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Use of Nuclear Techniques for Improving Livestock Production and Health in Sri Lanka: A Review of Studies Conducted and Strategies for Technology Transfer

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ABSTRACT

The use of nuclear techniques for studies on livestock production in Sri Lanka commenced in the 1970's with the establishment of a Radioimmunoassay (RIA) technique for measuring reproductive hormones in the blood and milk of buffaloes, cattle and goats. Progesterone measurement was used in a series of studies to monitor reproductive status of ruminants under small-holder farming conditions in different ago-ecological zones, to identify the major constraints and to test methods for improving fertility. Thereafter, other isotopic techniques were established and used together with conventional methods for studies on nutrition, environmental physiology and disease control. In the early 1980's the nuclear-related technique of Enzyme-linked Immunosorbent Assay (ELISA) was established and applied for studies on the immune response of buffaloes to *Toxocara vitulorum* infection. Subsequently, ELISA techniques were used for studies on sero-epidemiology and control of important viral and bacterial disease of cattle and buffaloes (rotavirus infection, haemorrhagic septicaemia, brucellosis, rinderpest and foot-and-mouth disease). The most recent development has been the use of ELISA for diagnosing viral diseases of poultry. In order to transfer the findings from research to the end-users, a multi disciplinary programme was launched in 1995, with the focus on improving buffalo production. Selected farmers in three regions of the country participated in the testing, modification and evaluation of appropriate technology packages aimed at improving the productivity and health of their animals in a sustainable and economically feasible manner. They were provided assistance to upgrade their operations to the status of "Model" farms, which are now serving as demonstration sites and training locations for other farmers. Nuclear and related techniques have proved to be valuable tools in research for identifying the true nature of problems facing livestock farmers in Sri Lanka. Using this knowledge to formulate technologies for overcoming these problems, and their field testing, requires the researchers to be sensitive to the rural farming situations and to work closely with the farmers and the extension services. Although the technologies applied in the field will rarely if ever contain a "nuclear" component, nuclear techniques will continue to have an important role in monitoring the responses to these improved technologies.

Keywords: Nuclear techniques, livestock, production, health, technology transfer

INTRODUCTION

Agriculture in Sri Lanka has traditionally been based on mixed crop-livestock systems, undertaken mainly by rural small-scale farmers. Cattle and buffaloes are kept as a secondary activity, and provide the farmers with draught power, milk, meat, fuel and fertilizer (de Silva *et al.* 1985). They also serve as a means of accumulating capital, as savings for use in times of need and for cushioning the risk associated with crop failures (Abeygunawardena *et al.* 1994).

The profitability of livestock production systems depends to a large extent on four major factors (Perera and Dargie 1994). Firstly, the animals must be suitable for the environment in which they are to be raised. Secondly, they must be managed and fed in accordance with their genetic make-up and production potential. Thirdly, they must reproduce efficiently. Finally, they must be free of infectious and non-infectious diseases. In all these areas, nuclear techniques can provide crucial information on the current status of productivity and health of animals (Richards *et al.* 1992), and also give insights to problems that may otherwise go unnoticed. However, as with all sensitive and powerful research tools, they must be used judiciously and in combination with traditional methods, in order to obtain meaningful results which have practical applications (Garcia *et al.* 1995).

In studies on environmental effects and adaptation, physiological parameters such as water metabolism and turnover can be assessed using tritiated (^3H) water (Ranawana *et al.* 1980). In nutrition, both stable (^{15}N) and radioactive (^{14}C) isotopes can be used to assess the function of the rumen and the feeding value of different types of locally available feeds (Jayasuriya and Karunaratne 1984). Hormones such as progesterone, which are present in blood and milk in minute quantities, can be measured by Radioimmunoassay (RIA) using tracers such as ^3H or ^{125}I (Perera *et al.* 1978). This has applications in determining the reproductive performance of animals raised under different conditions (Perera and Abeyratne 1979), and for monitoring the responses to measures aimed at improving fertility (Perera 1986). Parasites which cause disease can be tracked through the animal's body by labelling with radioisotopes such as ^{37}Se (Roberts 1990). Other immunoassay techniques such as the Enzymelinked Immunosorbent Assay (ELISA) have important practical applications in the detection of organisms which cause disease in livestock, as well as for detecting antibodies produced by the host animals in response to infection by, or vaccination against, such organisms which may be parasites (Amerasinghe *et al.* 1984), viruses (Sunil Chandra and Mahalingam 1987) or bacteria (Horadagoda *et al.* 1994).

