New Concepts In Animal Production With Special Reference to Tropical Conditions

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I. Introduction

Animals are kept for many purpose throughout the world, thus discussing all the new concepts that could be applied to them is a daunting task. To this consideration must be added the fact that most new concepts arise in the developed parts of the world where the constraints to animal production are very different to those in tropical countries. In the former areas various developments have resulted in an over-production of many animal products and as a consequence techiques that result in increased production are no longer in vogue. Even improved efficiency normally leads to greater production and ultimately to depressed prices and sometimes massive subsidies. The problem is compounded by the fact that in many of these countries populations are becoming more interested than in the past in the quality of the food that they eat and the methods of animal production used to produce it.

Consumers in these countries, who are comparatively rich, are willing to pay more for so-called "*health foods*" produced by more traditional methods without the use of artificial stimulants. They are also very concerned about animal welfare and are becoming less and less willing to tolerate forms of production which are conceived to be cruel, such as for example chickens kept in battery cages and veal calves kept in the dark and fed on liquid milk wihthout solid food. More recently many people have expressed opposition to the use of bovine somatotrophin (BST) in milk production. Other techniques used in biotechnology may also come under scrutiny. These techniques include manipulating a genotype by inserting novel genes, supplementing the animal's natural hormones with genetically engineered ones, *in vitro* fertilization and embryo transfer, producing newer and better vaccines for disease control.

The situation in many tropical countries is rather different from that in developed ones. In these countries there is perceived to be a deficiency of animal protein although in fact there may not be one intruly nutritional terms although there may be a problem of maldistribution (Table 1). Consequently in these countries the aim has been and is to increase the output of animal protein. Where this has been achieved by the use of intensification it may have actually

Table 1. Relative importance of four sources of animal protein (1985).

Region	Animal protein per head daily (g)	Meat %	Milk %	Eggs %	Fish %
Far East	9.1	36	25	8	31
Africa	10.8	51	22	4	23
Near East	13.4	43	47	4	6
Latin America	23.4	56	32	4	8
Europe	41.6	44	40	7	9
North America	69.0	53	34	8	5
World	24.8	38	45	6	11

Source F.A.O. Yearbook, 1985

Table 2. Efficiency of protein utilization by various classes of farm livestock at two levels of output

	Annual crude protein consumed kg	Annual crude protein yield kg	% of food protein recovered for human consumption
Laying hen (250 eggs/annum)	6.6	1.71	26
Laying hen (50 eggs/annum)	5.1	0.34	6.7
Dairy cow (8000 1/annum)	650	260	40
Dairy cow (2000 1/annum)	306	65	21
Beef steer (gaining 1.5 kg/day)	252	33	13
Beef steer (gaining 0.25 kg/day)	124	5.5	4.4

Source : **Smith, A.J. (1981). Intensive animal production in developing countries. British Society of Animal Production, Edinburgh**

Note : According to F.A.O. estimates a person requires an average 6.5 g of animal protein a day and so even in the Far East there is in theory enough animal protein available for every person's needs. However, poor distribution means that a number of individuals will receive far less than 9 g of protein a day.

reduced the amount of protein available to the human population (Table 2). This is particularly true where non-ruminants have been used for this purpose. Thus the aim in these countries must be to make the best use of local resources to maximise food production whether it be from animal or plant sources.

The purpose of this paper will be to examine the innovations currently available in the field of animal production and to see which can, with advantage, be applied in the tropical countries.

II. Animal Breeding

(a). Artificial Insemination

One of the most effective innovations in the field of animal breeding has been the deep freezing of cattle semen which has enabled genetic material to be transferred from developed to developing countries. This has been a mixed blessing in some cases especially where local breeds were well adapted to the local environment. This technique also enables genetic material to be stored at low cost. Innovations in this area that are likely to be important are the improvement of AI techniques in other species - pigs, sheep, goats, camels and buffalo and possibly in the future the ability to separate the chromosomes into those bearing an X and those bearing a Y chromosome.

