AN OVERVIEW AND ANALYSIS OF ISSUES AND CURRENT PRACTICES IN THE INTERNATIONAL EXCHANGE OF ANIMAL GENETIC RESOURCES

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1. INTRODUCTION

Historically, Animal Genetic Resources (AnGR) have managed to traverse the borders of countries, regions and continents, especially so when this was facilitated by human intervention. Today more than ever before, globalization has resulted in greater movement of AnGR across the planet. While movements of AnGR across countries of the developed world and from developed countries to developing countries have not given rise to much controversy, their movement from developing to developed countries appears to be a cause of concern to some. Perhaps this is due to the greater awareness among nations concerning the value of AnGR and the sovereignty of nations over their genetic resource heritage. For the purpose of good governance over the management and utilization of AnGR, the current practices in the exchange of AnGR need study so that the issues involved may be elucidated. This paper attempts to examine the current practices in AnGR exchange by considering several examples, thereby elucidating the issues involved in the exchange and trade of AnGR.

2. CURRENT PRACTICES

The exchange or trade in AnGR was, in past times, enabled through the conveyance of live animals, or in the case of poultry, the transport of eggs. Improvements in technology have resulted in the exchange of AnGR not only in the form of live animals but also in the form of frozen semen and embryos, although in the future this will also include transactions in tissues, ova, and other forms of genetic material. Transportation was mostly by land or sea, although nowadays transport by air is preferred, particularly for deep frozen semen and embryos.

The provision of AnGR from one country to another is usually through agreements signed between institutions within these countries. For instance, this could take the form of transfer of genetic material from a gene bank in one country to an interested agricultural institute in another country. The reasons behind the exchange of genetic material could be many and varied. For example, it could be due to the provision of these resources in an aid package, or for mutual cooperation. It could be to promote better political relationships between countries or to promote business. Exchange could also be due to bilateral relationships between countries of the same region, so as to better conserve regional transboundary breeds. Not always the exchange is of genetic material for genetic material. It could be genetic material for aid or genetic material for trade. In some instances, there are agreements between countries on the terms of use of the genetic material provided and these are often regulated by a Material Transfer Agreements.

The exchange of AnGR between countries is here illustrated with several examples, with the aim of elucidating the issues involved in the exchange of AnGR.

2.1 Cattle Breeds from the Indian Sub-Continent

Several tropical breeds from the Indian Sub-Continent have been exported to countries near and far. Early exports were probably during the era of the South Indian Cholan Empire (about the 10th Century A.D.) and these Indian cattle could have been brought along in Indian warships to places as far away as the island of Bali in Indonesia. The Madura cattle of Indonesia, found on the island of Madura, are probably a mixture of Indian and local Banteng cattle. The late 19th century and early 20th century probably witnessed the transfer of much cattle genetic material from India to other parts of the world through the agency of colonists and migrants. Migrants from South India to Malaya (now Peninsula Malaysia) brought with them breeds such as the Kangayam and Hallikar and other non-descript breeds, now called Malaysian Local Indian Dairy. The British brought Sindhi cattle and later Sahiwal cattle (called Montgomery cattle) to Malaya to improve the genetic quality of dairy cattle kept by the migrants. The Dutch probably brought Nellore and Gyr cattle into Indonesia. The Brahman of the United States was developed from genetic material originally from India-Pakistan. From the Brahman, several synthetic breeds have been created such as the Charbray (in USA, Charolais x Brahman ancestry), Brangus (in USA, Brahman x Angus ancestry), and Droughtmaster (in Australia, Shorthorn x Brahman ancestry). Several synthetic dairy breeds have also been created using Indian breeds. The Jamaica Hope has Jersey, Holstein, Sindhi and Sahiwal inheritance. The Australian Milking Zebu (AMZ) was founded using Jersey, Sindhi and Sahiwal breeds. The Australian Friesian Sahiwal (AFS) is composed of Friesian and Sahiwal breeds. The Mafriwal cattle of Malaysia was founded using Holstein, AFS, Kenyan Sahiwal (there is a well-managed purebred Sahiwal herd in Kenya, Africa) and Brazilian Gyr breeds, and undergoes similar breeding to the Frieswal of India. These Indian breeds have not only been exported to distant lands, but have been value-added and re-exported to other countries. The present situation of Brazil as the world's top beef exporter can be explained by the perfect adaptation of Indian breeds to the vast tropical region of the country. This success story will be reported in the following section.

