp buffalo karyotype categories are 2n=48 and 2n=49. On the other hand, if FI (50:50) is backcrossed with riverine buffalo the resulting F2 (75:25) has karyotypes of 2n=49 and 2n=50. In the three- quarters swamp and three quarters river types, the respective karyotypic categories are in ratios approximating 1:1. The distribution of chromosome categories among the F2 hybrids and backcrosses suggests that only genetically balanced gametes of the FI hybrids are capable of producing viable F2 and backcross generations (Bongso et al. 1983).

In China, three-way crossbred hybrids were obtained by crossing swamp buffalo x Murrah x Nili Ravi or swamp buffalo x Nili Ravi x Murrah. They had two chromosome categories viz. 2n=49 and n=50, respectively. The two types of karotype exist not only in the progenies of three-way crosses, but also in the F2 hybrids and F3 hybrids of grading crosses. It could be observed that during the meiotic division, the FI hybrid with 2n=49 chromosomes produced 24 synaptonernal complexes (SC), which consisted of 22 divalents, autosome trivalent and a XX divalents. During the synapsis, the rneme 1 from swamp buffalo undergoes partial alignment with submetacentric chromosome 1 and telecentric chromosome 9 from river buffaloes. The synapsis is kept up until metaphase 1. The disjunction occurred during anaphase 1 when it was observed that the metacentric chromosome 1 from swamp buffalo was pulled on one pole to another pole, which resulted in production of two types of sperms viz. n=24 and n=25, respectively. The male river buffalo (2n=50) produced only one type of sperm (n=25). Therefore, the hybrids of three-way crossbred and FI and F2 grading crossbreed hybrids had two types of karotypes viz. 2n=49 and 2n=50. The ratio of the types of karotypes was near 1:1 in the hybrids of three-way crossbred and the FI grading crossbred hybrids (Huang, 2006).

Performance of crosses and backcrosses

Milk Yield: Chinese swamp buffalo has generally low milk production between 500-800 kg/lactation (Yang et al., 2007). However, selected Chinese swamp buffaloes have higher milk yield, as in the case of animals at government institutions where recorded average milk production is 1,092.8 kg/lactation. Under similar conditions, purebred Murrah and Nili Ravi milk yield/lactation were reported to be 2, 132.9 kg and 2,262.1 kg, respectively (Yang et al., 2004).

The F_1 crosses of swamp buffalo with Murrah breed had an average of 1,233.3 kg milk/lactation, equivalent to 12.3% increase in milk production. In the Philippines, the recorded yield of swamp buffalo x Murrah crosses is 4.14 kg/day and represents 176.0% increase, mainly because the milk yield of Philippine swamp buffalo is only 1.5 kg/day on the average. On the other hand, Chinese swamp buffalo crossed with Nili Ravi registered milk yield of 2,041.2 kg/lactation, an increase of 86.9% over the swamp buffalo parents.

Backcrossing the (MxNL) F_1 with Murrah or NL F_1 with Nili Ravi resulted in milk yield of 1,585.5 kg and 2,267.6 kg/lactation, respectively. Clearly, the backcrosses with 75% riverine bloodline have higher milk yield than FI crosses. Among the MUIT'ah backcrosses, the increase over the swamp parents is 45% and 28.5% over the F_1 cross. Similar trend is demonstrated among Nili Ravi backcrosses, with reported increases of 107.5% compared to swamp parents and I 1.0% compared to LF I crossbreds.

Growth and Meat Production: There is no difference in birth weight between the two breed groups, but the growth rate of crossbreds started to move ahead than that of the swamp buffaloes starting at age of 6 months up until 36 months, with growth advantage that ranged from 10-31.1%. At four years of age, FI crossbred (50:50) and backcrosses with 75% Murrah blood registered weight advantage of 9.8% to 2 1.4% over the swamp parents (Faylon, 1992).