(b). Embryo Transplants and Embryo Storage

In order to be successful in an embryo transplant operation it is important to produce a large number of embryos from animals that are regarded as having superior genetic merit. This is achieved by the process of superovulation using injected gonadotrophic hormones such as follicle stimulating hormone or pregnant mares serum gonadotrophin. These embryos can be collected non-surgically from some species such as cattle and can now be frozen and stored at the late-morula to early-blastocyst stage of development (6-7 days after fertilization) and the proportion that survives after thawing is only slightly reduced as compared with fresh embryos (Polge, 1985). Frozen embryos can then be thawed and transplanted to recipients as required. It also means that gene banks can be established and it would be a good idea if gene banks of fertilized ova were established from some of the rarer tropical breeds before their genes are either diluted or eliminated by exotic imports.

(c) *In vitro* Fertilization

The technique for transplanting cattle embryos (and those of other domestic species) first undertaken by Walter Heape at Cambridge University in 1890 using the rabbit, is now established and is being used commercially on an ever-increasing scale as a means of genetic improvement to overcome certain types of infertility and as a convenient (and physiologically advantageous) method of transporting genetic material throughout the world.

Present techniques are cumbersome and expensive, involving superovulation of donor cows by hormonal treatment, artificial insemination of the donor cow and flushing the six-day-old blastocysts from the cow for implantation in the uterus of recipient cows hormonally synchronised to be at a similar stage of the oestral cycle as the donor cow (6 days) (Macfarlane, personal communication). In practise this is difficult to organise on any farm unless donor and recipients are in the same herd, otherwise recipient and donor cows have to be transferred to a special centre which is expensive and stressful to the cows. The technique is restricted to elite breeders and has no economic application for the commercial dairy or beef farm.

Two groups of workers have been working on the possibility of using ova obtained from the ovaries of slaugter cows in the abattoir, fertilizing *in vitro* and developing to blastocyst implant stage in the laboratory (Lu *et al.*, 1987).

Ian Gordon's team at the Dublin School of Agriculture, have been successful to a limited extent. They have successfully extracted ova form ovaries obtained from the abattoir, fertilized them *in vitro* in the laboratory, and cultured them to blastocyst stage *in vivo* and then implanted them into recipient cows. They have used sheep for the *in vivo* culture but this is cumbersome and adds expense.

Polge of Animal Technology (Cambridge) Ltd. in conjunction with the Animal Physiology and Genetic Research Centre at Cambridge have now developed a similar technique to the Dublin workers for obtaining and ferilizing ova but, in addition have developed suitable diluents and techniques for maturing the fertilized ova to blastocyst stage without using sheep. An entirely *in vitro* technique. The blastocysts are frozen in LN_2 for storage.

The technique can be made routine and cheap and in the future farmers will simply phone their AI centre as they do for AI, when their cow is day 6 post heat, and one or two, if they wish twins, embryos will be implanted non-surgically using the normal AI Gun and Cassou straw with embryo. Dairy farmers are expected to be the main users. Cows, such as Holsteins, not required to produce replacements, can be transplanted with one, or two, beef embryos.

Embryo transplants have tremendous potential for introducing exotic blood to developing countries. Most disease resistance is passed to the foetus *in utero*, and during the first six months of life from the environmental challenges. Similarly, acclimatization to heat stress is most easily achieved in the first six months of life.

(d). Sexing of Embryo and Monozygotic Twins and Clones

It is now possible to determine the sex of embryos at an early stage by detecting male specific antigens.

Monozygotic twins have been produced in sheep, cattle, pigs and horses and quadruplets or triplets have been produced (Willadsen, 1981) and identical quintuplet lambs derived from a single celled embryo have been produced (Fehiltz *et al.*, 1984) It is hard to visualise much value for either of these techniques in the third world at the present time.

(e). The Introduction of Major Genes into Populations to Improve Productivity.

The productivity of native stock can be improved slowly by exploiting the genes already in the population and progress inevitably slows as the best genes spread widely throughout the entire population. If the genes have a major effect then the introduction and multiplication of these genes is relatively simple. Examples of such genes are given below.