2.1.1 Cattle Exchange between India and Brazil

When the Americas were conquered, there were a few domesticated animals in the continent. The natives exploited a number of those species, such as camelids and guinea pigs. Most introductions occurred during the first years of colonization, by the Spanish and Portuguese settlers who brought animals of the main domesticated species found on the Iberian Peninsula. Only in 1534, the Portuguese settlers began bringing their own livestock to Brazil. For this reason, in the early colonial era, all cattle found in the country were of European origin, specifically from Portugal and Spain. Zebu cattle were introduced only in the early 19th century. Probably the first pure herd was established in 1826 in Rio de Janeiro, consisting of animals from the region of the Nile River in Africa (Magnabosco *et al.*, 1997). Since the performance of these animals was not satisfactory, breeders started to take more interest in zebu cattle from India. Coffee producers in Brazil were the first supporters of these breeds. They needed cattle to transport their coffee production, and found that the zebu cattle were tougher and faster for this work.

There were different arrivals - bulls, couples or small lots, from 1850 to 1883. Most significant imports occurred early in the 20th century, reaching a peak in 1920 with a total of 2,075 animals. In 1921, an outbreak of rinderpest, carried by animals that passed through Antwerp Zoo, led to a ban on further imports by the Brazilian Government. From 1921 to 1962, there were periods when such imports were permitted and then banned. Several importations occurred during this time, but from 1962 these were definitively prohibited. A summary showing the number of animals imported from 1850 to 1962 is shown on a table presented in Appendix I.

Zebu breeds raised in Brazil

The zebu breeds originally introduced in Brazil are: Gyr, Guzerat, Nellore and Sindhi, while Tabapuã and Indubrazil were formed through crossbreeding different breeds. Table 1 shows the number and percentage of registered animals for the different breeds raised in Brazil.

Table 1. Number and percentage of animals of the different zebu breeds raised in Brazil, registered in 2006.

Breed	Registered animals	
	Number	**Percentage**
Gyr	7,853	3.86
Guzerat	6,647	3.27
Nellore	171,813	84.53
Red Sindhi	669	0.33
Indubrazil	940	0.46
Tabapuã	7,571	3.74
Brahman	7,751	3.81
TOTAL	**203,240**	**100.00**

Source: ABCZ, 2008.

The evolution of the zebu population in Brazil is even more impressive when comparing the volume of imports of European genetic material (approximately 800,000 animals including Iberian, British and continental breeds) and Indian (≈6,300 animals), with the volumes reported at present by the Breeders Associations. Nowadays, the number of registered animals with European origin is much smaller than that found for zebu breeds.

Guzerat – Guzerat (or Kankrej as known in India) arrived in Brazil in 1870. This breed had the highest population until the 1920's when the Indubrazil breed was formed by crossing Gyr, Guzerat and Nellore animals. Some new imports of Guzerat occurred in 1962 and 1963. Guzerat animals are known by their quick growth and their heavy weights. Currently, breeders are crossbreeding Guzerat and Nellore, to form bulls to be used on cows of different European breeds.

Gyr – The Gyr breed arrived in Brazil in 1911, but only in the 40's did this breed became more popular. New imports occurred in the 1960's with emphasis on milk production, originating a line called Dairy Gyr. This latter breed is presently increasing rapidly in numbers. Dairy farming in tropical countries needs options that allow more efficient exploitation within economic and environmental realities and the Dairy Gyr fills this need. Interest in animals or semen from this breed has been growing, not only in Brazil but also in other tropical countries. Proof of this can be seen in the 500,000 semen doses sold per year. Later, a Polled Gyr was formed, using a local breed with Iberian origin, called National Polled.

Nellore – Even though today the Nellore has, by far, the largest population of all cattle breeds raised in Brazil, it was one of the last Indian breeds to attract interest of Brazilian breeders, particularly due to the shape of its ears, which were not thought to be standard among zebu breeds at the time. Among several important imports, 1962 stands out the arrival of the Karvadi, Kurupathi, Godhavari, Golias and Taj Mahal bloodlines. Its high adaptability to the tropical climate, strong defense instinct and excellent calf survival capacity led the Nellore to account for about 84.5% of the animals registered with ABCZ today, participating in approximately 80% of Brazil's beef production.

