

THE ROLE OF BREEDING AND GENETICS IN ANIMAL
PRODUCTION IMPROVEMENT IN THE
DEVELOPING COUNTRIES

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ABSTRACT

Availability of animal protein for human consumption is very low in the developing countries mainly because of low productivity of existing livestock; ways and means to improve productivity through breeding are discussed and some basic issues requiring further research pointed out.

THE BASIC SETTING

THE human population of the world today is approximately 4 billion of which three-quarters are in the so-called developing countries. In 1980, there are likely to be more than 5 billion people on the earth. A major portion of the increase will take place in the developing countries. With regard to land resources and total numbers of farm animals, there is a fairly reasonable distribution between developing and developed countries. However, when we look at the total production of the main food commodities, particularly animal products and their availability *per caput*, there is a very marked maldistribution between the two groups (Figure 1). Total meat production *per caput* in 1969 was thus only 11 kg in the developing countries as compared to 54 kg in the developed ones. For milk the disparity was even larger—23 kg versus 322 kg (JASIOROWSKI 1973).

The total production of meat and milk has increased very considerably over the last 20 years both in the developing and developed countries, but due to the population increase, the net production *per caput* has hardly increased at all in the developing countries while the situation is much brighter in the more advanced countries of Europe, North America and Oceania. The total increase of meat and milk production in the developing countries is mainly a result of increased livestock numbers rather than a rise in productivity per animal. The development in the latter respect has been particularly poor in Latin America and Africa. As the room for a continued increase in livestock numbers, at least for the ruminant species, is very limited, special attention will have to be given to measures which improve the productivity per animal. These measures will have to include a whole range of activities such as improvements in animal health, feeding and management, as well as work in animal breeding and genetics. Generally speaking, improvement in one field cannot be seen in isolation from

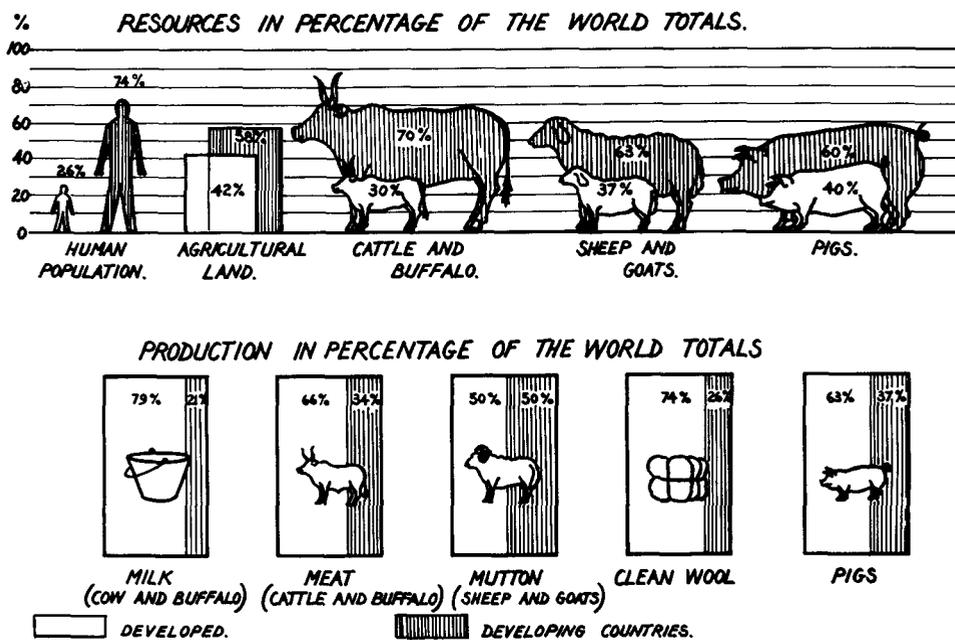


FIGURE 1.—World human population and agricultural resources and production (JASIOROWSKI 1972).

that of the others. However, depending on the circumstances, the order of priority between them can and should vary.

CATTLE AND BUFFALO BREEDING FOR MILK PRODUCTION

Milk production under traditional conditions in Africa and Asia has since long been a part of *extensive production systems* where the production of milk is combined with or exists as a sideline to beef production (e.g., the Sahelian zone of Africa), the production of draught animals (e.g., India) or a combination of all three (e.g., buffaloes in India and Pakistan). Milk production per animal in these traditional systems is very low. AMBLE and JAIN (1965) estimated that the average annual milk production of the 45.5 million cows of India was only 174 kg, while the corresponding average for the buffaloes was 491 kg. The traditional systems are likely to continue for quite some time but simultaneously more intensive systems are being developed. As will be shown below, breeding measures have a very important role in the development of these improved production systems.