(i). The halothane gene : It has been found that certain pigs react to halothane anaesthesia and that this reaction is heritable (Southwood, Simpson, Curran and Webb, 1988). The test is carried out when the piglets are 24 hours old. It is also known that the halothane homozygotes show a higher incidence of stress deaths and produce poorer meat *post mortem* than non-reacting pigs. The halothane reaction is believed to be inherited as single autosomal recessive gene with incomplete penetrance. Thus using the halothane test to eliminate homozygotes will reduce stress death. Unfortunately halothane reactors tend to be leaner and grow more efficiently than non-reactors. Consequently selection for these two traits tend to increase the frequency of this gene with undesirable results.

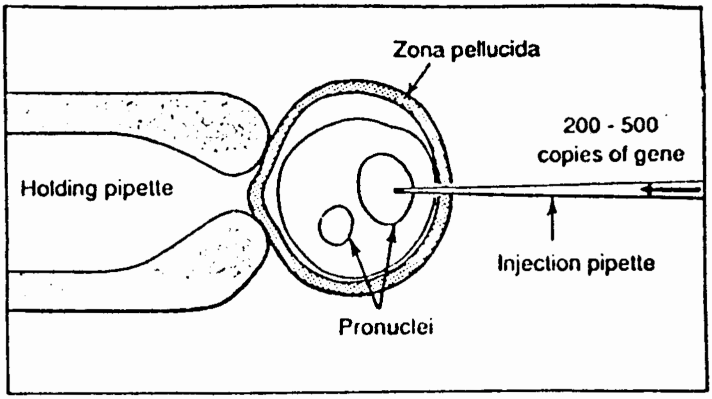
(ii) Dahlem red naked neck gene : This major gene not only results in chickens that carry it having no feathers on their necks but it also reduce body feathering by 20 to 30 % in the heterozygous condition and by up to 40 % in the homozygous state. The gene is incompletely dominant and the heterozygous birds have a tuft of feathers on the neck whereas the heterozygous birds have completely bare necks. Because this condition is produced by a single major gene it can be introduced into new breeds or strains. The major advantage of introducing the gene seems to be that it increases heat loss under hot climatic conditions and is most effective when introduced into heavy weight breeds such as the Rhode Island Red (Horst, 1988). The main disadvantage with the introduction of the gene is that it increases mortality of chicks by up to 10 %.

(iii) Booroola gene in sheep : This gene was found in a strain of Australian Merino and induces higher litter sizes from female sheep that contain the gene. When the gene is introduced into a breed litter size may increase by one or two lambs (Smith, 1984). There will be a greater range of litter size with many triplets but mortality could be high and lamb growth retarded. To cope with extra lambs, new husbandry systems will need to be developed. The effect may be moderated by putting the gene in crossing ram breeds so that crossbred ewes would be heterozygous for the gene. Alternatively the gene might be put into a less prolific meat producing breed to make the breed more prolific.

However such changes could well be inappropriate for sheep in the tropics, most of which are found in semi-arid areas. In these areas the production of more than one lamb per ewe per year is very undesirable because of the limited food resources available.

(iv) The use of genetic engineering to introduce beneficial major genes into a population : There are probably other naturally occurring major genes that could be exploited to improve animal production. This process can also be augmented using new bioengineering processes. Biologists can isolate a gene from one animal, multiply it in the laboratory and introduce it into an individual of the same or different species. The simplest way of achieving this is to inject a few hundred copies of one directly into the nucleus of the fertilised egg (Figure 1).

1. Gene injection : transgenic sheep came from fertilised eggs that were injected with a few hundred copies of a foreign gene. It takes a steady hand and patience, but sometimes it works, and the new gene becomes incorporated into all the animal's cells



From Webster (1988)

Animals carrying the new genes are said to be transgenic. In most cases the transgene will be passed onto offspring in the same ways as its own genes.