Sindhi – Even though the Sindhi was imported from Pakistan, in Brazil it is considered as another Indian breed. The Sindhi was introduced in Brazil in the 30s of last century, but it was in 1952 that occurred the most significant introduction of these animals, through the importation of 31 females and males. The breed has as main characteristics the red coat color, ideal for the tropics and subtropics, the small size, good reproductive efficiency and especially good ability to produce milk. The Sindhi adapted to the hot temperatures of the semi-arid Northeastern region of Brazil.

Indubrazil – The Indubrazil is a double purpose zebu breed created in the early 20th century, by Brazilian breeders, by crossbreeding Nellore, Guzerat and Gyr, bringing together the characteristics of the three main Indian breeds found in the country. This breed dominated the Brazilian beef industry between 1925 and 1945, but thereafter the numbers decreased, when the Nellore became dominant.

Tabapuã – The Tabapuã is a polled zebu breed, formed in Brazil. Originally, Nellore cattle were crossed with National Polled animals (a naturalized cattle breed formed from animals of Iberian origin brought by the Portuguese settlers), and later Guzerat bulls were used on the crossbred Nellore x National Polled. In 1943, some three-cross animals were taken to a farm in the Tabapuã municipality where, after a 30-year selection program, the Tabapuã breed was created.

Recent exchange agreements between Brazil and India

After the last ban that forbid the importation of zebu cattle from India in 1962, Brazil and India re-started the discussion about animal genetic resource exchange in 1998, and two Agreements have been signed since then:

Agreement to import embryos from India – When the importation of embryos from India to Brazil was approved by both countries, a Brazilian delegation visited four Artificial Insemination Centers in India and approved three of them. Later, the approval of these three AI Centers was confirmed by the Indian Government. This first Agreement established that 5,000 embryos were to be imported to Brazil, and this number includes the Ongole, Kankrej and Gyr breeds. In the future, Red Sindhi and Sahiwal may be imported. The donor cows from the three breeds that are going to be used to produce embryos for importation were selected by the members of a second delegation that went to India, and included breeders and researchers from different Brazilian institutions. The first lot of 350 embryos has been transferred to recipient cows. These recipient cows belong to breeders and have been sent to a Quarantine Station belonging to the Ministry of Agriculture 30 days before the embryo transfer, and should stay there six months after transfer. Another lot of embryos (400) has already arrived in Brazil and is being tested for different diseases before transfer. Two other lots (400 and 1,000 embryos) have already been collected and should soon be transported to Brazil. Two Normative Statements have been approved in 2006 and 2007 by the Brazilian Ministry of Agriculture, Livestock and Food Supply, regulating animal germplasm imported from India. The first (I.N. No. 6, of February 13, 2006) regulates the import of genetic material from India, while the second (I.N. No. 12, of April 18, 2007) regulates the selection and management of recipient cows used for transfer of embryos imported from India.

Agreement to import semen from Brazil - To increase milk production in tropical regions of Brazil, where European breeds have to be kept in artificial environments for production, Brazilian breeders and researchers decided to cross Gyr with Holstein, and formed a breed called Girolando (in Brazil, Holstein cattle are called “Holandes”, so, Girolando is the fusion of Gyr + Holando, without the H). The high milk production of the Girolando cattle, allied to its adaptation to the tropical climate, attracted the attention of Indian breeders, who now want to import Girolando and dairy Gyr semen, from animals selected for warm, tropical regions.

2.2 Boran Cattle

Boran cattle are indigenous to Kenya, Ethiopia and Somalia. Ranchers in Kenya recognised them for their beef potential and worked to improve them through selection. In Africa, the Boran is presently found in South Africa, Zambia, Tanzania and Uganda. CSIRO (Commonwealth Scientific and Industrial Research Organization) in Australia realized their heterosis potential (in terms of their distant relationship with the Brahman), their high fertility, superior mothering ability, good temperament and high tropical adaptability. They managed to source Boran cattle from Zambia and to collect embryos from them. In 1988, these embryos were implanted into Australian-born recipient females in the Cocos Islands, a location devoid of a local cattle population. Boran calves born in the

Cocos Islands were then imported into Australia after undergoing stringent quarantine testing. There is a sizeable population of Boran cattle in Australia. From Australia the genetic material has made its way to various parts of the world. The sale of Boran genetic material by Australian cattle breeders has attracted some accusations of biopiracy (Oduor Ong'wen, 2010).

