Animal production and health

by J.W. Czerkawski, J.D. Dargie, L.-E. Edqvist, M.C.N. Jayasuriya*

Developing countries in the tropical and subtropical regions of the world suffer from a chronic shortage of livestock products, principally meat and milk. This is not because of any serious lack of livestock (in fact these countries have over 64% of the world's cattle, 51% of the sheep, 94% of the goats, and almost 100% of the buffaloes), but because animals in these countries are simply much less productive than their counterparts in more highly developed countries in temperate regions. The most serious consequence of this is of course that the quality of human nutrition in industrialized countries is considerably superior to that in the developing countries – a point clearly borne out by the fact that whereas *per caput* daily consumption of animal protein is 75 gram (g) in the former, it is only 5 g/day in the poorest countries. The reasons for such low levels of animal productivity in developing countries are extremely diverse; and appropriate strategies for improvement therefore differ between and within regions, and must take account of traditional patterns of farming and social practices.

Nevertheless, three basic features of the environment in which animals exist in developing countries contribute directly or indirectly to their inefficiency of production: the temperature and/or humidity is high, grazing is invariably scarce and of a low nutritional value, and parasitic and infectious diseases are endemic. As a result, many animals die, often when they are very young. Those which survive grow slowly and produce few offspring and therefore, of course, give little milk.

The activities of the Animal Production and Health Section of the Joint FAO/IAEA Division are aimed at improving animal productivity in developing Member States. In brief, the Section promotes applied research into ways of improving the nutrition, reproductive capacity and disease status of indigenous and imported breeds of livestock. In many instances the first stage in this process involves the collection of baseline data on different types of animals kept in both the same and differing environments, in order to identify constraints on productivity. Having identified these constraint(s), research can then be undertaken with a view to reducing their impact by introducing changes in the animal management system at minimal or no cost. As will be explained in the discussion which follows, the use of nuclear techniques helps animal scientists not only to identify constraints on livestock productivity, but to minimize their impact.

* The authors are in the Animal Production and Health Section of the Joint FAO/IAEA Division.

Animal nutrition

Work on the nutrition of ruminant animals (cattle, buffalo, sheep, goats, etc.) forms a large proportion of the Section's activities. This is because such animals can eat poor quality feeds such as straw, non-protein nitrogen, and agro-industrial by-products which are not suitable for human consumption, and convert them into valuable products such as milk, meat, and wool. In advanced countries, animal feeding systems are intensive and require large quantities of expensive concentrates that could often also be used as a source of food for man. In developing countries, the resources available for feeding animals are restricted; so the main thrust of the Section's efforts to enhance nutrition is directed towards research aimed at maximizing the intake and utilization of straws and other low-quality forage, and discovering cheap local sources of supplements based on crop residues and other agro-industrial by-products.

The scarcity of resources for feeding ruminants in most developing countries means that it is vital to maximize the use of the least-cost constituent of the diet. This is invariably a lignocellulose material, such as straw or forage, that has to be broken down by microbes in the rumen before it can be digested. Optimum conditions for the fermentation of lignocellulosic materials in the rumen can usually be created by supplementing the diet with an easily-fermented nitrogen compound such as urea. The next step is to provide "by-pass" nutrients in the feed: that is, nutrients which can pass without degradation from the rumen to the intestines, where they can be digested and absorbed to meet the animal's requirements during growth, pregnancy, and lactation. Isotope techniques are used to measure rumen fermentation processes, the utilization of protein in the rumen, and its flow to the intestines. Such techniques help research workers to understand the basis of rumen function and nitrogen metabolism, and to formulate new approaches to feeding ruminant animals in developing countries. We describe here some examples.

A process for producing a straw/hen or pig manure/bran silage for feeding cattle has been developed in the Republic of Korea. This product has a nutritive value similar to that of hay made from improved pastures. Fed to lactating cows as a source of roughage, it increased both intake and milk production, resulting in a reduction of 15% in feed cost per unit milk yield compared with wild grass. The results were even more striking when the silage replaced rice straw: it was possible to increase the intake of cheap roughage by 60%, cut the feeding of expensive concentrates by half, and still increase milk yield by 24%. The reduction in feed cost per unit milk yield was 35%. The economic and productive potential of this silage having been shown, tracer techniques are now being used to study and improve the efficiency of the animals' fermentation and digestive processes and hence, their response in terms of weight gain and milk yield.