The objectives of this paper are: (a) to review the establishment and application of nuclear techniques in Sri Lanka for studies on livestock production and health, (b) highlight some of the results obtained, particularly those which have potential field applications for improving farm productivity, and (c) to describe an approach that has been taken to use these research results for generating appropriate technologies, testing and transferring them to the end-users, the village farmers.

ESTABLISHMENT OF NUCLEAR TECHNIQUES IN SRI LANKA

The first application of nuclear techniques to studies on farm animals in Sri Lanka was in reproduction, when the radioimmunoassay (RIA) technique for measuring progesterone in blood of cattle and buffaloes was established (Perera *et al.* 1978). The technology used at that time involved sample extraction, use of ^3H-progesterone as tracer, an antibody raised in rabbits (kindly supplied by Prof. Lars-Eric Edqvist of Sweden), separation of bound and free fractions using dextran-charcoal and liquid scintillation counting. A similar technique was also developed for measuring testosterone (Perera *et al.* 1979). Subsequently, a direct (non-extraction) method for measuring progesterone in milk was established, based on the same liquid-phase ^3H technique (Perera *et al.* 1987), followed by an assay for Luteinizing Hormone (LH) based on the double-antibody technique and employing a ^{125}I tracer (Mohan *et al* 1990).

Currently, the routine assay in use for plasma and milk progesterone measurement (Abeygunawardena *et al.* 1996a) is the FAO/IAEA/DPC solid-phase pre-coated assay tube system using ^{125}I as the tracer (Plaizier *et al.* 1992). A recently developed variant of this method, the FAO/IAEA "self-coating" system based on a monoclonal antibody, has also now been established.

In studies on ruminant nutrition, the nuclear technique used in Sri Lanka was the *in vivo* ^{14}C-acetate method to determine the production and relative proportions of volatile fatty acids (VFA) in the rumen (Jayasuriya and Karunaratne 1984). Subsequent studies have focussed on non-nuclear but complementary methods (Premaratne 1990; Perera 1992; Pathirana *et al.* 1993) to evaluate locally available feedstuffs, and to monitor rumen function in animals fed various supplements. The tritiated water (^3H_2O) technique for measuring body water was established (Ranawana *et al.* 1980) and used for studies on the comparative adaptability and responses of buffaloes and cattle to environmental stress (Tilakaratne *et al.* 1980; Rajaratne *et al.* 1981). This technique was also used for determining the milk yield of suckled buffaloes by monitoring the water turnover of their calves (Horadagoda *et al.* 1989).

In studies on animal diseases, a technique to radio-label a specific parasite of buffalo calves (*Toxocara vitulorum*) was established using ^{37}Se-methionine (Roberts 1990), and used for tracking the life-cycle of this parasite, and to evaluate strategies for its control. The production of an irradiated vaccine against the tick-borne parasite *Babesia* was done on a pilot scale (Weilgama *et al.* 1988) using a ^{60}Co source, and was found to be technically feasible.

The ELISA, which is a non-nuclear technique, is nevertheless considered to be within the family of nuclear and related immunoassay methods (Dargie and Perera 1994). This was established in Sri Lanka initially for studies on the immunological responses of buffaloes to *Toxocara vitulorum* infection (Amerasinghe *et al.* 1984; Fernando *et al.* 1989).

Subsequently, ELISA techniques were established for a wide range of applications, including serological studies on rotavirus infection (Sunil Chandra and Mahalingam 1987), haemorrhagic septicaemia (Horadagoda *et al.* 1994), brucellosis (Silva *et al.* 1995), rinderpest (Silva and Dangolla 1996) and foot-and-mouth disease (Kodituwakku 1997) in cattle and buffaloes. The latest addition has been a range of ELISA methods for diagnosing viral diseases in poultry (P. Wijewantha, Personal Communication).