Breed comparisons

Excessive heat has a detrimental effect on milk production. The most common tests to measure the animals' reaction and ability to tolerate high ambient temperatures are based on the changes in rectal temperatures, respiration rate and feed intake (McDOWELL 1972). European-type dairy cattle show a marked

decrease in feed intake when kept for prolonged periods at 27° and above. Zebu-type cattle do not start losing appetite until temperatures of about 35° are reached. However even at these temperatures, the feed intake and milk production generally remain considerably higher in absolute terms for European-type dairy cattle than for zebus. There are individual variations between cows within breeds in their ability to maintain feed intake and production under heat stress (BRANTON, McDOWELL and BROWN 1966). Although heat tolerance tests and the various indirect ways of measuring adaptability to hot climates may become important in selection for high milk yield in hot climates in the future, the main criterion for selection at the present time is performance, i.e., milk yield under the existing type of climate.

Numerous reports are available in which comparisons have been made of the productivity in tropical environments between European breeds, indigenous cattle and European × indigenous crosses. Few of these reports are based on studies properly designed for making comparisons between different breeds and different levels of European-type blood. Milk yield per lactation has been increased quite considerably through crossing. Age at first calving is often reduced by one year or more in first crosses between European and indigenous zebu cattle as compared to the parental zebu strains.

Earlier studies in India (AMBLE and JAIN 1965) and Africa (MAHADEVAN and HUTCHISON 1964) as well as some recent results from cattle kept at the coast of Kenya (MEYN 1970) indicate that there is an optimum level of European-type blood above which milk yield, viability and fertility, i.e., overall productivity, decreases. However, reports from Israel, Egypt, Iraq, Iran and southern United States (RENDEL 1972) on crosses between European breeds and zebu or local indigenous cattle showed a continued increase in milk yield with increasing level of European-type blood, although in several cases the F₁ crosses were above the average of the two parental breeds.

A great disadvantage of practically all strains of zebu and other types of cattle indigenous to the tropics is their lack of dairy temperament. The presence of the calf during milking is necessary for milk let-down and if the calf is taken away or dies, the cow usually dries up quickly. Short lactations due to lack of dairy temperament have been a serious problem in the National Sahiwal Stud in Kenya and in the early stage of the development of the Australian Milking Zebu, but rigorous selection for dairy temperament has reduced the incidence considerably (MEYN and WILKINS 1973; HAYMAN 1973).

Research required

Continued efforts to compare the adaptability of different breeds and crosses to hot climates will be required. These would require a more precise description of environmental stresses and the inclusion of at least one common breed for all comparisons, e.g., the Friesian which has been used quite extensively in the tropics. The optimum level of European-type blood under different environmental stresses and levels of management also needs further study and consideration.

Non-linear genotype and environmental interactions may be important when the differences in environment are as large as those between the temperate zone and the tropics. It is important therefore to know whether sires with superior progeny proofs from the temperate zone would be equally superior when they are progeny tested in the tropics on crossbred or purebred progeny, or whether the ranking between genotypes would be different in the two environments. Evidence on this may be forthcoming from a large-scale crossbreeding experiment organized at Haringhata, outside Calcutta, by the Indian Council of Agricultural Research, FAO and the U.S. Agricultural Research Service, in which semen from Holstein-Friesian, Jersey and Brown Swiss bulls progeny tested in U.S.A. or U.K. have been used on Haryana cattle. Some 600 crossbred female offspring have so far been produced. The volume of lactation data is as yet limited, but some interesting information has become available on the frequency of lactation anestrus in Haryana cattle and the marked improvement in overall fertility which occurred in the first generation crossbreds (non-return rate to inseminations was 27% in Haryana heifers versus 48% in the F_1). Low fertility appears to be a serious problem in large segments of the Indian cattle population. The causes, which evidently are at least partly genetic, warrant further intensive study.

In India and Pakistan *water buffaloes* are the most important dairy animals, not cattle. The buffaloes are often said to be superior converters of high roughage diets and to have excellent adaptability to difficult environmental conditions (for an extensive discussion and references see COCKRILL, in press). In relation to its economic importance very little is known about the genetics of various traits related to milk production in the buffalo and extensive research seems warranted.

