Animal Science: Isotopes and Nuclear Techniques

by John E. Vercoe

In many regions of the world, animal production is limited by poor growth, reproductive performance and milk output of livestock, thus limiting the availability of animal products such as meat, milk, leather, etc., for use by man. Reduced animal production results from inadequate or unbalanced nutrition, lack of adaptation to climatic conditions, and parasitic and other diseases The production from animals can be improved on the one hand by improving genotypes (the breeds and strains within a given species) to make them better suited to the environment to which they are exposed, and on the other hand by modifying the components of the environment which are limiting the production. In practice, a combination of these two strategies is usually desirable but the relative importance of each is determined by short- and long-term economic considerations and the likely environmental consequences.

Isotopes and radiation play an important part in identifying and alleviating the genetic and environmental limitations to animal production.

GENETIC IMPROVEMENT

Unlike their plant breeding colleagues, animal breeders cannot use ionizing radiation to produce mutations which are more productive in a particular environment. Instead, animal breeders use information from isotope and other studies of physiological attributes of animals to elucidate those characteristics which are related to the ability of certain species and breeds to maintain high production or to adapt well in the presence of adverse environmental conditions. These desirable characteristics can then hopefully be combined through cross-breeding and selection to provide animal types that produce well in adverse environments.

For example, species raised in hot dry locations have to compromise their productive potential with the necessity to conserve water while keeping their body temperature within physiological limits. Comparative studies between breeds and species using tritiated water can identify those animals where the compromise is geared to both production and survival and not towards survival alone. Similarly breeds and strains differ in their susceptibility to various parasitic diseases. Isotopes are used to identify those breeds and strains which are immunologically better able to cope with the challenge and those least affected by the parasitic infestation in terms of either blood loss or damage (depressed protein levels and low red cell counts). Armed with this information on parasitic resistance, the animal breeder, if he desires, can cross-breed or select for increased parasitic resistance or tolerance.

Dr. Vercoe is Head of the Animal Production and Health Section, Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture.

Levels and patterns of hormones (chemicals that control body functions and processes) can be measured using radioimmunoassay techniques. Hormones are especially important in regulating reproductive function and a more accurate knowledge of them may be used in breeding and selection programmes to improve herd fertility either genetically or phenotypically.

Applications of isotope and nuclear techniques in these areas are only in their infancy. In fact, animal breeding based on sound physiological knowledge and measurements is still largely confined to research stations. However, as breeding programmes are designed for application in tropical developing countries where environmental constraints such as poor nutrition, climatic factors, and parasitic and other diseases are more severe, the need to know what factors should be selected for becomes more precise. For example, selection for increased growth rate under grazing conditions in a tropical environment may be largely for adaptive attributes (low maintenance requirement, heat tolerance and internal and external parasitic resistance) and may be against productive attributes (food intake capacity). An analytical approach to selection criteria is necessary so that the two basic components of production (inherent potential and degree of adaptation) can be selected for independently and real progress be made.

ENVIRONMENTAL MODIFICATION

(1) **Nutritional factors.** (i) Rumen Metabolism: Ruminant animals, e.g. cattle, sheep, goats and water buffalo, are able to synthesis microbial protein from roughage diets and non-protein nitrogen sources and to use this protein fro production of meat, milk, etc. In other words, diets which are inadequate in protein for non-ruminant species are adequate in some circumstances for ruminants. Isotopes of nitrogen, sulphur and phosphorus have been used to measure how much and how efficiently dietary nitrogen is converted into protein which can be effectively used by the animal.

In addition, the growth of the rumen microbes is accompanied by break-down of the fibrous roughages in the rumen into volatile-fatty-acids, substances which can provide a substantial amount of the energy requirement of the animal. Isotope dilution techniques enable the rates of production and amounts of these acids to be measured on a variety of diets and this can be equated with the amount of microbial protein synthesis.

The effectiveness of different rations in promoting maximum rumen function and therefore production can be measured and the information used in formulating rations using locally available feedstuffs.