2.3 Bali Cattle

The domesticated Banteng (Bali cattle) are found in several parts of South-East Asia and in Australia, but the largest populations are in Indonesia. Males and females have mature weights of 550 kg and 300 kg, respectively (DAD-IS, 2010). The Banteng are fine-looking beasts with horns that are curved and pointed upwards. They have a ridge on their back above their shoulders. Their coat is tan in color, with a black dorsal stripe, the coat in males turning black with age. Legs have white stockings on the lower portion. The rump and muzzle are also white in color. Weight gain is satisfactory for a tropical breed, while fertility is excellent in the tropical environment. They are utilized mainly for beef production, contributing much to economic development and supporting livelihoods by generating rural employment. Certainly there are some cross-border movements of Banteng cattle between Indonesia and Malaysia. In the past, Indonesia has sold limited quantities of frozen Banteng semen to Malaysia. Live animal exports from Indonesia have however been banned or restricted under the present government.

2.4 Murrah Buffalo

Murrah buffalo (*Bubalus bubalis*) originates from the Indian Sub-continent. The Murrah has a small head, slightly prominent forehead and short and flat horns turning backwards, upwards and curling inwards in a spiral form. The body is massive, long, deep and wedge-shaped. The udder is well developed with sizable teats. In India, the average lactation yield is 2,032 kg over a 347 day lactation period, the milk containing 7.66 percent fat. The first calving age is 44.4 months with a calving interval of 511 days (Singh and Barwal, 2010). Elite Murrah buffalo cows give 3,294 kg of milk (Anand Jain *et al*., 2010), which is a considerable amount of milk for buffalo. As Murrah is considered a premier milking buffalo, this has made it a candidate breed for bioprospecting by many countries. Other than in India and Pakistan, Murrah buffalo are reported to be in Azerbaijan, Brazil, Bulgaria, China, Ecuador, Guatemala, Indonesia, Lao Peoples' Democratic Republic, Malaysia, Nepal, Philippines, South Africa, Sri Lanka and Vietnam (DAD-IS, 2010). In Malaysia, Murrah buffalo were brought in by Indian/Pakistani migrants in the early 1900s. Murrah were introduced into China in 1957 and used for crossbreeding with Chinese Buffalo (Yang *et al*., 2010). In Bulgaria, Murrah buffalo bulls were first crossed with Bulgarian buffalo cows in 1962, to produce a hybrid superior to Bulgarian buffaloes in milk yield and body weight (Anand Jain *et al*., 2010). The Philippines has had a long history of importing Murrah buffaloes. The first batch of 67 head of Murrah buffaloes were imported from Calcutta, India in 1918. In 1994, 200 head of American Murrah Buffalo were imported from Arkansas, USA. In 1995, 1996 and 1998, a total of 1,940 head of Bulgarian Murrah buffaloes were imported. In 2001, frozen Murrah embryos were imported from Frigorifico Allana Limited in Aurangabad, India to facilitate the infusion of top quality Murrah genetics into the Philippines. The latest infusion of 2,000 head of purebred Murrah buffalo from Brazil was concluded in January 2010 (Philippine Carabau Center, 2010). In this respect the operations of the Philippine Carabau Center have made Murrah buffalo breeding very successful in the Philippines.

2.5 Boer Goats

The Boer goat is a composite breed comprising of mainly African tribal goat breeds with an infusion of Indian and European genetic material. The Boer goat was recognized as a breed in the early 1900s when South African farmers started improving the breed for meat performance. The South African Boer Goat registry was established in 1959 and this breed of goat has undergone intensive performance testing and selection. The Boer goat is adaptable to a variety of environments. It is a

horned breed with lop ears, with a variety of color patterns, although there is a preference for a white body with a reddish brown head. In the tropics bucks are capable of growth rates exceeding 120 g/d with superior animals capable of growing at 200 g/d. They have a very compact, meaty body making them very desirable as a meat goat. They are also considered quite fertile. The Boer goat has been reported to be present in 53 countries (FAO, 2007). Commercial trade in purebred or crossbred Boer goat is a thriving business, particularly in Australia and the United States.