Another example comes from work on buffalo nutrition in Sri Lanka. The aim of this work was to upgrade rice straw using urea as a source of ammonia, and to prepare rations suitable for grazing and milk-producing animals kept under small farm conditions. As in other studies, radioisotopes have been useful in monitoring the effects of differing straw treatments on rumen function. The results are very encouraging. Using ammoniated rice straw supplemented with cheap and locally available feedstuffs (such as rice bran or tree legumes), it has been shown that milk yields can be increased from 4 to 6 litres a day, and that animals can gain up to half a kilogram a day at times of the year when shortages of fodder normally limit production severely. Other work, in Malaysia, has shown that the digestibility of a highly lignified, low-protein product of the palm oil industry (palm press fibre) is substantially increased if it is treated with sodium hydroxide or supplemented with fish meal. Perhaps a more significant finding is that the rate of degradation of this fibrous by-product is higher in buffalo than in cattle.

Finally, work in another part of the world (Peru) has focused on supplementing with fish meal the diet of sheep grazing at high altitudes. Disappointing results were obtained when castrated sheep were used; fish meal supplementation did not lead to any improvement in weight gains. However, supplementation of the diet of breeding ewes during gestation and at lambing increased not only the final weight of the animals but also the number of lambs born alive, the birth weight of the lambs and the number of lambs which were weaned. Except for wool growth, which increased by nearly 50%, none of these changes was large (about 10%), but they were significant; and they illustrate the benefit to reproductive efficiency of improving animal nutrition. This work also illustrates the type of approach to animal production problems which is particularly encouraged in the Section – an approach which depends on examining problems within a multidisciplinary context.

Animal reproduction

The reproductive efficiency of livestock in tropical and subtropical regions is generally lower than that of animals in temperate parts of the world; they reach puberty later and have more prolonged post-partum anoestrous intervals. Indeed, it is considered normal in many developing countries for a cow to produce only one calf each two or three years: in advanced countries one calf a year is normal. It is generally accepted that meat and milk production in developing countries can be increased by increasing animal fertility, that is, the number of offspring produced during the animal's lifetime. There are essentially two ways to accomplish this: reducing the time it takes for the animal to reach an age at which it can be bred (i.e. the age to puberty); and, more importantly, minimizing the time interval between the birth of successive offspring. This in turn involves ensuring that female animals are inseminated at the correct stage of their reproductive cycle, that pregnancy is confirmed as early as possible after insemination, and that reproductive processes begin to function again as soon as possible after the offspring have been born. All of these processes depend upon the action of hormones on the animal's reproductive organs.

Monitoring the reproductive function of domestic animals was in the past hampered by the lack of techniques adequate to measure the minute levels of hormones which are normally present in body fluids. However, the development of radioimmunoassay (RIA) and related measurement techniques has added new dimensions to the study and improvement of livestock reproduction. Such techniques are highly sensitive and specific, require only small amounts of material for assay, and because they are carried out in a test tube do not require the administration of radioactive substance to the animal. They are suitable not only for basic physiological research, but also as diagnostic aids to identify and elucidate reproductive problems in the field.

The measurement of one reproductive hormone, progesterone, in blood or milk is particularly valuable for monitoring the reproductive function of the females of most domestic species. This is because progesterone is secreted by a structure in the ovary called the *corpus luteum*, which is formed upon ovulation and therefore reflects sexual function. In non-pregnant animals, the production of progesterone waxes and wanes with the reproductive cycle, being low before and high after ovulation; for pregnancy to be maintained progesterone must be produced continuously. Measurement by RIA of progesterone in blood or milk can therefore be used to determine the onset of puberty, to diagnose pregnancy and non-pregnancy, and to follow the onset of sexual functions after the birth of offspring. RIA can also be used to monitor the effects of treatments which are prescribed by the veterinarian to correct reproductive problems, and to diagnose genital disorders. The farmer himself can collect samples for analysis.