RESULTS AND FIELD APPLICATIONS FROM STUDIES IN SRI LANKA

The main focus of the above studies has been the buffalo (*Bubalus bubalis*), while some studies have also included zebu (*Bos indicus*) and temperate (*Bos taurus*) cattle. This resulted from the realization, in the mid-1970's, that while previous work had been mainly on cattle, the buffalo which had largely been neglected by Sri Lankan scientists had an important role to play in improving rural farm economies (Perera *et al.* 1989). Fortuitously, considerable financial support for studies aimed at improving buffalo productivity also became available at this time, through several international and bilateral programmes.

Reproduction

It had been generally assumed that the buffalo is a sluggish breeder, and that poor fertility is a biological phenomenon peculiar to this species. Initial studies using progesterone measurement provided information on the endocrine control of the oestrous cycle (Perera *et al.* 1978), pregnancy (Perera *et al.* 1980), parturition (Perera *et al.* 1981) and post-partum period (Perera *et al.* 1984 & 1987) of exotic dairy type (Murrah and Surti) as well as indigenous (Lanka) buffaloes. A large scale field survey was also conducted to obtain benchmark data on management and productivity of indigenous buffaloes reared under village systems (de Silva *et al.* 1985). It was found that the average calving interval was around 19 months. While this was as long as 24 months in some locations, denoting very poor fertility, in others it was as short as 1314 months, which is optimal. An association was found between calving interval and several factors, including management and seasonal fluctuations in rainfall and feed availability. Subsequent studies using RIA in combination with clinical observations (Perera 1986) confirmed that long calving intervals were due mainly to a long period of ovarian inactivity (acyclicity or anoestrus) after each calving. Sexual cycles resumed earlier if calving occurred during more climatically favourable times of the year, e.g. during or immediately after monsoonal rains, when adequate herbage was available to the animals. Once cyclicity had been established the cows readily conceived, particularly in management systems where intact bulls were present with the herds (Perera *et al.* 1988).

This pointed to the possibility of improving reproductive efficiency of the buffalo through provision of supplementary feed during adverse periods. However, to be economically viable, such supplements must be cheap and locally available. The concurrent studies on nutrition using nuclear techniques addressed these issues, resulting in a dynamic interdisciplinary effort (Abeygunawardena *et al.* 1996b), which is now being translated into field applications as described below.

Another factor which was shown to influence the resumption of sexual cycles in buffalo cows after calving was the type of management under which their calves were raised. A longitudinal study using progesterone measurement done under a traditional system of management, where calves were raised separately from their mothers from the time they were one week old and allowed access only for suckling once a day, showed that the reproductive performance of the cows was excellent (Perera *et al.* 1987). Subsequent studies under more controlled conditions showed that restricted suckling induced earlier onset of sexual cycles in the buffalo cows, while causing no detrimental effects on the calves (Mohan *et al.* 1990; Perera *et al.* 1992; Abeygunawardena *et al.* 1996c). The management changes involved in raising calves under a regime of restricted suckling are feasible in many situations and, when introduced together with other improved technologies, have found ready acceptance by smallholders (Abeygunawardena *et al.* 1996d).

Artificial Insemination (AI) is a universally accepted method for genetic improvement of livestock populations. However, in the implementation of field AI programmes, several factors can influence the success rate. Although conception rates to AI can usually be determined from conventional techniques, the actual reasons for conception failure are difficult to identify. Measurement of progesterone in milk samples collected from cows at defined times in relation to AI provides a powerful tool of this purpose. The collection of milk is also non-invasive and can even be done by the farmer. A study in the mid-country of Sri Lanka, using three samples of milk collected at days 0, 7 and 23 relative to AI showed that the major problems included poor oestrus detection, AI at the wrong time and high variability in the performance of individual AI technicians (Mohamed 1990; Mohamed *et al.* 1990). This study showed that on state farms and smallholdings respectively, 37% and 39% of heats were incorrectly detected; 29% and 23% of AI were done during the luteal phase (i.e. incorrect time); and the number of services per conception was 3.2 and 2.9. The average interval to onset of ovarian activity after calving was around 140 days, indicating that nutrition was also a limiting fertility in this population.