Development programs

The need for research on problems connected with dairy cattle breeding in the tropics and in developing countries should not be taken as an excuse for postponing developmental breeding projects as enough knowledge is available for deciding the main line of attack and approach. As most cattle strains in the developing countries have not been subject to systematic selection for milk yield, most breeding programs aimed at increased milk yield should involve a substantial infusion of genes from specialized dairy breeds, mainly from the temperate zones, into the local cattle strains. The breeding programs can conveniently be divided into four groups: (a) straight-forward upgrading to a temperate dairy breed; (b) crossbreeding between a temperate breed and local strains for the production of a new breed; (c) selection within an improved local strain; and (d) rotational crossbreeding. Which approach to choose will depend on the climatic stress and on the available local resources and infrastructure.

a) *Upgrading to a temperate dairy breed*: The best example of a successful upgrading program for dairy cattle in a subtropical area is given by the Israeli Friesian breed which was built up by continuous upgrading of local, mainly Damascus cows, to Friesian bulls according to a breeding policy established shortly after World War I (HIRSCH and SCHINDLER 1957). Milk production per

cow and year has risen continuously during the last decades and is now on the average above 6,000 kg milk with about 3.3% fat for the milk-recorded cows.

The common technique of storing frozen semen and artificial insemination allow upgrading to be organized much more cheaply and quickly than before. Upgrading is an attractive alternative in many areas where the managerial skill is sufficiently high and the climatic stress not too severe, e.g., the Teheran plateau, the Kenya Highlands, large areas of Latin America; it is also suitable in areas with more severe climates if stall or yard feeding is applied. The upgrading program may conveniently involve the establishment of a Nucleus Breeding Unit of say 400–500 pure exotic cows within which a thorough production recording system should be developed. The breeding unit may be a large governmental station or a number of cooperative private and/or governmental units with common recording and registration.

Several of the developing countries already have a relatively large number of purebred or high grade European-type cattle and the Nucleus Unit should then be established from the best European-type cattle within the country. Once the Nucleus Unit is established, there should be little need to import any more purebred breeding bulls or cows. The cows should be inseminated with frozen semen from outstanding dairy bulls in countries with good selection and progeny testing schemes and frozen semen available for distribution. It would be sufficient to use semen of say two to three bulls from one country during one year, semen from another country in the next year, etc. This system would enable the receiving country to draw on the very best genetic material available in the world, without going into any time-consuming and expensive selection schemes. At the same time, the risk of inbreeding would be minimized. The best young bulls from the Nucleus Unit could be used for A.I. if such services were available or for natural matings in other herds with good management. The rest of the bulls could be used for upgrading local cattle in the area, either A.I. or (most likely) through natural breeding. The model is outlined in Figure 2. Without A.I. or additional herds of European-type cattle for bull multiplication, a Nucleus Unit of the size indicated in Figure 2 could provide young bulls for mating 10–15,000 cows yearly. With A.I. or “multiplication herds”, this number could be increased considerably. The model is, therefore, very flexible. On purpose, nothing has been said about the breed to be used. Many breeds (e.g., Friesian, Ayrshire, some of the Scandinavian Red breeds, etc.) would appear to qualify equally well. An unorthodox approach using semen from good bulls of several different breeds would probably give the best basis for further improvement. However, most countries are not willing to accept so much unorthodoxy at present, but prefer upgrading to Friesian or some other popular temperate breed.

b) *Crossbreeding for the formation of a new breed*: In many tropical and subtropical areas, particularly where grazing is applied extensively, conditions are too severe for purebred European-type cattle. Efforts may then be made to create new breeds through crossing between local cattle and imported breeds and subsequent selection. This procedure comprises nothing basically new as many of the temperate cattle breeds were themselves formed in this way. An interesting de-