(ii) Mineral Metabolism: Mineral deficiencies and toxicities, whether clinical or subclinical are most effectively studied using isotopes. This is true not only for the macro-elements such as calcium and phosphorus, but also for the trace elements such as copper, cobalt and selenium.

Differences in the availability of elements from different sources, and differences in absorption and metabolism are readily measured using isotope techniques and the need for supplements in particular diets or in particular areas can thus be ascertained.

(iii) Digestion: In addition to studies on rumen metabolism, isotopes are used to measure the rate of movement of food and liquid in the digestive tract and the rate of absorption of nutrients from its various parts. These parameters are related to the nutritive value of a diet

An international group of scientists, participating in an FAO/IAEA co-ordinated research programme, inspect dairy cattle forage in Bandung, Indonesia Photo IAEA/Kallfelz

and modification of the diet (e.g. by protection with formaldehyde or by grinding and pelleting) can alter the amount eaten and the efficiency with which it is utilized, especially in ruminants.

(2) Reproductive Factors. Hormones, as mentioned earlier, are most accurately and efficiently measured using radioimmunoassay techniques. The hormones that control the maturation of follicles, ovulation and oestrus can be monitored during the oestrus cycle and patterns associated with normal and abnormal function can be established. Optimum breeding times can be detected even in the absence of overt signs of oestrus. The effect of adverse environmental factors such as poor nutrition, heat, and parasitic stresses on hormone level and patterns can be defined and steps taken to either alleviate the stress or utilize only those animals least affected, i.e. use the information to select better adapted individuals.

In some circumstances hormonal therapy may be possible to remedy an abnormality or to synchronize oestrus for artificial insemination purposes, or in special cases to cause super-ovulation for ovulation transfer procedures.

Studies of hormonal patterns using radioisotopes can, therefore, be used to modify the environment or implement genetic improvement.

(3) Health and Disease Factors. Radioisotopes have been used extensively to study the effects of parasitic diseases on blood changes in the host. The rate at which various blood protein fractions are turned over and red cells are made and broken down can be determined accurately in normal and parasitized animals, and the variations with physiological state (growth, pregnancy, lactation) of the animal, level of nutrition, and other environmental variables, can be determined. In the cases of blood-sucking parasites, the amounts of blood removed by the parasite can be measured. This type of knowledge enables better management procedures to be implemented and less affected genotypes to be identified.

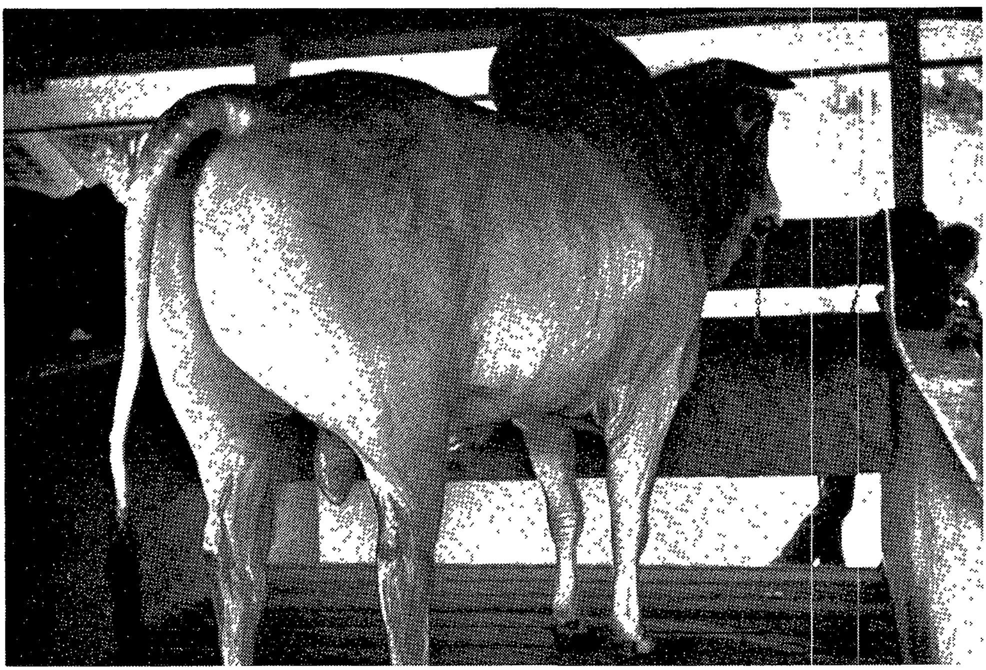
Ionizing radiation has been used to successfully produce attenuated vaccines, e.g against lungworm in cattle, sheep and goats and hookworm in dogs. Similar techniques have been used with other parasitic diseases with partical success under experimental conditions. Parasitic diseases with more complex life cycles need more basic studies on the antigenicity of the various stages in order to fully realize the potential of attenuation by ionizing radiation.

