Japan's Embryo Transfer Technology and Its Feasibility in Hastening Livestock Improv in Southeast Asia

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SUMMARY

In Japan, progress has been achieved in the development of embryo transfer (ET) technology in the last few years. Researches on the other related technologies such as cryopreservation, *in vitro* fertilization, embryo manipulation and sexing are actively being carried out. However, its practical application is still limited. It is now being used for rapid proliferation of desirable dairy and beef cattle. About 100 organizations are involved in ET practice and research. The number of ET trained technicians has also increased. However, ET is still a relatively expensive technique which involves great effort and financial risk.

In Southeast Asia, a large livestock population is present and livestock raising plays an important role in the livelihood of the people. However, livestock production is a small scale enterprise. Poor genetic make-up, poor nutrition and management practices and diseases have been accounted for their low productivity. Proper breeding and selection have only been undertaken recently, hence, selected indigenous animals are few and non-existent. Artificial insemination (AI) has long been used in the livestock improvement program in the region. Moreover, the potential of ET technology to improve livestock productivity among the countries in this region has been recognized but problems in its adoption exists. The presence of few commercialized livestock enterprises apart from technical and financial constraints have hampered its practical use.

ET and related technologies should be applied firstly, to accelerate the multiplication of the already existing purebreds used in crossbreeding schemes. Similarly, it should be carried out to amplify the multiplication of offsprings from selected indigenous cattle, goats, sheep and water buffaloes. Cryopreservation can be incorporated in the above program as a means to establish a reserve of genetic material. Embryos of endangered species of wild life could also be preserved.

In this region, a successful ET program can only be accomplished with strong government support. It should be introduced without any delay for genetic improvement of livestock. Existing infrastructure and supporting facilities should be improved and strengthened. Team effort should always be borne in mind for the success of ET is not a one's man job. Finally, ET research should be geared towards the development and improvement of superovulation, embryo recovery and transfer techniques in the indigenous cattle, goats, sheep and water buffaloes.

Dairy and Beef Industry in Japan

Japan's agriculture is based on the family enterprise with an average landholding of 1.1. hectares, but productivity is very high. The number of household engaged in farming totalled 4.3 million in 1986, or 11.1 % of all household in Japan. The livestock industry's share in agricultural production rose from 14.5 % in 1960 to 25.1 % in 1973. The percentage of farm household income from livestock farming also rose from 17 to 25 % in the same year. In 1970, about 4.76 million tons of milk were produced as compared to 7.3 million tons in 1985. Beef production showed an increase of 0.28 to 0.56 million tons during the same period. Concurrently, there was an increase in the daily per capita consumption for meat, milk and milk products leading to increased imports every year. Owing to the increased demand for meat, import of meat showed more than a 3.9 - fold gain, from 220,000 tons to 851,000 tons during the same period (Japan Statistics Bureau, 1987).

Dairying in Japan started about a century ago. Most of the large-sized dairy farms are found in the eastern and northern parts of Hokkaido. The main breed of dairy cattle is the Holstein, while most beef cattle are Japanese Black. The other beef breeds are the Japanese Shorthorn, Japanese Brown, Japanese Pooled and Aberdeen Angus. The Japanese Pooled resulted from the crossing between the Japanese native cattle and the Aberdeen Angus. Dual purpose breed of cattle is usually not reared. In 1986, the total number of dairy and beef cattle were about 2.1 and 2.6 millions, respectively. The average number of dairy and beef cattle raised on a farm is 21 and 7. Up to 1983, about 92,000 farmers were involved in dairy farming.

The Japanese Shorthorn is usually found in Northern Honshu. The Japanese Brown beef cattle are mostly found in Kyushu and Shikoku, and are usually grazed on prefectural grazing lands, while the Japanese Black cattle are usually kept by the farmers, each farmer having 2 to 3 heads. The Japanese Black cattle is traditionally fattened using wheat bran, barley etc. in order to achieve the characteristic marbling which is required in certain types of Japanese cuisine. This meat is highly priced and is usually known as Kobe, Tajima and Matsuzaka beef. Moreover, dairy bull calves from Hokkaido are usually sent by trucks to the Chugoku and Kyushu regions for fattening with concentrates. These calves are sold at 1 week, 2 months or 6 months of age.

