

Nuclear techniques in animal agriculture

by B. A. Young*

Animal husbandry has come a long way since man's first steps in domesticating animals. Nuclear technology now plays an integral part in research to improve the health and productivity of animals.

Throughout the world animals play an important role in furnishing man's needs, be they a beef steak in Europe, milk for school children in Africa, or draught-power to pull a plough in Asia. The largest proportion of domestic livestock is the multi-stomached ruminant species (cattle, sheep and goats, etc.). The dependence of man on ruminant animals is increasing, particularly in the developing countries, because ruminants can convert material of little or no value to man to products (such as meat, milk, fibre, leather, etc.) which are of considerable economic and nutritional value.

To a large extent animal production in developing countries is limited by poor reproductive performance, lack of efficient utilization of available feedstuffs, poor adaptation of the animals to the environment, and infectious diseases. Considerable improvement in animal production can be gained through recognizing suitable animals (species, types, and strains) for a particular environment and also by altering the environment to make it less challenging to the animal. Traditional European farm species and breeds, as well as traditional European practices, have been used in many parts of the developing world, sometimes with success but more often with failure because full account has not been taken of the new environment, nor of social and economic circumstances.

Indigenous local animals and husbandry have often been overlooked, particularly in equatorial regions where species adapted to the heat, such as the water buffalo, and the tropical breeds of cattle and goats, can be successfully utilized. Despite this, considerable efforts continue to introduce temperate-region species into tropical environments where they are ill-equipped to survive, let alone to produce at levels obtainable in the relatively stress-free temperate regions. High ambient temperatures and humidities, nutritional imbalances and deficiencies, as well as infectious diseases of the tropics, need to be overcome by utilizing locally-adapted resistant animals. Research is needed to develop management and disease-control practices to minimize the effects of stress.

Survival and reproduction of the animals must initially have greater priority than high productivity. However, once a viable self-sustaining population can be maintained within the prevailing environmental, social,

and economical constraints, then there should be more emphasis on increasing the level of productivity. With indigenous animal species the first step has in some cases been achieved, and research efforts can be directed immediately to increasing the level and efficiency of production.

The Animal Production and Health Section of the Joint FAO/IAEA Division is primarily concerned with improving animal production in developing countries. Although there is much information in the developed countries with their advanced veterinary and animal research centres, the same is not true for much of the developing world. For the reasons just mentioned, it is often not possible simply to transfer and apply research findings to the different environments which prevail in the developing world. Therefore research on applied problems must be done in the country or location where the problems occur. Thus, the Joint FAO/IAEA Division assists training programmes and the transfer of knowledge and technology to research institutes and universities in developing countries. Through the IAEA Technical Assistance programmes help is being provided to 25 Member States in the area of animal production and health. Furthermore, through co-ordinated research programmes in the areas of application of nuclear techniques in studies on animal reproduction, ticks and tick-borne diseases of animals, improving domestic buffalo production and the utilization of non-protein nitrogen and agro-industrial by-products in animal diets, the IAEA has research contracts and agreements with institutes in 31 Member States.

Reproductive hormone analyses

Reproductive efficiency in animals is influenced by a multitude of genetic and environmental factors which impinge on their hormonal system. The development of radio-immunoassay techniques has given researchers the opportunity of measuring and following precisely hormonal patterns in animals over the reproductive cycle. Simply by analysing a sample of blood, milk, or other body fluid, minute hormone concentrations can now be assayed and the reproductive status of the animal assessed. The radio-immunoassay procedure uses antigens which are isotopically labelled, usually with iodine-125, and antibodies specifically developed for each hormone. The onset of sexual maturity, of oestrus, or the influence of environmental, nutritional or other factors on the reproductive state of an animal can be studied. As a result, practical means can be devised to improve reproductive efficiency.

An example of the use of the radio-immunoassay technique is illustrated in the co-ordinated research

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programme of the Agency which focuses on improving domestic buffalo production. This programme is a part of the Regional Co-operative Agreement* between countries in Asia and is bringing nuclear technology to the assistance of the small farmer in Asia. The results and success of the programme are evident from presentations made at a recent research co-ordination meeting held in Bangkok, Thailand

"There is a tendency in some quarters to regard the buffalo as symbolic of a backyard and primitive agriculture. Do techniques like *Radio-immunoassay* and *Plasma progesterone profiles* remind you of primitive science — or of the most modern tools available to the animal scientist anywhere in the world? An Indonesian scientist has used radio-immunoassay to study the oestrus cycles in swamp buffalo, and a Malaysian physiologist is going to report plasma progesterone profiles in relation to buffalo reproduction. It seems that FAO and IAEA are trying to compensate for the years of indifference to, and lack of support for, buffalo research and development in Asia. It was high time that this was done because, in the traditional agriculture of countries in this region, the small farmer depends upon buffalo to carry out agricultural operations for crop production, and for the transport of the produce. The buffaloes serve as his assets — his walking savings bank — ready for sale when in need of cash in any emergency. After its usefulness as draught-animal is over, the animal serves as source of meat." (B.K. Soni, FAO Regional Animal Production and Health Officer, Thailand.)