In Australia, Lempke (2004) reported that the introduction of Riverine blood from the USA in 1994-1997 radically altered the productivity of TenderBuff. Growth rates in the crossbred from 3/8 and above are outstandingly greater than the purebred swamp available in the NT. Some 40% improvement in growth rates has been recorded in comparisons. Results from the NT Government Beatrice Hill Farm regularly confirm this trend. The more crossbred carcasses that are processed, the better the production data becomes.

International collaborations, the Philippines experience

The crossbreeding program in the Philippines is a result of various collaborations that involved many international institutions and entities that started as early as 1917 up until to date. These collaborations may be classified into three major areas, namely, genetics, system development and genetic utilization, and promoting enterprises as summarized in Table 5.

Phase I of germplasm infusion occurred between 1917 to 1956 and involved live animals from India on a government to government arrangement. Many bulls were assigned in the government breeding centers throughout the country and were used in natural mating. There were also Murrah bulls loaned out to private commercial buffalo farms for crossbreeding purposes. While there were good number of crossbreds produced out of these efforts, the monitoring and mating of these animals were not properly pursued, and thus with time, the female crossbreds were mated by native bulls. Also, due to the absence of organized breeding program, the purebred dairy breeds which were distributed to several government institutions failed to increase in number and in quality as desired.

Phase II of genetic infusion started in 1981, this time through frozen semen of Murrah and Nili-Ravi from India. Organized AI to produce crossbreds for research under the 10-Year United Nations Development Programme-Food and Agriculture Organization (UNDP-FAO 1982 to 1992) project were initiated.

The resulting F_1 crossbreeds were found to grow significantly faster than the swamp buffalo and to produce milk three to four times more than the native parents. It was also demonstrated that males and females F_1 crossbreds (2N= 49) were fertile. However, based on the analyses of breeding and performance records, it is not recommended to pursue an F_1 x F_1 mating, thus the route pursued and expanded towards the end of the project and onward is the continued backcrossing with the riverine type. Backcrosses with increasing blood composition of the riverine breed registered linear increment in milk yield without detriment to the reproductive and adaptive performances. With these production potentials, the social and economic benefits accruing to rural farmers from raising crossbred and backcross carabaos instead of the local breed became pronounced.

On the basis of these encouraging results, the government established in 1984 the country's first frozen buffalo semen laboratory and implemented a national artificial insemination program for swamp buffaloes utilizing frozen semen of selected Murrah sires. Estrus synchronization procedures were also developed to permit synchronized breeding and allowed the coverage of many breedable females, which are scattered quite thinly in the villages all over the country, utilizing the relatively few available AI technicians.

The phase III of genetic infusion started in 1995 with the infusion of Bulgarian Murrah buffaloes. About 3,142 animals (216 males and 2,926 heifers), together with 3,000 doses of frozen semen from elite progeny tested bulls were imported between 1995 to 1998. As the number of Bulgarian Murrah available for importation became so limited on later years, importation of 2,038 Murrah from Brazil was made in 2010. This followed by planned importation of 1,025 Italian Mediterranean buffaloes and some 5,000 straws semen in 2013.

Development of organized genetic improvement program that involved selection and progeny testing among purebred dairy buffaloes started in 1995. Purebred dairy buffaloes were reared at institutional facilities and accurate animal ID, pedigree and performance data were taken. In 2000, purebred animals at the farmer coops were enrolled at the genetic improvement program. Collaboration with the Australian government thru the ACIAR towards refining the data analysis system was initiated in 1999 thru 2004.

Technical assistance from the Japanese government thru JICA followed in 2000 to 2005, and such cooperation focused on improving system for utilization of selected sires, improvement processing of buffalo semen, and refinement of AI system. These initiatives were very important elements for progeny testing system. Towards the middle of 2008, collaboration with the US government, thru its PL480 program was initiated aimed at enhancing institutional capacities for buffalo R&D. This program focused on improving laboratory facilities and equipment and on human resource development.

Genetic conservation was put in place through the establishment of cryobank facilities with the assistance from KOICA and other partners such as the Taiwan Livestock Research Institute, Hankyong National University, and Institute of Animal Sciences of Korea.