Current Status and On-going Research Program

The history and current status of ET in Japan have been discussed previously by Kanagawa and Abas Mazni (1986) and Zanwar *et. al* (1987).

Continuous financial support coupled with a strong desire and interest of the government to improve and develop the dairy and beef industry have been instrumental in the current success of ET technology in this country. The Ministry of Agriculture, Forestry and Fisheries (MAFF) with the active participation of

the Ministry of Education and Culture (Monbusho) and private organizations like feed and dairy companies have brought about this rapid development. The intense competition among the different organizations with respect to ET research has brought about some successful research findings.

There was an increase in the number of organizations involved in ET practice and research from 1972 to 1985 (Fig. 1) as well as in the number of technicians trained in various ET courses. A breakdown of the various organizations in 1985 is shown in Fig. 2. The organizations that are at present actively involved in bovine ET and achieving an average conception rate of more than 40 % are shown in Table 1. ET training courses are held in Hokkaido and several other Prefectures, and in the MAFF Livestock Experimental and Breeding Stations in Hidaka, Fukushima and Tottori. The Japan International

Table 1 - Organizations that are actively involved in bovine ET with average conception rate of more than 40 % in 1987

Organizations	No. Transfer	Contraseption Rate (%)
Hokkaido Agricultural Development Corp.	205	64
Hokuren Livestock Experimental and Training Farm, Kunnepu.	57	57
Snow Brand Milk Company, Bekkai	54	57
Snow Brand Milk Company ET Research Station	249	56
Snow Brand Milk Towada	127	53
Hidaka Breeding Farm, MAFF	70	56
Araki Livestock Clinical Station (Private)	82	53
Miyagi Prefecture Livestock Research Station	61	53
Livestock Improvement Association	138	52
Chubo Feed Company (Shimoyama Research Station)	69	52
Okayama Prefecture Livestock Research Station	68	48
Kumamoto Prefecture Dairy Association	145	46
Fukushima Breeding Farm (MAFF)	78	46
Koiwai Farm Ltd.	68	45
Shintoku Livestock Research Station, Hokkaido	43	43
Miyazaki Prefecture Livestock Research Station	51	40

(Source : MAFF Statistics, Unpublished data, 1988).

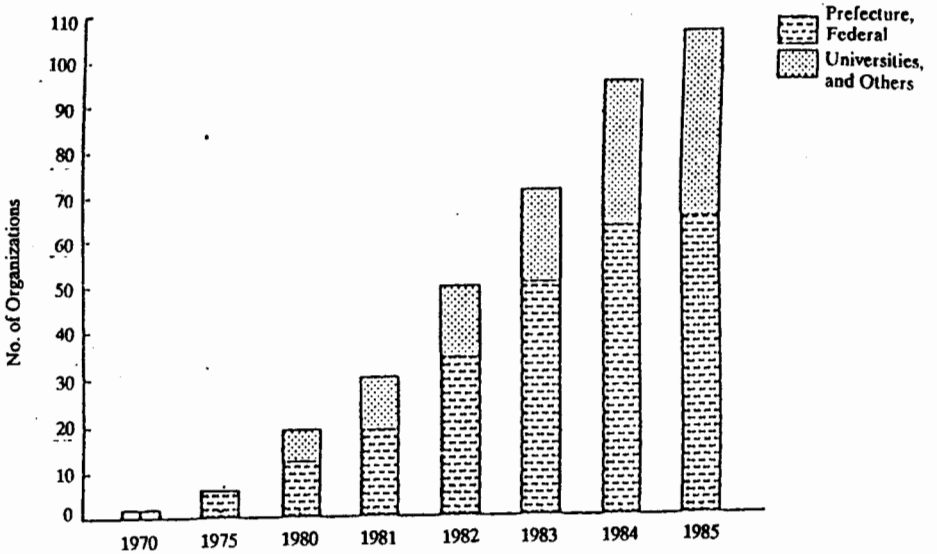

Figure 1 - The number of ET organizations from 1970-1985 (Source : Japan Livestock Improvement Association, 1986)

Cooperation Agency (JICA) is also conducting ET training courses in the above centers for ET technicians from developing countries since 1985.