It may be possible in the future to identify genes for resistance to specific diseases or for tolerance to high temperature stress or high levels of salt intake and transfer them onto individuals in vulnerable populations that could eventually make the population better adapted to the adverse environment in which they are kept.

(f) Genetic Fingerprinting.

Techniques have been developed in Edinburgh that enable the sire of an offspring to be identified by characteristics in that offspring's blood (Spooner, personal communication). If this knowledge were applied to, for example, range herds of cattle it should be possible to identify which bulls are passing on the most desirable characteristics and implement some form of selection policy using this information.

(g) Improving Animal Graowth by Conventional Selection.

Conventionally, breeders of meat producing animals have selected sires on their basis of growth or weight for age. The main consequence of this policy is that animals become bigger at maturity. However, they also produce animals that are leaner and use their food more efficiently to slaughter weight because animals are normally slaughtered at a fixed weight. This fixed weight becomes a smaller percentage of the adult weight as the selection process proceeds from generation to generation. However the penalty imposed by this process is that the cost of maintaining the parent population increases as mature body size increases. This is not a problem when the parents are highly prolific (pigs and poultry) but it becomes a serious problem when the species has a low productivity rate (sheep, cattle, buffalo). For example, with cattle the amount of food eaten each year by the parents is equal to that eaten by their offspring in the same period (Webster, 1988; Table 3). Thus selecting for growth rate also results in parents that eat more food and thus the advantages of the selection process are lost.

Table 3. **Input and outputs from various domestic species showing effects of fecundity on relative food inputs**

	Broiler fowl	Pig (Pork)	Sheep	Cattle (beef)
Weight of dam (kg)	3.0	180	75	450
Weight of product (carcase kg)	1.5	45	18	250
Carcase:dam ratio (weight)	0.50	0.25	0.25	0.55
Progeny/year	240	22	1.5	1.0
Weight of carcase per year/ dam weight	120	5.5	0.36	0.55
Proportion of food energy per year				
to dam	4	16	70	50
to progeny	96	84	30	50

After Webster (1988)

The amount of food fed parents can be reduced by conventional ploys such as selecting for more extreme types of the male line (of which fewer needed) in, for example, chickens or by the use of AI so as to virtually eliminate half of the parent generation. Even so, selecting for rapid growth rate can still cause problems and may lead to parental types which are distorted in the extreme and very difficult to manage as is the case with broiler breeders and modern strains of turkey. Any technique which will increase growth and efficiency without the penalty of overweight parents is obviously an advantage.

III. Animal Physiology

(a) Manipulation of Animal Growth.

According to Lamming (1985) there have been a number of important developments in the last decade in the control of growth and definite progress has been made in three areas: (1) the use of anabolic agents to increase protein deposition and therefore the yield of edible protein particularly in ruminants, (2) the use of antimicrobial agents as food additives for all four major farm species in order to increase growth rate or at least to prevent a decreased growth rate in relation to disease incidence, and (3) the use of immunological methods to enhance the rate of growth and to increase the lean content of the carcase.

With respect to the use of anabolic agents, the earliest ones to be used were the synthetic stilbenes (*diethylstiboestrol, hexoestrol and dinoestral*) but the use of these has now been banned in many countries because of their potential carcinogenic activity. These have been replaced by cheap exogenous sources of the natural gonadal steroid hormones (oestradial 17B, testosterone and progesterone). In addition two anabolic agents, trenbolane acetate and zeranol are also available. The former is of similar structure to testosterone, the latter an oestrogene anabolic agent. In general terms androgenic agents are more effective in females and oestrogene in intact males. In steers the maximum effect is produced by a combination of the two and increases in daily liveweight gain may be as much as 35 per cent over the finishing period. However, the greatest response is obtained, according to Lamming (1985), in cattle already growing at high rates thus their use must be of limited value in third world countries that have limited food supplies and long dry seasons. Somatotrophin injection have been used to increase the growth rate of pigs and some response in the growth rate has also been found in cattle.