**BREEDING SCHEME: PUREBREEDING OF FRIESIAN CATTLE
AND UPGRADING OF LOCAL CATTLE TO FRIESIAN BULLS.**

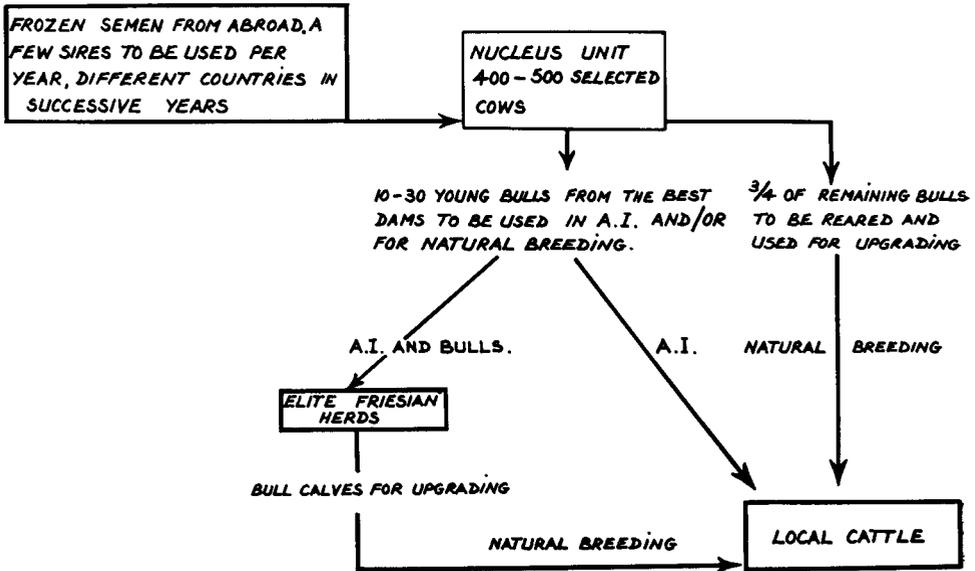


FIGURE 2.—A model for upgrading of local cattle by use of frozen semen and a Nucleus Breed Unit.

velopment in this direction is presently going on in Australia, where a program to establish an Australian Milking Zebu has been in progress for some 20 years from crosses between Sahiwal or Red Sindhi bulls and Jersey cows (HAYMAN 1973). Interestingly enough, the program also includes selection for heat and tick resistance. Even though the Australian Milking Zebu (AMZ) has not yet been released for widespread commercial use, progress has been quite promising. There is now little difference in milk yield of the AMZ's and the *Bos taurus* animals (mainly Jerseys) in the experimental station and the AMZ's have proved to be highly resistant to the tick, *Boophilus microplus*, which is a considerable problem in the Australian tropical areas.

c) *Selection within an improved local strain.* There are some local strains of cattle in the tropics which appear to have fairly good milk yield, e.g., the Sahiwal, Sindhi, Tharparkar and Gir of India, the Butana, Kenana and Gash of the Sudan and Damascus cattle and related strains in Syria and southern Turkey. Most of the improvement programs for these breeds have so far been relatively inefficient, and based on selection within isolated small or medium sized governmental herds rather than on an integrated program comprising all governmental and private herds above a certain level of management. The National Sahiwal Stud in Kenya has probably the best improvement scheme in use at present for any strain of dairy zebu cattle. The stud comprises at present one elite herd of 180 cows for the production of young bulls and a rather large unit for progeny testing. A total of 75 young bulls enter the improvement scheme each year in a test for growth rate

and the ten best bulls are selected for milk progeny testing. The average lactation milk yield in the stud has gone up from 1,042 kg in 1965 to 1,527 kg in 1971. With the present selection procedure, annual genetic gain is projected to be 0.12 genetic standard deviations or 43.4 kg (MEYN 1973).

In so far as buffaloes are concerned, there are no highly improved strains available which could be used for upgrading or crossing, and in this case, therefore, there is no alternative to selection within local strains. However, very little systematic selection for milk yield has as yet been carried out. Improvement has generally been based on selection (if any) within isolated and relatively small governmental herds. For a few years, an interesting improvement scheme has been under way in the Anand Dairy Cooperative, Gujerat, India, with several hundred thousand buffaloes owned by small farmers. The cooperative runs a large-scale A.I. scheme and the genetic improvement is based on occasional milk recording and a program of progeny testing (KURIEN 1973). The efficiency of the system from a genetic point of view has not yet been subject to analysis. The general approach, however, seems promising.

d) *Rotational crossbreeding*: It seems that the general trend as well as the general interest of governmental officials in the dairy sector of developing countries is towards upgrading of local stock with temperate breeds and massive importations of improved dairy breeds. As already pointed out large-scale animal imports are certainly unnecessary and a waste of money as the same goal may be obtained much more cheaply by use of imported semen or bulls and semen from national nucleus breeding units of the temperate breed. To satisfy the initial needs of the developing countries in this respect, FAO has organized a special Bull Semen Donation Scheme. Upgrading beyond 75% temperate blood may, however, lead to problems if the climatic conditions are severe or the level of management does not develop in parallel with the genetic potential of the stock. It may then be necessary to use bulls or semen of a local strain or crossbreed bulls in rotation with temperate bulls to secure enough strength in the general population. The main difficulty here is the present shortage of improved strains of tropical dairy cattle. Improvement of promising local dairy strains should therefore be encouraged. The Australian Milking Zebu, as well as the Kenyan Sahiwal, may become very useful in the developing countries as bulls in systematic crossbreeding programs as a complement to the breeds of European-type dairy cattle.