"The Philippine water buffalo, commonly called *carabao*, is a valuable farm draught-animal and is also an important meat-source, of a protein quality comparable to that of beef. The extraordinary quality of carabao milk (9.5% fat and 5.26% protein) is also recognized. While the acceleration of carabao production is a priority goal of the Philippine Government, a major constraint is the poor reproductive efficiency of this animal, with the occurrence of weak oestrus or 'silent heat' (30–40%), rendering oestrus detection and proper timing of breeding, difficult. Since oestrus detection is a behavioural manifestation that is hormonally based, a study has been made of the native buffalo serum reproductive hormones, coupled with behavioural and clinical observations on this animal species." (A. Alejandrino *et al*, Philippine Atomic Energy Commission.)

The following contribution is from a scientist in Sri Lanka. "The water buffalo *Bubalus bubalis* is an important source of milk, meat, and draught-power in many Asian countries. In Sri Lanka too, this species plays a significant role in the rural agricultural economy. The development programmes currently being undertaken in the country, such as the Mahaweli River Diversification Scheme and the resultant increases in the irrigable land area, are likely to increase the demand for

buffaloes. The envisaged areas of new colonization will be ideal for promoting systems of integrated crop-live-stock farming, where the potential of the buffalo can be realized to full advantage.

"A major factor limiting more efficient utilization of this animal resource, however, is its poor reproductive performance. Some of the common reproductive problems encountered in river-type buffaloes in Sri Lanka include difficulty in oestrus detection, seasonal fluctuations in fertility, and long calving intervals. A series of studies has therefore been undertaken in Sri Lanka to investigate the causes of poor reproduction in buffaloes, and to develop procedures and practices which could overcome some of these limitations.

"From 17 post-partum periods studies so far, completed profiles up to subsequent conception are available for 10 cases. In these the progesterone levels remained basal (< 0.25 ng/ml) for periods ranging from 115 to 210 days. In 8 out of 10 cases conception occurred at the very first major elevation (> 0.7 ng/ml) of progesterone. In all animals progesterone remained elevated above 1.5 ng/ml after conception. In three instances the first marked post-partum progesterone elevation was preceded by a minor elevation (0.3 to 0.6 ng/ml) of short duration.

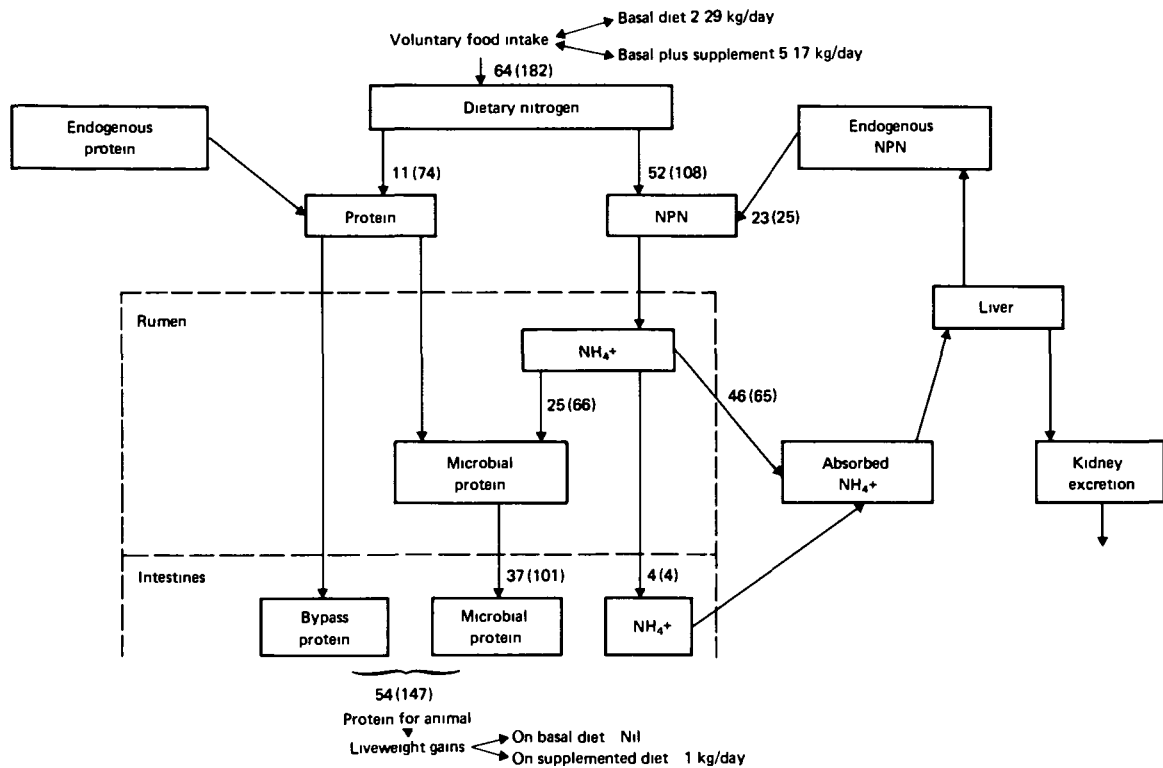
"Based on the clinical and hormonal data, the mean calving to conception interval in this herd *Gannoruwa* during the period of study was 161.5 days (range 126 to 207, $n = 11$) and the mean gestation length was 309.9 days (range 297 to 324, $n = 8$).