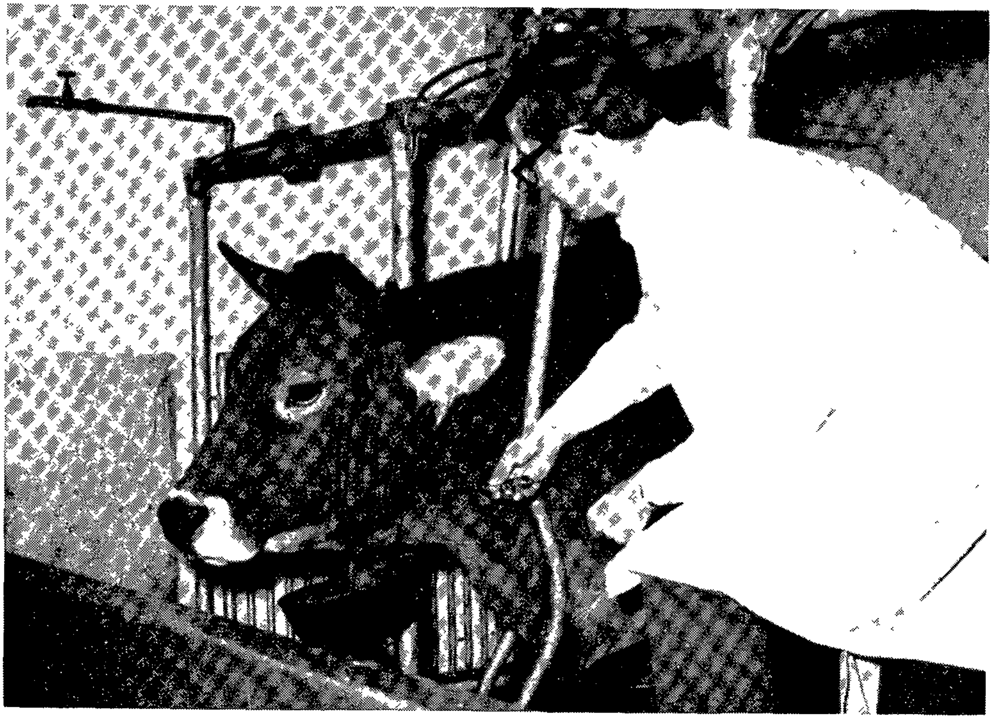
CONCLUSION

Increases in food and other products from animals require improved technology and understanding as well as better utilization of existing knowledge. Existing technologies must be developed into better biological and social systems so that they can be implemented on a wider scale particularly in developing countries.

The Joint FAO/IAEA Division through its co-ordinated research programmes and technical assistance activities is helping to promote these goals.

Imported Brahman bull at an artificial breeding centre in Indonesia Photo IAEA/Kallfelz.





Injection of radioactive tracer into the jungular vein of a cow.

Positioning a detector for monitoring the radioactivity in the thyroid gland following injection of a radioactive tracer