A study is currently underway to monitor AI using milk samples collected on days 0, 10 and 21-23 after AI, with detailed observations on the farm, the cow, the semen and the inseminator (Alexander *et al.* 1997a and b). The results from smallholder farms in four veterinary ranges in the mid-country region showed that the interval from calving to first service was very long (mean 183 days), and was attributable to poor nutrition of the cows, misconceptions among farmers on the correct time for breeding their cows and poor heat detection. Around 20% of the animals presented for AI had high progesterone levels and therefore could not have been in heat. Even in those with low progesterone levels at the time of AI, only about 55% appeared to have had a normal ovulatory oestrus. The average first service conception rate was 45%, which can be considered to be in the lower range of acceptability. The main factors which appeared to influence this were: location, feeding and body condition score of the cows; the interval after calving, time of year and the interval from detection of heat to AI; bull, semen type and origin; and technician. This study, which is being conducted in close collaboration with the field veterinary and AI services, should provide the information needed to pinpoint the reasons for AI failures and thereby assist the veterinarians and AI technicians to take appropriate remedial action.

Other contributions to knowledge from studies using progesterone RIA include the diagnosis of non-pregnancy 21 days after AI in buffaloes (Perera *et al.* 1980), the accurate determination of gestation length in Lanka and Murrah buffaloes (mean ± SD, 316.3 ± 9.2 and 309.9 ± 6.5 days, respectively; Perera and de Silva 1985) and the monitoring of responses to oestrous synchronization (Rajamahendran and Thamotharam 1983; Perera 1987). A long-term study is currently underway to compare the reproductive performance and milk production of different genotypes of buffaloes (pure indigenous and its crosses with Surti, Murrah and Nili-Ravi) under a standard management system.

In buffalo bulls, measurement of testosterone in blood samples collected at frequent intervals over several hours, and repeated during different periods of the year, has shown that seasonal differences exist in the pattern of secretion of this androgen (Perera *et al.* 1979; Gunarajasingham *et al.* 1996). The changes which occur during the early stages of life through puberty have also been documented (Gunarajasingham and Rajamahendran 1982). It was also shown that use of stimulation tests with Gonadotrophin-releasing Hormone (Gn-RH) or Human Chorionic Gonadotrophin (hCG) can overcome some of the disadvantages of repetitive sampling which is usually required to assess testosterone status in the male (Perera *et al.* 1986).

Nutrition

A major factor limiting the efficiency of livestock production in Sri Lanka is inadequate or inappropriate feeding of animals. The reasons are diverse, but can be broadly categorised as: (a) fluctuations in the quality and quantity of the major conventional roughage feed resource, natural grass, which depends on the seasonal and often erratic pattern of rainfall; (b) high cost of the conventional concentrate feeds, coconut poonac and rice bran; and (c) lack of knowledge and prevailing prejudices on the potential and appropriate use of non-conventional feed resources and supplements.

One of the potential feed resources which is often available, but not used by farmers is rice straw. The major reason is the low digestibility and palatability, which result in low intake. Studies using nuclear techniques, where the rate of production, pool size and half-life of acetate (an important VFA) in the rumen was used as criteria, showed that the digestibility of straw can be improved by either supplementation or treatment with urea at a level of 4% (Jayasuriya and Karunaratne 1984). The improvement in digestibility was greater with treatment than with supplementation, but the former process required the straw to be stored (ensiled) for 3 weeks before feeding to animals. When glyricidia leaves were added at the time of ensiling, however, it was necessary to store the straw only for 4 days.

A series of subsequent studies examined technical as well as practical aspects of using urea-treated rice straw under smallholder farm conditions. However, the adoption of this technology by Sri Lankan farmers has been low. This is thought to be due to several logistic problems, including factors associated with the seasonal availability of rice straw, problems in transport and storage, and the demands on time and effort in relation to the benefits accrued (Owen and Jayasuriya 1989).

The digestibility and feeding value of a variety of local feeds, including grasses, legumes, tree fodders, crop residues (e.g. rice straw) and agro-industrial by-products (e.g. coconut poonac, rice bran, molasses, etc.) have been well documented in Sri Lanka through related studies using non-nuclear techniques (Premaratne 1990; Pathirana *et al.* 1993; Perera and Perera 1996a). This knowledge has enabled nutritionists to determine the most appropriate and economical means of providing a balanced diet to animals with different levels of productivity, using locally available feed resources (Ibrahim 1988).