(b) The Use of Immunological Methods of Controlling Growth

These methods of controlling growth, such as immunizing against somatostatin and gonadotrophin releasing hormone have not yet been developed sufficiently to allow commercial application (Lamming and Peters, 1987).

(c) Control of Milk Production

The most dramatic way which milk secretion is controlled (Mepham (1987) is by the daily injection of bovine somatotrophin (BST) prepared by genetic engineering techniques. (The gene for BST was inserted into a bacterium). The use of this substance can increase milk yield by up to 20 per cent. After an initial period in which body reserves are depleted the increased yield necessitates increased food intake so that increased efficiency is brought about by reducing the proportion of the food eaten that is used for maintenance by the cow. Eventually a technique will be developed to produce a long acting slow release preparation of this product. Unfortunately this technique is only of value where concentrate foods are available. BST will increase the intake of concentrate food but not of low quality fibrous foods. Thus the usefulness of this technique in third world countries is likely to be limited.

(d) The Use of Immunological Methods for Controlling Milk Production

It may also be possible in the future to control milk yield and quality by using immunological techniques. Recent studies on the goat have shown that milk contains a chemical which tends to inhibit secretion and it remains in the lumina of the mammary alveoli (Mepham 1987). This is the principal reason why thrice milked animals yield more milk than twice milked ones. The inhibitor is believed to be present in the whey fraction and when identified it should be possible to raise antibodies to it and so mimick the effect of frequent milking.

IV. Animal Nutrition

(a) Genetic Manipulation of Micro-organisms in the Rumen

According to Munn (1985) our knowledge of rumen bacterial genetics is very limited. The aim of genetic manipulation of rumen microorganisme is to improve the digestion in the rumen by increasing the degradation of some feedstuff components either within the rumen or in the pre- treatment of feedstuffs, by increasing the amount of some fermentation products and by controlling the growth of some bacterial species. The progress to date has been limited to work on characterising the cellulose and glycosidases of rumen protozoa, and on inserting genes into rumen bacteria. As yet none of the work has achieved results of practical significance for the third world, but obviously because of the importance of ruminants in the third world, this work should continue.

The main areas where changes could be made are given in a table from Amstrong and Gilbert (1985).

Some potential objectives in the application of biotechnology to rumen micro-organisms

1. Enhanced cellulolytic activity.
2. Introduce capability to cleave ligno'hemicellulose complexes.
3. Reduce methane[2] production.
4. Decrease proteolytic and/or deaminase activities.
5. Increase biuretase activity.
6. Increase microbial production of specific amino acids.
7. Introduce *capability for N fixation*[3].

[1] Note all known organisms that can degrade lignin are aerobic, conditions in the rumen are anaerobic.

[2] Methane production accounts for 5-8 % of the gross energy contained in a feed.

[2] A cellulolytic nitrogen fixing organism has been isolated from some species of woodworm.

Obviously advances in these areas will demand very sophisticated techniques and progress may be slow. There is perhaps a role for scientists in the third world to help with this work. There may for example, be very useful micro-organisms occuring naturally in the rumens of ruminants in the tropics. One such species has already been identified, namely the bacteria which will detoxify mimosine in the rumen. It is known (ILCA, 1986) that bacteria in the rumen of cattle, sheep and goats break down mimosine into a compound known as DHP which accumulates in the body and interferes with iodine and tyrosine metabolism. The characteristic signs of mimosine DHP toxicity include hair loss, reproductive distrubance and reduced appetite. Goats in Hawaii were observed not to exreate DHP in their urine. This was because it had been degradated by naturally occurring bacteria. These bacteria can be cultivated *in vitro* and will spread from animal to animal in their saliva. These bacteria will remain in the rumen provided they are not deprived of leucaena in the diet for more than nine months.