2.6 Meishan Pigs

Meishan pigs are one of the several breeds of pigs originating from the Taihu lake region of China. Taihu pigs have very thick and wrinkled skin, a large head with wide forehead and long droopy ears. They are slow growing and yield a fatty carcass. However, they reach sexual maturity in 2.5 months and the females have a litter of 14 -15 piglets as compared to 10 piglets for Western breeds (Cheng, 1984). They have excellent mothering ability and are able to convert roughages better than Western breeds. In addition to this, they produce meat which is both juicy and tasty. The superior fertility and meat characteristics of the Meishan breed attracted much attention from Western swine breeders, who started to import the Meishan and similar Chinese breeds in the 1970s and 1980s. Initiatives were made to introgress the desired fertility and meat characteristics of the Meishan breed into purebred Western breeds such as the Large White. Several companies have reported the development of a commercial Meishan hybrid which has the Meishan's fecundity and meat quality whilst having a high lean growth rate. The Meishan together with other Chinese pig breeds has also been used directly as a line for crossbreeding (Cesar *et al*., 2010). Although Chinese pig breeds have been used to improve Western breeds, it must also be said that China has been importing improved Western pig breeds for its Swine Industry, and benefits much from the utilization of these breeds. Some of these Western breeds have been used to form new lines, such as the Taihu-Duroc cross production line, which is a popular commercial hybrid line in China.

2.7 Ostriches

Ostriches (*Struthio camelus*) are large flightless birds originating from the African continent. There are several sub-species associated with different points of origin (different country origins) in Africa or the Middle East. Three breeds are listed in DAD-IS, namely African Black, Australian and Kenyan Red. Generally adult males have mostly black feathers, white primary feathers and a white tail. Females have grayish brown and white feathers. They have long necks and legs and can run at speeds up to 70 km/h. Adult ostriches weigh between 60 to 150 kg. They are farmed commercially around the world for their hide, feathers and meat. Where they are commercially farmed, they may be subjected to crossings between different sub-species. Other than in Africa, this transboundary species is reported to be in Australia, Belgium, China, Cyprus, Indonesia, Malaysia, Pakistan and Ukraine (DAD-IS, 2010). *Struthio camelus* are listed on Appendix I of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) (Only the populations of Algeria, Burkina Faso, Cameroon, the Central African Republic, Chad, Mali, Mauritania, Morocco, the Niger, Nigeria, Senegal and the Sudan; all other populations are not included in the Appendices).

2.8 Booroola Gene

In the late 1940's, Australian sheep farmers noticed that Merino sheep owned by Jack and Dick Seears (Seears Brothers) from their Booroola Station were consistently producing 170-180% lamb crops as compared to typical Merino sheep, which gave less than 100% lambing rates. These Booroola sheep were studied by CSIRO and eventually led to the discovery of a single gene of large effect which increases ovulation and lambing rate. Researchers have mapped the Booroola Fec B gene to sheep chromosome 6 (Montgomery *et al*., 1994). Since the 1980's, sheep carrying the Booroola Fec B characteristic have been available commercially. For example, Texel sheep known for lean double muscled carcasses have been improved for prolificacy by crossing with DNA Certified

BB Booroola Rams. In India, with Australian cooperation, Decanni sheep are being improved for fecundity by being bred with sheep carrying the FecB gene. In Israel, both the Awassi and Assaf sheep breeds have been improved for prolificacy with support from New Zealand (Gootwine, 1995). There is much evidence to indicate that the Fec B gene in Australian Booroola Sheep originated from Garole sheep in West Bengal, but is also naturally present in other sheep populations, such as the Hu and Han sheep of China (Davis *et al*., 2006). The Fec B gene has currently spread to over 48 breeds and composites in at least 19 countries, mainly through the Booroola Merino (Davis, 2008).