Recent studies have explored the use of urea as a source of non-protein nitrogen, in combination with other essential nutrients, in the form of Urea-Molasses-Multinutrient Mixtures (UMMM) or Blocks (UMMB). Such supplements have been shown to improve the digestibility of rice straw, by providing the required nutrients for microbial growth and multiplication in the rumen, thereby increasing its intake. The use of these formulations for supplementary feeding of cattle and buffaloes has now been tested under a variety of rural farming conditions and found to be acceptable to farmers as well as cost-effective (Abeygunawardena *et al.* 1996b). The technology is now being incorporated into extension packages.

Environmental physiology

Tropical environments impose many limitations to efficient livestock production. High temperature and humidity increase the rate of cutaneous and respiratory loss of water, reduce feed intake, milk production and working ability, and interfere with normal reproductive functions. Different species and breeds of livestock have varying abilities to adapt and produce under hot-humid environmental conditions.

In general, water buffaloes (as the name implies) are raised in wet-humid conditions, and are known to require frequent access to water for drinking as well as wallowing. Studies using tritiated water have enabled the body water content and water turnover rates to be determined in buffaloes of different ages and physiological states (Ranawana *et al.* 1980). Weaning of calves was followed by a marked increase in the rate of body water turnover, and lactating cows had a higher rate of body water turnover than dry cows. The daily water turnover of the buffalo was found to be much higher than those reported for *Bos indicus* as well as *Bos taurus* cattle, indicating that the buffalo has comparatively a higher requirement of water.

Subsequent studies combining nuclear techniques with conventional physiological measurements and observations have yielded valuable information on the comparative adaptability of cattle and buffaloes to different environmental and management conditions. Even under conditions of free grazing under coconut plantations, buffaloes of the Surti breed were found to suffer from heat stress as the air temperature increased during the day (Tilakaratne *et al.* 1980). Lack of wallowing and restriction of drinking water aggravated the stress. Compared with adult cows, growing heifers appeared to rely more on the respiratory tract rather than on the skin for evaporative cooling. Temperate and zebu cattle as well as buffaloes were found to be more stressed by hot-humid than hot-dry conditions (Rajaratne *et al.* 1981 and 1983). Under a given set of conditions, however, temperate cattle were the most stressed, while buffaloes were intermediate and zebu cattle were the least stressed. Body water content and turnover were significantly less in the zebu when compared with the other two groups.

In summary, these results indicate that the buffalo has a relatively labile body temperature, and is able to store body heat for a period and dissipate it quickly by wallowing (Ranawana *et al.* 1984). Therefore the buffalo can withstand hot-humid conditions, provided it has access to water. This is usually assured in the traditional extensive systems of management that prevail in many regions of Sri Lanka. These systems are, however, becoming increasingly difficult to sustain due to competition for land and are being replaced by more intensive systems with animals of improved genotypes (Abeygunawardena *et al.* 1996b).

Studies aimed at developing practical methods of alleviating heat stress in buffaloes have shown that several different regimes of cooling by sprinkling water on housed animals can be effective (Perera and Perera 1996b). As expected, increasing duration and frequency of sprinkling improved the efficiency of cooling. To be effective, sprinkling needs to be done hourly during the period of high ambient temperature, and each sprinkling should last 6-9 minutes. These findings have important practical implications for intensively managed buffaloes where facilities for wallowing are not available.

A further application of the tritiated water technique is for assessing the daily milk yield of cows which are suckled by their calves. The conventional method is to weigh calves before and after suckling, but this is prone to error. The measurement of daily turnover of body water in calves which are fed exclusively on milk affords an elegant method to calculate the total intake of milk by the calf, which is equal to the total daily production of milk by the cow. In a study on Lanka buffalo cows using this method, the total milk yield averaged 3580 ± 824.6 g per day or approximately 3.5 litres (Horadagoda *et al.* 1989), which is higher than previous estimates.

Diseases

In Sri Lanka, parasitic, viral and bacterial diseases are important causes of direct as well as indirect losses to the industry. Direct losses occur through deaths and lowered productivity, while indirect losses include cost of prevention and treatment and lowered value of livestock products.