(b) The Use of Antimicrobial Agents

The use of of feed additive growth promoters such as flavomycin and bacitracin have been shown to increase growth rate by five per cent and feed conversion efficiency by three to four per cent. In non-ruminants the effects of the antibiotics and antibacterial additives is thought to be by inhibiting the action of gut micro-organisms and possible thinning of the intestinal epithelium (this possibly increases efficiency of nutrient absorption or changes in metabolic energy costs). In ruminants the beneficial results lie in the effect of the substances on the microbial species inhabiting the reticulo-rumen changing the balance so that a higher level of rumen propionate is produced at the expense of acetate and sometimes butyrate production and there are significant reductions in energy losses in the form of methane.

(c) Genetically Engineered Crops for Animal Feeding

The quality of foods available in the tropics for animal feeding is often very low. Mucch of this food comes from by-products such as rice straw. The quality of these products from an animal feeding point of view has sometimes diminished as a result of the production of high yielding varities. For example, the increased production of rice and sorghum has been achieved using short strawed varieties that don't lodge. Thus the net result has been less food of a poorer quality available to farm livestock. When crop breeding programmes are undertaken in future the use of the whole crop and not just that of the grain should be taken into consideration.

The use of Floury 2 and Opaque 2 genes to improve the protein quantity and quality is well documented, but varieties containing these genes have not been a success because of reduced crop yields associated with these genes. However the first truly genetically engineered animal food plant to be released into the environment has been a modified pea plant. Genes which provide the codes for sulphur rich amino acids have been transferred from pea seeds to the leaves of the plant. Since wool growth in sheep is limited by the supply of sulphur rich amino acids this technique could be of value, especially since pea albumen unlike most other resist breakdown in the rumen and so almost all their nutritive value can be absorbed by the sheep.

Whit non-ruminants it may be easier to produce additives such as amino acids using biotechnological techniques. Thirty four thousand tonnes of L lysine are already produced each year by microbial processes (Armstrong, 1986) and the possibilities for future development are promising.

(d) Improvements in the Nutritive Value of Conserved Forage

Bacterial species can be added to silage with and without added enzymes. Some of these additives have been shown to increase the content of lactic acid in the silage and to increase organic matter and N digestabilities (Armstrong, 1986).

The usefulness of straw and hay are limited by the intimate association of useful carbohydrates, cellulose, hemicellulose and pectins with the non-carbohydrate lignin and inorganic silicon. The principal methods of improving the availability of these useful ingredients include grinding, heat and the use of sodium hydroxide or urea. Another method is the use of microbial fermentation outside of the rumen, especially to rupture the bands of the ligno-hemocellulose complex. This is achieved by certain white rot fungi and other actinomycetes. The known micro-organisms used for this purpose use up a lot of energy from cellulose and hemicelluloses in the breakdown process. The use of genetic engineering may enable this problem to be overcome.

(e) Removal of Undesirable Constituents from Foods

Many plant products contain substances which render them less useful for animal feeding. For example, rapeseed contains erucic acid, cottonseed contains gossypol and canavala a toxix amino acid canavaline. Techniques used in genetic engineering supported by traditional plant breeding practices may well lead to the production of cultivars that have a lower content of these toxic factors. However a word of caution should be added, these toxic substances may be in the plant for a purpose. For example cotton plants that contain a low percentage of gossypol are more susceptible to insect attack.

V. Animal Health

The control of animal diseases can be achieved by many means. These include organisational measures at a national level, such as quarantine, slaughter of infected animals, animal movement control, compulsory vaccination or dipping of vulnerable animals, training of veterinarians and veterinary assistants. On-farm measures such as mixed grazing to reduce parasite infection, disinfection of facilities and various forms of prophylaxis are available. Development and research measures such as vaccine production, studies of epidemiology and the development of new methods of diagnosis and vaccine preparation are options that are open. It is only in the latter two areas that biotechnology has been applied with some success.

(a) Diagnostic Methods

The effective diagnosis of infectious disease is fundamental to the maintenance of animal health and productivity. New serological and molecular techniques have been developed which show improved sensitivity, specificity and efficiency of testing. The advances that have enable this to happen include the application of monoclonal antibody technology, enzyme immunoassay, reverse passive haemagglutination, viral genome characteristics and in the future the use of gene probes (Dawson, 1986).