As the crossbred and backcrosses animals have been produced and the numbers have continuously increased, farmers were organized and were trained to milk and assisted to set-up milk collection centers. The Korean (KOICA) and Japanese (KR2) governments assisted in this aspect through provision of post-production facilities and technical expertise to allow value adding of dairy products and facilitate viability of buffalo-based enterprises.

INSTITUTIONALIZATION OF BUFFALO DEVELOPMENT PROGRAM

The program of transforming the Philippine swamp buffaloes to producers of milk and meat has been institutionalized after the establishment of the Philippine Carabao Center and in China, after the establishment of the Guangzi Buffalo Research Institute. The components of the national program in the case of the Philippine experience are herein discussed.

Establishing the ground for genetic improvement

The fundamental initiative that is most consistent with the envisaged improvement in the productivity of the swamp buffalo is the establishment of germplasm pools from where superior materials can be obtained on a sustainable basis. Efforts along this line have yielded concrete results, as follows:

Gene pools for selected native Philippine Carabao (PC): While exotic germplasm were introduced for the specific purpose of improving milk and meat, the government also ensured that the existing swamp buffalo germplasm are conserved for long-term genetic improvement program. The general premise is that through the years, domestic stocks of swamp buffaloes have adapted to the local conditions and therefore there are certain genes that can be very useful for future breeding and genetic improvement. Gene pools for the Philippine carabao were established in the three main islands of Luzon, Visayas and Mindanao. The animals are kept as Open Nucleus Herds (ONH), and selection of better stocks from thc surrounding communities is done on a continuing basis. Selected animals outside of institution herd are taken in and shall form part of the ONH for the Philippine carabao. These animals have been chosen primarily for size, growth rate and reproduction ability.

There is also a swamp buffalo sanctuary in a separate island that is so well protected from the introduction of any exotic germplasm of buffalo of any form. Farmers are utilizing the indigenous buffaloes for their farming activities and this will certainly be carried through for many generations to come. Monitoring of the animals is regular.

Gene pool for improvement for milk production: Elite herds of "Bulgarian Murrah" are reared at the National Riverine Buffalo Gene Pool and at two separate institutions in the southern islands. Animals with outstanding performance at fannercooperatives are also enrolled as part of the gene pool. With organized selection and testing system in place, the country is now assured of sustained sources of genetic materials for improvement of milk production. The system can produce about 400 bulls of good quality per year, with the top-ranking bulls subjected to organized progeny testing and then assigned as semen donors for use in the nationwide Al program, while the above-average bulls are used in the wide-scale bull loan for crossbreeding in the villages.

Embryo Biotechnology Laboratory: Attempts to hasten the envisaged genetic improvement have also led to the development of facilities and reproductive biotechniques that can be used as important tools in some specific areas not normally achieved through the traditional breeding techniques. To date, the facilities established at the PCC Central Research Station and in the satellite laboratory in Maharastra, India have developed technologies to produce high genetics embryos through the in-vitro system. These efforts are complemented with the newly refined ovum pick-up procedures, obtaining oocytes from superior donors for IVM/IYF as an alternative option to superovulation scheme that proved to be less predictable and more expensive. Likewise, the facility has just embarked on attempts to propagate superior genetics dairy buffaloes through the use of somatic cell nuclear transfer technique (SCNT).

Use of DNA-based biotechniques as a tool for genetic improvement: As can be gleamed from the latest studies in bovine, the use of recently developed biotechnologies, such as marker-assisted-selection (MAS), has provided adequate opportunities to enhance selection and thus genetic improvement. This area will therefore receive considerable attention in the future.

Genetic evaluation system: Breeding research that aims to improve the milk production potential of the riverine buffalo population in the country is carried out by putting in place a system of ranking and selecting the best animals. This is done by developing a BLUP animal model for determining the genetic merit of individual animals with milk production record. Initially, evaluation of cows was based solely on milk volume, but starting in 2005, milk fat and protein percentages were included as additional traits in the evaluation.