Buffalo calves are highly susceptible to infection by the parasitic round-worm *Toxocara vitulorum*. In many village production systems this worm causes heavy calf mortality, particularly during the first two months of life. Studies using ^{37}Se to track its life cycle showed that the larvae are present in an encysted form in the adult cow, and are therefore protected from the immune system as well as from attack by anthelmintic drugs (Fernando *et al.* 1989). At the time of calving the larvae are mobilized and migrate to the udder, from where they are passed in the colostrum and milk to the calf. ELISA techniques were also used to supplement these findings by determining the maternal transfer of antibodies from buffalo cows to their calves (Rajapakse *et al.* 1994). Further studies showed that the parasite is susceptible to anthelmintics within the calf, and that the optimum time for treatment was 10-14 days after birth of the calf (Roberts 1990). The drug Pyrantel, which is used in children and therefore cheaply available in any local pharmacy, was found to be completely effective. This treatment regime is now being widely used in Sri Lanka, and has dramatically reduced the death rate of village buffalo calves. Furthermore, this pioneering work lead to the adoption of similar control strategies for this parasite in several other Asian countries.

Babesiosis (tick fever) is caused by an intra-erythrocytic parasite which is transmitted by ticks. Temperate cattle are highly susceptible while zebu cattle and buffaloes are resistant to the disease. Conventional vaccines against babesiosis rely on isolates of the causative organism, *Babesia bigemina* and *Babesia bovis*, which are attenuated by passage through calves. As an alternative method, the parasites can be attenuated by exposure to ionizing radiation from a ^{60}Co source. When blood from infected calves was irradiated at an energy of 300 - 350 Gray and inoculated into susceptible calves, acceptable levels of immunity developed in the recipients (Weilgama *et al.* 1988). Some degree of heterologous immunity (cross protection) between the two species of *Babesia* was also observed. However, the need to perform irradiation within 6-8 hours of collection of infective blood and the short shelf-life of the irradiated vaccine were the main disadvantages from a practical point of view.

Diarrhoea in young cattle and buffalo calves is a common problem in Sri Lanka, and is often due to a combination of factors including management, feeding, hygiene and infectious agents. The use of an ELISA technique showed that rotaviruses were present in the faeces of diarrhoeic buffalo calves (Sunil Chandra and Mahalingam 1987). In the human as well as in several animal species, rotaviruses can initiate enteritis and pave the way for other more pathogenic organisms to gain a foothold and cause serious disease. Further epidemiological and pathological studies in buffaloes (Sunil Chandra and Mahalingam 1994a and b; Ariyaratne and Mahalingam 1996) have shown that variations occur in the electropherograms of rotaviruses on the same farm over a period of time, and that more than one serotype is present in Sri Lanka. These findings have application in formulating strategies for reducing the incidence of calf diarrhoeas.

Rinderpest is a deadly viral disease of cattle and buffaloes, which was eradicated from Sri Lanka in the 1940s. The disease was re-introduced in 1987 through livestock imported from India to feed its Peacekeeping Force. An emergency programme of vaccination was launched in the high risk areas of the country. This incidence of reported cases diminished gradually thereafter and the last recorded outbreak occurred in 1994. An ELISA technique to detect antibodies to rinderpest was used for a large scale epidemiological survey, and revealed a low prevalence of reactors in the population (Silva and Dangolla 1996). As Sri Lanka moves towards international acceptance as a rinderpest-free country, the ELISA will serve as a important method for confirmation of the absence of this disease.

Another killer disease of cattle and buffaloes in many tropical countries is haemorrhagic septicaemia (HS), which is caused by the bacterium *Pasteurella multocida*. Control of the disease is by vaccination, but the currently available vaccines confer immunity which is of relatively short duration. Pioneering work on this disease done in Sri Lanka has contributed to a detailed understanding of its epidemiology, pathology and immunology (de Alwis *et al.* 1996)). Studies using ELISA to detect antibodies after infection and vaccination showed that this technique was more sensitive than conventional methods (Horadagoda *et al.* 1994). However, the results also indicated that there is no correlation between serological tests and protection levels as determined by the direct challenge test. The field has therefore been thrown open for further studies to develop alternative tests which reflect the level of protective immunity.