Development of new techniques for bovine ET is being carried out by various organizations like by Hokuren in cooperation with the Hokkaido Livestock Improvement Association under the supervision of the MAFF. Attempts have also been made by several centers to produce bisected bovine embryos by microsurgery to give ET an additional value such as decrease ET expenses by half, effective use of recipients, possibility of achieving identical twins and sexing can also be done. Plate 1 shows the successful production of monozygotic twins from a bisected embryo. However, the success rate is still very low. Sex determination of embryos by chromosomal analysis is also being carried out, but the determination rate (30 %) is still low for practical use (Snow Brand Milk Company, 1985).

The twin production technique by transfer of two embryos is being developed as a means of increasing the number of Japanese Black cattle because a shortage of this highly priced beef of this breed is expected in the future. Two embryos of the Japanese Black cattle is

Plate 3 - Holstein calves resulting from IVF

Status of Livestock Production in Southeast Asia

A Large ruminant population is found in this region. However, the livestock industry is generally characterized by small scale units or what is usually termed a smallholders' industry. Commercialized goat, sheep, cattle and buffalo production have not been undertaken extensively, and development in the ruminant sector has progressed rather slowly despite government efforts to promote and develop the industry.

Cattle and buffaloes are major sources of draught power and are also suppliers of meat, milk, and other by-products. Goat and sheep which are becoming more popular as sources of meat and milk are now also being integrated with planntation crops. However, there is still shortage in the supply of meat and milk leading to importations. Domestic milk production can only supply 20 % (Indonesia), 5 % (Malaysia), 1 % (Philippines) and 3-4 % (Thailand) of their total milk requirements. In the last decade dairy production programmes have been earnestly promoted by every government in the region.

Problems and Major Constraints of Ruminant Production

In general, the indigenous goat, sheep, cattle, and buffalo have low productivity. They are small, late maturing, with low average daily gain and milk production. Exploitation of their genetic resources through proper breeding and selection has only been recently undertaken. Hence, selected indigenous animals are few or non-existent. Their poor performance can also be attributed to poor nutrition and management

practices. Large scale cattle and goat farms under intensive system developed by the government such as those in Malaysia so far has not proved to be successful and economically viable (Samuel, 1987).

The adverse hot and humid environmental condition is not conducive to their growth and production. It has been shown that these animals give better performance when they are raised under more favorable condition coupled with proper feeding and management practices. However, their performance is still not comparable to the performances of their temperate counterparts. This has led to the active introduction of exotic breeds like Jersey and Holstein for upgrading and crossbreeding purposes. Implementation of the program was not done systematically and lacked perspective. In addition, poor breeding practices and improper crossbreeding program with lack of selection have led to the slow development of a productive and adaptable animal. As a consequence, up to the present time no definite conclusion as to the type of breed or crossbred which is suitable for dairy production has been reached.

In the early 1980's, Malaysia imported a large number of Friesian Sahiwal from Australia and New Zealand as a means to rapidly increase its dairy base cattle population. Similar importations were carried out by the Philippines and Indonesia. This heat tolerant crossbred which was expected of being a potential milk producer, however, had variable milk production ranging from 5-10 kg/day. Poor management practices might be one of the causes of the low milk production. Similar problems are also faced by the other local crossbreds which are at present having mixed breed composition due to indiscriminate breeding either naturally or through AI.

Status of ET in Southeast Asia

The current status of ET in this region has been discussed by Zanwar, *et. al.* (1987). ET has already been carried out by international private ET companies in most of these countries, but only in a limited scale. Initial ET research in ruminant is being conducted by different universities and government reserach stations.

Constraints of ET Development in Southeast Asia

Selection of indigenous animals is still in its initial stage and upgrading of these unproductive indigenous animals is actively being carried out. The current policy is to produce and multiply an improved animal which is within the management capability of the farmer rather than raise excellent, high producing animals. In the last decade, though AI has progressed tremendously, there is still a lot of improvement to be done. Furthermore, most of the semen required are imported and not produced locally. Hence, the need to incorporate ET into the breeding program to produce genetically superior young sires for future use in AI services is still far-fetched. The use of ET by AI organisations may be limited unless incorporated into schemes for genetic improvement and further collection of embryos from potential bull mothers.