Junior bulls are also ranked accordingly and selected animals are subjected to growth performance, after which selected bulls are sent to semen laboratory for testing of semen quality. Top ranking selected bulls are then included for semen collection and processing and then into progeny testing. Progeny tested bulls become sires of future generation animals.

Cryobanking of animal genetic resources: Genetic materials in the form of frozen semen, embryos, DNA and tissues are also collected from distinctly different breed groups and lines as well as from outstanding animals in the gene pools and are cyropreserved and stored in the gene bank.

Included in the gene bank are samples collected from livestock species such as indigenous cattle, goat, sheep and the Tamaraw (2n=46), an animal within the buffalo family that is classified as an endangered species and is found only in the Philippines.

EXPANDING USAGE OF SUPERIOR GERMPLASM

The utility of superior genetics obtained from the sustained selection and testing efforts is expanded by using females as dams of future sires while proven sires are used for AI. Outstanding sires tested and selected from the gene pool have been fully harnessed as semen donors in order to cover as many native swamp buffaloes as possible to effect the desired genetic improvement. Component activities/strategies on how to expand usage of superior genetics are as follows:

Semen Processing Laboratory: In support of genetic improvement efforts, the country established semen processing facilities as early as 1984, and to date, such facility houses 100 semen donors. Frozen semen from progeny-tested bulls are produced at a quantity more than sufficient to meet the national requirements, including the needs of the technicians of all local government units (LGUs) and nongovernment associations (NGOs) as well as private AI technicians.

Intensified Artificial Insemination and Bull Loan Program: In cooperation with the Local Government Units (LGUs), crossbreeding of swamp buffaloes with the dairy breed to improve the genetic potentials for milk is carried out nationwide. This system has current annual Al service coverage of about 100,000 head with planned expansion up-to 250,000 in 2016. As a way of government subsidy to the genetic improvement program, frozen buffalo semen are provided free of charge up until now. However, as the scheme to privatize the Al services is gaining acceptance, frozen semen are provided to private Al technicians at cost. Provision of liquid nitrogen to preserve quality of frozen semen is at the shared account of national and local governments, but will likely be provided at a later stage at cost to private technicians who, in turn, charge for their services at a reasonable rate.

In the past two years, efforts were directed at privatizing the Al services by developing village-based private technicians in order to augment the limited technicians of the national government agencies and the local government units. Based on the data so far, these private AI technicians are more cost- efficient and more responsive in many respects compared to LGU technicians. Their main advantage is their constant presence in the village service area and their "pay-per-service" system that releases the government from costly subsidies in the form of salaries and allowances. Under a condition where animal ownership per farmer is only I to 3, and households are scattered widely in the rural communities, it appears that harnessing village-based AI technicians offers many advantages. In communities where advanced stage of privatization has been achieved, Al technicians are also trained as para-vets and they are also organized. As a group they source their AI supplies, including liquid nitrogen (LN_2) and frozen semen at cost.

The AI is augmented with the bull loan program, which is undertaken in villages where AI services are not available. In fact, even in some areas where Al services are accessible, many farmers have high preference for natural mating, owing to very good success rate in this method compared to AI. A system of incentive is offered to farmers tending breeding bulls in the village wherein full ownership of the bull is awarded once the bull has sired at least 50 calves. Many farmers get their bull ownership in just a period of 2 years. In service areas of both AI and bull loan, the important consideration is to avoid inter-se matings of crossbreds. This is achieved by a programmed castrations of all crossbred males in the field and ensuring that semen for AI and bulls for natural service are of purebred riverine buffalo genetics.

SUPPORT TO ESTABLISHMENT OF BUFFALO-BASED ENTERPRISES

Two approaches are being introduced in areas considered to be impact zones for the project. These areas are considered as such in view of the density of breeder stocks in the community likewise being a major consideration. In these communities, massive AI services are carried out with the intent of producing critical number of crossbreds all of the crossbreds and backcross males are for meat or for draft and females are retained as potential dairy animals. While this activity covers many animal raisers, the process is relatively slow owing to the long gestation of buffaloes and their late maturity. As a way of "shortcutting" the process, incubator modules composed of purebred buffaloes are introduced in the impact areas. These modules serve as show window for the farmers to see and appreciate the benefits of rearing the correct animal and adopting the proper management and breeding practices. In the impact areas, carabao raisers have been organized into cooperatives to collect, process and market milk and milk products in a systematic manner. Support to these cooperatives takes the form of organizational as well as technical trainings and the provision of post-production equipment, mostly to preserve the quality of the milk and assistance to market access.