Brucellosis is caused by the bacterium *Brucella abortus*, which infects cattle and buffaloes. The disease often goes unrecognized and is only suspected when there is an unusually high incidence of abortions in a herd. However, this disease can be transmitted to humans and is therefore a zoonotic condition; infection usually occurs through drinking unboiled milk or by handling infected material at time of abortion or parturition. Control and eventual eradication of the disease requires repeated testing of animals and removal of all positive reactors from the population. The conventional tests used (such as the Rose-Bengal Test, Milk Ring Test, Plate Agglutination Test and the Complement Fixation Test) each have their advantages as well as limitations. The ELISA technique for detecting antibodies is now accepted internationally as a valid alternative for large scale screening of herds. A sample survey conducted in cattle and buffaloes in 23 districts showed an overall prevalence of positive reactors of 5.6% in cattle and 3.4% in buffaloes (Silva *et al.* 1995). Some districts, however, had prevalences above 10 %, indicating an upsurge in brucellosis in certain regions of Sri Lanka. This emphasizes the need for a well-designed national programme to control and eventually eradicate this disease which not only causes insidious losses to the livestock industry, but is also a hazard to human health.

Foot-and-mouth disease (FMD) is a highly infectious viral disease which occurs sporadically in Sri Lanka, and causes economic losses in cattle and buffalo production. Although FMD can usually be diagnosed from its characteristic clinical signs, the presence of different antigenic strains of the virus necessitates accurate identification in order to use the correct type of vaccine during a given outbreak of disease. ELISA techniques can be used for serotyping virus isolates as well as for monitoring the antibody response elicited by different types of vaccines which are used for controlling the disease. An ELISA technique for antibody detection has now been established in Sri Lanka (Kodituwakku 1997) and the studies underway will help in improving the current control methods for FMD.

Within the livestock sector in Sri Lanka, the poultry industry has shown the most rapid growth and expansion over the past decade, with imports of many different breeds and strains of layers as well as broilers. While this has benefitted the farmer as well as the consumer in many ways, it has also resulted in the introduction of many new and exotic viral diseases to Sri Lanka. Control of these modern diseases require modern weapons. The ubiquitous ELISA technique has once again been enlisted in the fight against these diseases. Diagnostic methods have now been established in Sri Lanka for a range of these diseases, including New Castle disease, infectious bursal disease, infectious bronchitis, avian encephalomyelitis and reovirus infection (Wijewantha, Personal Communication). These methods, in addition to facilitating rapid and accurate diagnosis, will also be necessary for surveillance and certification purposes when Sri Lanka steps in to the international export market for poultry products.

A STRATEGY FOR TECHNOLOGY TRANSFER

As outlined above, a variety of nuclear, related and non-nuclear techniques have been used to obtain information on fundamental as well as applied aspects of animal production and health in Sri Lanka. These findings need to be translated into field applications if the end-users, the livestock farmers, are to benefit from them. A case study of such an effort, aimed at "getting research in to practice" (Perera 1996) is presented below.

The Buffalo Research and Development Programme

This programme to improve the productivity of buffaloes in rural farming systems of Sri Lanka had its origins in the late 1970's, when the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture based in Vienna awarded a Research Contract to study the endocrinology of reproduction in buffaloes. This lead to a close collaboration with the Swedish University of Agricultural Sciences at Uppsala for further studies on buffalo reproduction, with support from the Swedish Agency for Research Co-operation with Developing Countries (SAREC). In 1980, SAREC sponsored a national workshop in Peradeniya, which brought together Sri Lankan scientists who were engaged in various fields of research on the buffalo. This workshop critically reviewed the research done up to that time on the water buffalo, identified gaps in knowledge and evolved an integrated programme of research to improve buffalo production.

The workshop resulted in the launching of a multidisciplinary research programme over a period of 10 years, funded by SAREC and administered by the Natural Resources Energy and Science Authority of Sri Lanka (NARESA). During the first five year phase, research focused on fundamental aspects of management, nutrition, reproduction, diseases and socio-economics. Large scale field surveys to obtain baseline information on rural management systems were used alongside nuclear and conventional techniques to elucidate basic biological functions. Two research farms were also established to undertake on-station studies into problems identified by on-farm studies. Research during the second five year phase focussed on more applied aspects of improving buffalo production (Perera *et al.* 1996) and yielded valuable information on new innovations and appropriate technologies which can overcome some of the constraints to improving productivity under local farm conditions.