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Local veterinarians or animal scientists that have already gone for training are interested to carry out ET, but poor back up facilities, lack of supervision and financial support have precluded their initiative. In addition, lack of cooperation, between capable personnel from different agencies to work together has rather slowed down its implementation.

ET involves various procedures and once the embryo is transferred, proper management of the recipient through parturition, and care of the progeny till it reaches the productive age should be carried out. However, in this tropical environment coupled with poor management and high calf mortality this can mean a great risk.

The transfer of frozen embryos has been introduced by private companies at a high price and the success rate is low. Since most of the cattle owners are smallholders having less than 5 cattle per farm, the demand from them is virtually non-existent. The local farmers usually depend on government support for the supply of improved animals. Only the institutional farms or universities that are interested in this field are taking initiative of introducing this technique for research or breeding improvement program.

ET as Tool To Hasten Livestock Improvement in the Region

The application of ET in research, breeding and animal production had been discussed by various authors. Its potential application in increasing livestock production in developing countries had also been discussed (Jillella, 1982; Kanagawa, 1985). ET is not a very potent genetic tool as compared to AI with respect to genetic improvement and multiplication of that improvement over the population. However, in combination with AI, it can be an ideal technique for the improvement of animal production. In this region, some of the ways in which ET can be utilized to hasten livestock improvement are the following:

1. Obtaining More Offsprings From Valuable Females.

Indigenous breeds of cattle like the Malaysian local Indian dairy and Kedah Kelantan, Indonesia's Benteng or Bali cattle (*Bos javanicus*), Philippine's Ilocos cattle and Thailand's local beef and dairy cattle constitute an irreplaceable stock of adapted germplasm. The number of these indigenous cattle have decreased markedly since they were decimated by premature upgrading and replacement programmes. Their environmental adaptational qualities like disease and parasitic resistance, ability to survive and reproduce in this hot and humid environment and ability to exist on low quality feed are some of their good qualities that should be further exploited. In rotational crossbreeding programme where exotic and indigenous breeds are used in rotation, selection among the indigenous breeds is an integral part of the programme. Selection among the indigenous animals should be carried out in the national herd to identify the good animals. They should be grouped together in the government breeding or multiplication farm forming a nucleus herd whose average genetic merit is far

greater than that in any of the contributing herds (Nicoll, 1976).

Once the good donors have been identified they should be superovulated, selectively mated to superior bulls, and the collected embryos transferred to less productive recipients. Through this mathod, the multiplication of this group of animals would be faster than with normal reproduction. This allows a few genetically superior cows to become the genetic mother to a far greater number of animals done otherwise possible. The average cow produces less than 1 calf per year, but with the aid of ET technology she might be producing to about 40 offsprings per year, though the level is not yet achieved as an average (Church and Shea, 1977). But because AI has not been extensively carried out, the use of ET will have a relatively greater impact than that of an AI population. Since AI is more economical and effective in increasing the rate of genetic improvement than does ET it should be carried out hand in hand with this techique. Once the national indigenous herd is established ET can be further used to select the potential dam of young bulls because through her sons a cow can influence the genetic merit of many thousand cows (Bradford and Kennedy, 1980).

Similar procedures can be applied to the swamp buffalo, indigenous goat and sheep. As for the crossbred animals, intensive selection is needed to find the few animals which combine both the high yielding character of the temperate breed with the resistance of the local breed. It is improtant that an appropriate breeding system be chosen to maintain the required blood level of exotic breed after the initial crossing. Once the breeding system has been decided, ET can be used on the selected crossbred dams to produce more offsprings.