(b) Vaccine Production

Virus vectors are being used to develop the next generation of vaccines which will consist of common vaccine strains of viruses modified to express the immunising proteins of other organisms. A virus vector is a virus modified to accept a foreign gene so that the latter may be introduced and expressed in a cell following infection by the modified virus. To be efficient vectors must be able to introduce many copies of the foreign gene so that it is translated readily into its product and expressed at its normal site. Vaccines based on r-DNA products are being developed including ones against neonatal bacteria in cattle and pigs and improved vaccines againts foot and mouth are being developed. A new vaccine against foot rot has also been developed. One hope is that these techniques will enable more rugged vaccines to be produced that will remain viable at high ambient temperatures. Such vaccines would obviously be of considerable value in the third world where maintaining the "*cold chain*" is often very difficult. However, these developments may not be of practical value for some time in the future since several strategies have been proposed for the production of new foot and mouth vaccine including the inserted gene method but there is a long way to go before they can be used commercially. The present vaccines, despite thermal lability will continue to be used for a long time (Spier, 1988).

(c) The Use of Naturally Occurring Disease Tolerance

Many local animals have a natural resistance to indigenous pests and diseases. For example, they may be more tick resistant, parasite tolerant or resistant to a specific disease, e.g. trypanotolerance. It may be possible to exploit this natural tolerance and transfer animals that carry this tolerance to other areas. One attempt to use this philosophy has been the programme to research and spread the use of N' dama cattle in West Africa. If it is possible to identify the genes responsible for disease resistance it may be possible to transfer them to different species using trasgenic techniques.

VI. Animals Used As A Source of Medical Products

Research in Edinburgh (Wilmot, Clark and Simons, 1988) has been undertaken to make transgenic farm animals that produce proteins needed for the treatment of animal disease, such as the clotting factors VIII and IX, vital to the clotting of the blood. Hemophiliacs have a congenital deficiency of one or other of the proteins. Treatment consists of giving routine injections of these proteins. At present the proteins are isolated from human blood and so are expensive. In addition there is a risk that the clotting factor will be contaminated with human viruses such as those causing AIDS and hepatitis. These clotting factors are normaly made in the liver and the Edinburgh workers are aiming to produce animals that will produce them in the mammary gland so that the relevant protein can be obtained from the milk. To achieve this a hybrid gene comprising the protein-coding sequence of the human factor IX and regulatory DNA sequencies from a sheep milk protein gene betalactoglobulin was injected directly into the pronucleus. Two transgenic sheep have produced low levels of human protein in their milk. It may be possibe to produce other factors of medical use in this way considerabbly reducing the costs of production.

Conclusions

It is possible to increase output of animals by new techniques but how germane are these techniques in third world countries ? Even in the U.K. where concentrate food is comparatively cheap and land expensive, Webster (1988) casts doubt for example on the sense of using Finnish Landrace X Dorset Horn ewes to produce five lambs a ewe under intensive conditions when 1.35 can be produced under extensive conditions if this is true in the U.K. it must be doubly so in most developing countries.

There are many other ways in which animal productivity can be improved in developing countries without resorting to biotechnology. For example one of the reasons for the failure of animal production to improve in developing countries has been the decline in the usefulness of veterinary services to the animal keeper. Ways of reversing this trend have been discussed by Haan (1986) and others and include privatising the veterinary services. Similarly farmers can be induced to produce and sell more if they receive what they consider an adequate return for their products and equally important there are goods available (e.g. education, clothes, agricultural equipment, radios) that can be bought with the surplus income. No amount of "*high tech*" or "*biotech*" inputs will help if the basic infrastructure and ambience do not exist. There is no point in introducing improved pasture plants into communally owned land, or new vaccines into a veterinary service without the means to deliver, or BST into poorly fed cows. If the basic agricultural structure of a country is poor I believe that advances achieved by biotechnology will have the minimum of impact.

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