Buffalo Information Dissemination Project

In order to further test, transfer and disseminate the knowledge and improved technologies to the end-users, SAREC is now supporting a third phase of activities (Siriwardene 1996). The approach taken is based on the farming systems research (FSR) concept, with a sequence of farmer-oriented activities including: selection of target groups; diagnosis of constraints and goals; on-station and on-farm trials of appropriate technologies with feed back loops for continuous refinement; and lateral dissemination of farmer approved results to wider groups of beneficiaries (Abeygunawardena *et al.* 1997). This is being undertaken as a collaborative venture involving scientists, field technical personnel and farmers, and also involves state, para-statal, co-operative and private agencies engaged in the livestock sector.

Through this approach a model for "Small-holder Intensively Managed Buffalo Units" (SIMBU) was designed, with the following characteristics: (1) appropriate and low-cost housing with adequate ventilation, hygienic floors, feed and water troughs, and storage space in the loft for crop residues; (2) each unit comprising 2-3 adult buffaloes and their calves, either pure-bred or cross-bred, with milk yields of 4-10 litres per day; (3) basal diet of grass and leguminous tree fodder with latter grown as alleys or on perimeter fence, full utilization of rice straw during dry seasons, supplementary feeding with UMMM or UMMB; (4) alleviation of heat stress by manual sprinkling of water as an alternative to wallowing; (5) improved reproductive management through heat detection, timing of service and timely pregnancy diagnosis; (6) suckling restricted to twice a day at milking time only; (7) health care through hygiene, strategic deworming to control *Toxocara vitulorum* and appropriate vaccination programme; (8) body condition scoring as an aid for matching feeding to reproductive status and productivity; (9) hygienic milk production and value addition by conversion to curd and other products; (10) recycling of animal and crop wastes to provide mutual benefits to crop and livestock production; and (11) maintenance of simple farm records and their use for making important decisions.

This basic package of practices, with modifications to suit each agro-ecological region, is being promoted through field projects which have been established in villages. Farmers selected on the basis of rapid rural appraisal (RRA) in three target regions were provided assistance and technical advice to upgrade their holdings to the status of "Model" farms under the SIMBU concept. These farms are now serving as demonstration sites and training locations for other farmers. In support of the innovative feeding package, UMMB manufacturing units have been established in state farms and dialogue has been initiated with the co-operative and private sectors to venture into this field. A documentation centre was established at the Library of the Institute for Continuing Education in Animal Production and Health (ICE/APH) to serve as a depository and resource base for future research and development on buffalo production. To document and disseminate the knowledge that has been gained, a series of publications is under preparation, including a book for scientists and students, a compendium of research information, a handbook for extension workers, and information leaflets for farmers (in local languages). A public awareness programme has been launched, through linkages with on-going agricultural programmes on television and radio, to promote buffalo farming based on sound principles and the production and consumption of wholesome buffalo products. Finally, the training needs of farmers, extension workers and field veterinarians were identified through farmer-participatory appraisal (FPA) workshops (Perera *et al.* 1997), appropriate training modules were developed, and on-site training is being conducted to update the knowledge and skills of farmers and livestock development personnel.

These activities have resulted in considerable interest in the rural farming communities where the work is in progress and the farmers who have participated so far have derived considerable economic, material and social benefits (Abeygunawardena *et al.* 1997).

CONCLUSIONS

Nuclear and related techniques are powerful tools for research in many disciplines of animal production and health. The appropriate use of these sophisticated techniques demands an understanding of their advantages as well as limitations. In most instances, such techniques need to be combined with conventional non-nuclear methods and the collection of relevant background information, in order to permit a meaningful interpretation of the results.

Critical review of the literature in this field from Sri Lanka shows that nuclear techniques have been used judiciously and rationally, to obtain important information which has helped in identifying the true nature of problems facing livestock farmers. Applying this knowledge to formulate technologies for overcoming these problems, and their field testing, requires the researchers to be sensitive to the rural farming situations and to work closely with the farmers and the extension services.

As farming systems change in response to the new challenges imposed by limitations of land and other resources, nuclear techniques will continue to play an important role in finding solutions to emerging problems. It is important to realize that the improved technologies which are generated for overcoming constraints to livestock production will rarely if ever contain a "nuclear" component in them. However, nuclear techniques will continue to have an important role in monitoring the physiological, reproductive and production responses of animals subjected to these technologies. The ultimate objective of these efforts should be the achievement of a sustainable improvement in the production of milk, meat, draught power and eggs, thereby improving the socio-economic status of the rural farmers and contributing to national development.

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