2. Multiply Exotic Breeds of Cattle, Goat and Sheep

Nucleus herd of purebred Holsteins are found in the cooler mountainous regions in each of these countries : Chiengmai, Thailand; Cameron Highlands, Malaysia; Mountainous Areas of Java, Indonesia; Bukidnon, Cavite, Bicol Region of the Philippines. Purebred exotic breed of beef cattle like the American Brahman, Droughtmaster, and Hereford are also maintained as purebreds in certain government and private farms. Similarly, purebred goat and sheep like Jamnapari, Saanen, Anglo Nubian, Dorset Horn and Wiltshire Horn are also kept for use in crossbreeding program. These small populations of already existing purebred herds in the country could be rapidly multiplied through ET if there is a demand to increase the number of a particular breed. It is more economical and practical than importing live animals which are expensive and furthermore these new animals do not acclimatize easily to the new environment. Since these ET offsprings come from selected dams they can be used to establish the national exotic herd for production of exellent dams and sires. Moreover, with the use of imported frozen semen from proven sires the local exotic breeds could be further improved. They can also be distributed to chosen farmers in a specific area where they can survive. The progeny produced this way are more adaptable to the environment and disease since they

complete their gestation in an indigenous female (Mitchell and Betteridge, 1977).

3. Cryopreservation and Importation of Frozen Embryos

Cryopreservation will play an important role in facilitating the implementation and development of ET programmes. It must be an integral part of the program since extra embryos collected from superovulated animals can be stored. Transfer of embryos can be done at the appropriate time when recipients are available, and also the birth of offsprings could be programmed at a preferred time of the year when feed supply is most abundant.

Furthermore, due to the large scale crossbreeding program in the region there will be a possible decrease in the number of indigenous cattle, goat and sheep. Embryo banks for these valuable genetic material should be established so that these indigenous breeds could be reestablished if the crossbreeding program leads to loss or excessive dilution of important genetic traits. The importation of frozen embryos of certain breeds could be done if it is needed for the improvement of the breeding program.

Freezing techniques should be acquired. However, freezing machines are expensive, and the current freezing procedures is time consuming and laborious. Other simple freezing techniques like quick freezing and vitrification exist but are still in the experimental stage. Once perfected, these techniques which are simple, inexpensive and do not require the use of freezing machines could be practically applied.

Conclusion

The government should provide every assistance especially in terms of financial support and personnel development to appropriate organizations that are currently carrying out ET research. Basic facilities as those found in universities and research organizations can be used but need further modification and improvement. International development organizations can help provide the basic equipments and training.

In each country, personnel from different organizations who have undergone certain kind of ET training should be encouraged to work together to develop ET. Manpower, ideas, and equipments should also be pooled to speed up the development of ET technology. Good team work with sense of responsibility, practice and patience are strongly required for the success of ET. It should always be borne in mind that its success is not a one man's job.

A number of trainees have been trained in various ET courses but only a few have managed to start ET work upon their return to their respective countries. Some of the factors which are hindering its implementation have been discussed, but it was also thought to be due to the improper selection of trainees. It is suggested that *in situ* ET training should be carried out in the place where actual work is being performed. Moreover, the ET experts should be invited to initiate the actual ET procedures in the host country. This would enable the experts to

fully understand the local problems and devise ways of overcoming them. In addition, more local personnel would benefit from this exposure. However, for personnel who are actively involved in ET, further training abroad in the form of regional, international or actual training in ET organization should be given if necessary.

ET research should be geared towards the development and improvement of superovulation, embryo recovery and transfer, and simple cryopreservation techniques in the indigenous and crossbred cattle, goat, sheep and swamp buffalo. Since embryo recovery in the buffalo has not yet been successful, more detailed studies regarding this aspect should be done. Environmental influences on superovulation, embryo quality, and conception rate after transfer should be further investigated.

With a definite long-term livestock improvement and breeding policy ET could be introduced to hasten livestock improvement. Selection, AI, and ET should be carried out to produce bull calves to be used as future sires especially in the indigenous and crossbred animals. Concurrently, progeny testing should be implemented. Hence, a national elite herd could be established at a much faster rate with the use of the ET technique.

Finally, in order for the ruminant sector to develop, a favorable atmosphere for its growth and development should be stimulated. Investment and commercialization should be encouraged. Further development of the industry should be carried out even if imports are cheaper and readily available. The price of imported beef, milk, and milk products are cheaper as compared to the locally produced ones, but with the influx of these cheaper commodities, the local producers will not be able to sell their products thus making their livestock enterprises unprofitable. In Japan, the foodstuff control system has stimulated agricultural production in various sectors by the introduction of measures which restrict the importation and marketing of imported products thus making local production profitable.

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