In the National Impact Zone (Nueva Ecija), primary cooperatives involving thousands of families have formed into the Nueva Ecija Federation of Dairy Carabao Cooperatives (NEFEDCCO) to supply milk and dairy products to major urban markets. Throughout the country there are 13 regional impact zones.

CONCLUSIONS

There are compelling social and economic reasons for the decision to pursue wide-scale crossbreeding and continuous backcrossing of swamp buffaloes with the riverine buffaloes in countries such as China and the Philippines. While there were apprehensions about the technical feasibility of carrying out such wide-scale efforts, first because of the differences in the chromosome numbers of these two buffalo types, and second, by the initial data about chromosomal behavior suggesting some potential reproductive abnormalities, performance of both male and female crossbreds and their backcrosses obtained in the field have shown otherwise. What has been avoided so far is the inter-se mating of F1 (2n = 49) as there are resulting F2 offspring with undesirable phenotypic performance, more practically noted on F_2s with 2n = 48. As a measure in the Philippines, crossbreds and backcrosses males are readily castrated and are destined for draft or for meat purposes.

Artificial insemination takes a major role in the genetic transformation of swamp buffaloes. The assignment of purebred riverine bulls in impact areas without AI services with the corresponding program to castrate the non-purebred males have guaranteed sustained backcrossing, generation after generation.

For wide-scale crossbreeding and backcrossing program to succeed, the mechanism needed for its implementation has to be institutionalized primarily because of the length of the required period, at least 15 to 20 years to achieve results of 3 to 4 generations of backcrossing. The establishment of Guangzi Buffalo

Research Institute in China and the Philippine Carabao Center in the Philippines are examples of institutional instrument needed to ensure sustained efforts throughout.

In the final analysis, the results of this genetic transformation of swamp buffaloes will find more meaning if the "new animals" designed to produce more milk and meat are fully utilized to benefit millions of farming families. The system should also recognize the requisites for "businessizing" the smallholders, rising them from subsistence way of husbandry to the level of entrepreneurship.

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Table 1. China & SEA GDP/Capita, agriculture as % of economy, % of labor in agriculture, buffalo population, and % change in buffalo population (1960 vs 2010).

Country	Human Population	Agri as % of Economy (%)	GDP/Capita ($)	% of Labor in Agri (%)	Buffalo Population 2011 (hd)	% Change in Buffalo Population (1960 vs 2010)
China	1,354,040,000	9.7	8,382	36.7	23.38	+27.7
Cambodia	14,478,000	34.7	2,490	57.6	0.72	+35.0
Indonesia	237,641,326	15.3	4,943	38.3	1.30	-30.7
Lao PDR	6,385,057	42.6	2,700	75.1	1.18	+166.1
Malaysia	29,631,000	12.0	15,800	13.0	0.13	-62.3
Myanmar	48,724,000	43.0	1,300	70.0	2.97	+174.2
Philippines	92,337,852	12.3	4,263	52.0	3.07	-5.2
Taiwan	23,315,822	1.6	21,592	5.2	0	-99.9
Thailand	65,926,261	8.6	5,382	49.0	1.69	-67.3
Vietnam	88,780,000	20.0	3,545	53.9	2.71	+27.7

Source: Wikipedia, 2013, FAO Production Yearbook, 2012; National Statistic Office of various countries 2010-2012

Table 2. Declining swamp buffalo population in selected SEA countries, 1960-2010.