RIA techniques are clearly unique tools for evaluating the significance of factors such as nutrition, patterns of suckling, and the presence of parasites, in causing low reproductive efficiency, and for assessing animals' responses to improved managerial practices which eliminate or reduce the constraints imposed by these factors.

Research on the water buffalo of South-East Asia and on indigenous breeds of animals in Latin America, Asia, and Africa show the usefulness of RIA techniques for improving reproductive efficiency and hence meat and milk production. RIA progesterone measurements were used to determine oestrous activity, pregnancy and non-pregnancy, and the influence of suckling (calf-removal) on the resumption of normal reproductive function in cows after the birth of their calves. The average lifespan of a buffalo cow is 15 years and she becomes sexually mature and first conceives at 3.5 years of age. Shortening the post-partum anoestrous period by 100 days, simply by restricting the time spent by the calf in suckling, therefore has the effect of increasing both the number of calves and the number of lactations produced by each cow from nine to 11 during her lifetime.

RIA techniques are also being used extensively in studies aimed at characterizing the reproductive performance of species and breeds of meat and milk-producing animals indigenous to developing countries – animals such as the vicuna and alpaca of Latin America and the indigenous cattle of Africa and Asia. These animals have received much less attention than temperate breeds introduced into the tropics, although it is known that they are well adapted to their local environments and, as far as survival is concerned, have qualities which imported breeds lack. Indigenous breeds are, in effect, a valuable genetic resource both in their own right and for possible use in cross-breeding programmes.

Research workers supported by the Agency's Co-ordinated Research and Technical Co-operation programmes are being encouraged to examine these animals from the standpoint of their reproductive efficiency. They are producing interesting data which may prove to be economically valuable. Breeds of cattle and sheep which, although reared in harsh climates, have very high reproductive efficiencies have already been identified. For example, a scientist in Malaysia who has performed detailed studies on the Kedan-Kelantan breed of cattle has found that this breed can conceive again as early as 25–30 days after calving, even though the cows are still being suckled by their calves. Although these animals are seasonal breeders, the early onset of sexual functions after calving allows for an average calving interval of 367 days – a breeding performance which matches anything known in temperate breeds kept under the best management. Work on similar lines in Morocco, with the indigenous D'Man breed of sheep, has shown that ewes can be bred successfully as early as 60 days after lambing: and, unlike many sheep in temperate regions which are seasonal breeders, the D'Man can breed all the year round.

Animal diseases

Particular attention in the animal disease component of the Section's programme is focused at present on helminth and protozoal parasitic infections. From an economic point of view, these are probably the most important group of diseases world-wide, causing losses estimated at US$ 250 billion a year. The programme emphasizes three particular applications of nuclear techniques: the use of radiation-attenuated organisms as potential vaccines against parasitic infections, the use of labelled substances in immunoassay tests to diagnose infections, and the use of radiation and radioisotopes to examine the nature of the immune responses of animals to parasites with a view to understanding the problems which have to be overcome before further vaccines can be developed.

In terms of vaccine development, particularly encouraging results have been obtained from Sudan with respect to Bilharzia (or Schistosomiasis) in cattle, and from a number of countries with respect to the tick-transmitted disease Babesiosis. In the Sudanese study, 30 calves were vaccinated by giving each animal a single intramuscular injection of 10 000 infective *Schistosome* parasites which had been exposed to 30 gray (3000 rad) of gamma rays from a ^{60}Co source. Another 30 calves served as controls (i.e. they received no irradiated organisms). All the animals were then put out to pasture with local herds in a village in the White Nile province. Dramatic differences between the two groups of calves emerged over the following 10 months. Nearly 40% of the calves which did not receive the irradiated vaccine died, whereas only 15% of the vaccinated animals succumbed to Schistosomiasis and other infections. In addition, the non-vaccinated animals grew at a slower rate and excreted nearly five times more parasite eggs onto the pasture than did the vaccinated animals, thereby contributing to a much greater extent to pasture contamination and the likelihood of further disease transmission. When the surviving animals were necropsied at the end of the trial, it was found that the vaccinated animals had 70% fewer parasites in their bloodstream than the non-vaccinated animals.