"The findings from this study demonstrate that the long calving intervals in buffaloes are due mainly to delayed resumption of ovarian activity after calving. Once ovarian activity commences, as evidenced by progesterone elevation in blood, conception appears to follow without delay." (B.M.A.O. Perera, University of Peradeniya, Sri Lanka.)

Animal nutrition

In many developing countries there are shortages of cereal grains even for human consumption and thus the use of these food sources to supplement animal diets cannot be realistically considered. Animals must therefore feed on pasture lands, on low-quality roughage materials, or on agro-industrial by-products which otherwise are of little or no use to man. Ruminant animals with the specialized microbial fermentation digestive system in their multi-compartment stomach are well suited to poor-quality feed. Throughout both the developed and developing world there are intensive research programmes to identify ways of obtaining more efficient utilization of locally available feed resources. By-product straw remaining after the harvesting of rice and other cereal grains, bagasse or fibrous waste from the sugar-cane industry, water hyacinth, leaves and stems of banana, etc. have

* Regional co-operative agreement for research, development and training related to nuclear science and technology



The dynamics of nitrogen and protein metabolism in the rumen of cattle given sugar-cane pith plus urea as a basal diet, or the basal diet supplemented with a small amount of sweet-potato tops and cottonseed meal. Values shown are estimates of flow of nitrogen (gN/day) as various forms of protein, ammonium, and non-protein nitrogen (NPN) between compartments for cattle on the basal diet and, in brackets, the basal diet plus supplement (Kempton *et al*, Dominican Republic and Australia).

potential as animal feeds. In some cases, all that may be needed is to supplement the diet with a non-protein nitrogen source such as urea, or other nutrient or mineral to make up for an imbalance or deficiency. Nuclear techniques, particularly the use of stable and radioactive tracers are providing important insights into the functioning of the digestive system of ruminants, its qualitative dynamics and metabolism.

For assessing the products of the rumen, particularly volatile fatty acids which become an energy source, and microbial proteins which become a protein source for the animal, materials labelled with C-14, H-3, S-35, N-15 and P-32 are being used. These tracers provide an accurate and reliable means of measurement in a complex system not presently possible by other means. As an illustrative example, the results of one study of nitrogen metabolism, microbial protein and rumen bypass protein synthesis in cattle are shown in the figure. One group of cattle was fed a basal ration of sugar-cane and urea; the other group received the basal ration together with a small energy- and protein-rich supplement. The animals which did not receive the supplement could not obtain enough protein to grow. However, with the supplement, the animals' appetites were stimulated three-fold, giving them not only more total nutrients but substantial increases in the protein

from both dietary (rumen bypass) and microbial sources. The supplement permitted a substantial growth by the animals. Through the use of nuclear techniques the mysteries of the complex digestive system of a ruminant animal are being resolved.

Diseases are an important factor limiting animal production and here again nuclear techniques are being used to solve practical problems. For example, worm infections can seriously reduce livestock productivity or even kill in large numbers. Treatment with anthelmintics is the normal method of worm control, but the frequent use of these compounds may result in the development of resistance among the parasites. Another, and more permanent, approach to controlling parasitism is to vaccinate the animals. Exposing the infective larvae to ionizing radiation has the effect of rendering the parasite non-pathogenic but still able to stimulate the animal's immune defence system when ingested. As a result, when the animal is exposed to infection in the field, the larvae which are ingested are unable to develop and the animal remains healthy. With IAEA assistance, this approach is currently being used to control lungworm infection in sheep and cattle in Ethiopia, India, and Brazil. Research into the possibility of developing vaccines along similar lines against other diseases, e.g. fascioliasis and babesiosis, is also being undertaken.