3. ISSUES

Under the Convention on Biological Diversity (CBD), Access and Benefit Sharing is an imperative principle. In this regard, important progress has been made by the adoption of the Nagoya Protocol, which among other things sets terms on how countries will permit access to genetic resources, including traditional knowledge related to these resources, and share the benefits arising from their use. Clearly the Protocol will improve trust and transparency between countries, enabling better cooperation in the utilization of these resources. Countries which once were exceedingly protective over their indigenous AnGR may now be more willing to exchange these AnGR with other countries, as there is now a instrument for the sharing of benefits. In implementing the Protocol however, there might be some problems such as:

- Determining the country of origin of AnGR, particularly when the exchange or trade in the AnGR has also occurred in the distant past.
- Claims of ownership by several states, especially in the case of transboundary breeds.
- Claims of ownership where the AnGR has gone through several different states, perhaps also being value-added along the way (e.g. through selective breeding).
- Benefit sharing for AnGR which are synthetic breeds, where AnGR from other states were used to create these synthetic breeds; sharing of benefits, where a breed is used in hybridization or a gene from a breed is utilized.
- Rights of immigrants to own AnGR from their originating countries.
- Tracking and policing the use of Traditional Knowledge.
- Defending the rights of farmers', livestock keepers and animal breeders.
- Conflicts in implementation of TRIPs (Trade-Related Aspects of Intellectual Property Rights) Agreement of WTO and the CBD.
- Poor Sanitary & Phytosanitary status in developing and transition countries hindering access to AnGR.
- Drafting suitable and practical Material Transfer Agreements between states.

The examples given in section 2 demonstrate some of the above problems which may arise in the international exchange of AnGR. However these problems can be better addressed given the recent adoption of the Nagoya Protocol.

4. CONCLUSION

In general, all countries are dependent on the utilization of AnGR from external sources. The exchange and utilization of AnGR is also closely associated with their conservation. Further, facilitating conservation and the world-wide utilization of gene pools is an idea which is in sync with the Global Plan of Action for AnGR for Food and Agriculture. Impeding the international exchange of AnGR would have disastrous consequences on the nations. In this regard the adoption of the Nagoya Protocol is timely as it would help to enhance the flow of AnGR. It also can be considered a milestone in ensuring that the provisions of the CBD on Access and Benefit Sharing are realized. The present developments will have a positive impact on enhancing livestock production and ensuring food security, particularly when facing the global challenges of population increase, resource depletion and climate change.

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Appendix I

Estimated number of zebu animals imported to Brazil, from 1850 to 1962.

Year	Number	History
1850	1	One Sindhi bull enters the state of Bahia
1868	2	A couple of Ongole animals on their way to the UK is sold in Bahia
1870	1	One Guzerat bull imported to Rio de Janeiro
1878	?	First lot of Ongole bulls imported from India
1880	?	Second lot of Ongole bulls imported from India
1883	?	Third lot of Nellore bulls imported from India
1890-1895	200	Bulls, including Misore, imported from India to Rio de Janeiro
1898-1905	?	Scattered imports of different breeds
1906	150	Animals of different breeds were imported
1907	98	Animals of different breeds imported by some breeders
1908-1909	200	Acquisition stimulated by the government of the state of Minas Gerais
1910-1913	977	Different breeds imported with the help of the Ministry of Agriculture
1914	350	Animals imported by two breeders
1915-1916	205	Animals imported by another two breeders
1917-1918	248	Animals imported by three breeders
1919	944	Animals imported after a visit of Brazilian breeders to India
1920	2,075	Different lots of animals arrive in Rio de Janeiro and in São Paulo
1921	Brazilian Government forbids imports of cattle from India	
1921	192	Cattle imported under a special permission and obligation of a 90-day quarantine
1921	Importation again forbidden	
1939-1959	?	Scattered imports of a few animals
1960	102	Gyr (70), Ongole (20), Guzerat (12), under a special authorization from the Government
Brazilian Government allows the importation with the obligation of a long quarantine		
1962	293	Brazilian breeders went to India and imported animals of different breeds: Gyr (153), Ongole (84), Guzerat (46), Kangayan (10)
1962	Importation again forbidden	
1998	Brazil and India re-start discussion on exchange of genetic material of zebu breeds	
From 1850 to 1962 an estimated total of 6,262 animals of different zebu breeds were imported from India		

Source: Adapted from Santiago, A.A. (1987)