Country	Year					
	1960	1970	1980	1990	2000	2010
Indonesia	2,893,280	2,885,000	2,457,000	3,335,080	2,405,280	2,005,000
Malaysia	345,151	310,402	285,339	205,163	142,042	130,090
Philippines	3,452,000	4,431,500	2,870,270	2,764,950	3,024,400	3,270,400
Thailand	4,963,580	5,734,500	5,650,790	5,094,270	1,711,570	1,622,650

Table 3. Recorded transport of riverine frozen semen to South East Asia.

Country	Year	Origin	Breed	# Straw/dose
Philippines	1981	Pakistan	Nili-Rav	1000
	1983	Pakistan	Nili-Rav	1000
	1987	Pakistan	Nili-Rav	1000
	1982	India	Murrah	1000
	1984	India	Murrah	1000
	1985	India	Murrah	1000
	2013	Italy	Italian Mediterranean	5000
Thailand	1979	India	Murrah	1000

Table 4. Recorded introduction of riverine buffalo in East and South East Asia.

Country	Year	Source of Genetic Material	Breed of Buffalo	No. (hd)		
				male	female	total
Live Animals						
Philippines	1917	India	Murrah			57
	1918	India	Nili-Rav			85
	1947	India	Murrah	7	43	50
	1947	India	Murrah	1	21	22
	1950	India	Murrah	3	116	119
	1953	India	Murrah	100		100
	1955	India	Murrah	4	319	323
	1956	India	Murrah		98	98
	1994	USA	Am-Murrah	70	154	224
	1995	Bulgaria	Bul-Murrah	51	408	459
	1996	Bulgaria	Bul-Murrah	49	304	353
	1998	Bulgaria	Bul-Murrah	116	1544	1660
	1999	Bulgaria	Bul-Murrah		670	670
	2010	Brazil	Murrah	11	2027	2038
	2013	Italy	Italian Mediterranean		1025	1025
China	1957	India	Murrah			55
	1974	Pakistan	Nili-Rav			50
Thailand	1962	India	Murrah			Various
	1979	India	Murrah			100
Vietnam	Late 1970	India	Murrah			
Taiwan	1957	Philippines	Murrah	3	4	7

Table 5. Summary of international collaborations related to transformation of swamp buffaloes from draft to milk and meat in the Philippines.

Theme	Institution/Entity	Date	Area of Collaboration
Genetics	Govt of India	1917 to 1956	Live Animals, Murrah (854 hd at various years)
		1982 to 1985	Frozen Semen, Murrah (3000 doses)
	Govt of Pakistan	1981 to 1987	Frozen Semen of Nili Ravi (3000 doses)
	FAO-UNDP	1982 to 1992	Research on Crossbreeding between swamp x riverime
	FAO	1994	Risk assessment on importation of live animals from India
	Govt of Bulgaria	1995 to 1999	Live Animal Importation, Bulgarian Murrah (3142 hd various years)
	Govt of Brazil	2010	Live Animal Importation, Murrah Breed (2038 hd)
	Govt of Italy	2013	Live Animal Imporation. (1200 hd, Mediterranean breed; 4000 straw of frozen semen)
System Development and Utilization of Genetics	Japanese Govt thru JICA	2000 to 2005	Genetic Improvement, AI improvement, Semen Processing
	Australian Govt thru ACIAR	1999 to 2004	Genetic Improvement focused on Animal ID, recording system and data analysis
	Korean Govt thru KOICA	2010 to 2012	Cryobanking of AnGR, DNA based biotechnology, Semen Processing
	US Govt thru its PL480 Program	2010 to 2013	Research and Development, Biotechnology Laboratories, Human Resource Development
	Taiwan Livestock Research Institute	2008 to date	DNA-based technologies, Screening of Genetic Defects, Cryobanking
	USDA	2012	Human Resource Development focused on Cryobanking of AnGR
	International Buffalo Genome Consortium	2011 to date	DNA-based MAS, Buffalo Genome
Enterprise Development	Japanese Govt thru it 2KR fund	2010 to 2013	Dairy Product Processing, Establishment of Milk Collection Scheme for smallholders
	Korean Govt thru KOICA and KAPE	2010 to date	Product Development, Product Standard, Product Traceability