Equally encouraging results have been obtained recently with respect to Babesiosis – a disease which is currently controlled through the use of drugs or by pre-immunization of livestock with infective blood from donor cattle carrying "attenuated" strains of the parasite produced by passing it rapidly through many animals. Immunization by this method often has adverse side-effects, and there are many associated logistical difficulties. For example, it frequently causes severe reactions and sometimes the death of calves, which therefore require close veterinary supervision and treatment. These shortcomings, together with the fact that "attenuated" strains are tick-transmissible and can revert to virulence when transmitted through intact animals, have prevented the establishment and/or expansion of pre-immunization programmes in almost all developing countries. However, it now seems likely that stable live vaccines which induce long-term protection against Babesiosis can be produced by exposing infective blood to around 350 Gy (35 000 rad) of gamma radiation and injecting this into susceptible animals. In one study, 27 animals were infected with 10^8 irradiated Babesia organisms; 26 of them showed only mild symptoms, not requiring chemotherapy. Three weeks later, six of these animals were challenged with virulent organisms. The remaining 20 were kept for a year before being challenged. All but one of the vaccinated cattle were solidly immune to reinfection and remained healthy, whereas animals which did not receive the vaccine either died or became very sick A further advantage of the irradiated vaccine shown by these studies was that whereas parasites attenuated by other methods go back to being fully virulent when passed through normal cattle, irradiated parasites *are not* transmitted by the tick vector and consequently cannot revert to virulence.

Another very promising approach to animal disease control is the use which may be made of genetic resistance to certain diseases endemic in the tropics. For many years it was considered that lambs could not be successfully vaccinated against intestinal parasites such as *Trichostrongylus colubriformis* because their immunological responses were poorer than those of older sheep. However, recent work being undertaken as part of the Section's programme has demonstrated clearly that a proportion of lambs can be vaccinated against this parasite, using irradiated larvae, just as well as adult sheep. Further, by using "irradiated vaccine responsive" males and females in breeding programmes, strains of sheep can be produced which can be vaccinated against this parasite much more sucessfully than the offspring of non-selected animals; this raises the possibility of developing in the future parasite control procedures which involve manipulation of the genetic make-up of meat and milk-producing livestock.

These are just three examples of the type of work being conducted under the Agency's programme on tropical and subtropical animal diseases. It is relevant to stress in this context that although irradiated parasites sometimes form the basis of vaccines, in many more cases, and for a variety of reasons, they will not. Failure to produce a successful irradiated vaccine should not, however, be interpreted as "lack of success". In the longer term the use of radiation-attenuated parasites coupled with studies involving isotopic and non-isotopic based immunological methods to probe the ways in which the immune system of different genotypes of livestock respond to parasites and other disease agents will provide the information which is needed to develop better methods of disease diagnosis and control. This in turn will reduce substantially the current dependence of developing countries upon costly chemotherapeutic and prophylactic agents.

Conclusions

These are examples of the type of work supported by the Animal Production and Health Section of the Joint FAO/IAEA Division. It is hoped that the impressions conveyed by this article are, firstly, of a broadly-based programme dealing with research into the main constraints on productivity faced by livestock owners in developing tropical and subtropical countries; and secondly, of a programme which is attempting to deal with these constraints in a multi-disciplinary fashion. It is a programme which is "problem" rather than "technique" oriented, since we believe that nuclear and other techniques should be applied to solve problems – rather than finding problems which fit particular techniques. Where new techniques need to be developed or existing techniques modified to suit conditions in developing Member States, this is a task for the Section's Laboratory at Seibersdorf. Expansion of laboratory support services to Technical Co-operation and Research Contract programmes will therefore go hand-in-hand with greater emphasis on interactions between genotype and nutrition, reproduction and disease, in an effort to achieve the ultimate goal: optimizing animal productivity through minimal or no-cost management strategies in developing Member States.