BEEF CATTLE

Beef production in the developing countries is carried out in a number of distinct *production systems* which might most conveniently be grouped into three main classes: (i) pastoralism; (ii) settled farming where beef production is a sideline to crop and/or milk production; (iii) ranching. It is not possible to design one single breeding plan which would be suitable for all existing production systems. *The breeding plan has to be an integrated part of the production system.*

Level of management is crucial to productivity. At present, the average annual production of beef per head of cattle in the developing countries is about 16 kg

and in the developed countries 77 kg. Often rather inexpensive and small changes in management can have a very positive effect on productivity and economic return. For the individual livestock owner, improvement in the management technique should often be given priority over genetic improvement.

The present problem, in many developing countries, of heavy overgrazing of grasslands, low productivity of livestock and high mortality may at least partly be overcome through a stratification of production whereby calves and store cattle are produced on the extensive ranges while the finishing can be carried out in feedlots in crop growing areas or in ranches with improved pastures. A successful scheme on this line has been developed in Kenya in cooperation with FAO. Among many things, the scheme demonstrated that local cattle, particularly improved Boran, responded very well to feedlot feeding. Boran steers of approximately 300 kg liveweight which were put on high energy rations for 110 days gained 1,260 g per day while the corresponding results for Boran × Hereford and Boran × Friesian were 1,384 and 1,388 g respectively. For a moderately low energy ration, the gains were 1,098, 1,069 and 1,060 g per day respectively (CREEK *et al.* 1973).

Production traits of particular importance

For beef production in general, fertility and growth rate are the main biological traits which decide on the economy of production. In the tropics, resistance to the environmental stress should be added to the important characters. Heat is only one of several causes giving rise to stress. Parasites, infectious diseases, periodic malnutrition, and shortage of water are often more important stress factors than heat. Beef cattle cannot be shielded off from the environmental stress to the same extent as dairy cattle. Their main function is to convert the pastoral vegetation into meat. Animals which can withstand the total impact of the environment are therefore required. Cattle of Indian or African origin have shown themselves to be considerably more resistant to harsh tropical conditions than European-type cattle. They have superior water economy and can walk long distances to watering points; their skin and hair coat reflect solar radiation well and they have a high degree of resistance or tolerance to parasites and infectious diseases.

The physiology and genetics of resistance to environmental stress in cattle have been given particular attention in a number of large-scale experiments at the Rockhampton Station, CSIRO Division of Animal Genetics, Queensland, Australia, just inside the Tropic of Capricorn. The studies are based on one strain of *Bos taurus* (Hereford × Shorthorn) and two strains with 50% zebu blood (one Africander × Hereford/Shorthorn cross and one Brahman × Hereford/Short-horn cross). All strains have been carried well beyond the F₃ stage. The growth rate of the Brahman cross up to 820 days has been considerably higher than in the Shorthorn Hereford strains, while the Africander strain has been intermediate (J. M. RENDEL 1972). The superiority of the zebu strains is largely due to higher resistance to ticks (*Boophilus microplus*) and tolerance to gastro-intestinal helminth infestations. Under identical conditions, the tick counts (number of engorged ticks of 5 mm length on one side of the animal) were about three times

as high in the British strain as in the Africander or Brahman strains. Experiments in which acaricide dipping was compared to no dipping showed that moderate tick infestations reduced gains of the British strain by 40–50 kg/year, had some effect on the Africander strain and practically no effect on the Brahmans. Tick resistant animals are able to reject the larvae. However, there is a considerable variation between animals within strains in tick resistance. In the Rockhampton studies, tick resistance has shown a fairly high heritability, 0.5–0.8 (SEIFERT 1971). Much in contrast to the results with ticks, there did not appear to be any difference in number of helminths between the zebu and British strains as fecal egg counts were practically alike. However, drenching (which kills the helminths) had a very positive effect on growth rate in the British strain but no effect on the two zebu strains. Similar parasite burdens therefore appear to affect well-being and growth differently in different strains (SEIFERT 1971; TURNER and SHORT 1972).

Very little is known at present about comparative fertility of various breeds and crosses. In the Rockhampton experiments, the Brahman strain (beyond the F_1 stage) had consistently lower fertility than the two other strains. There is some indication of low fertility of Brahman cattle also from other experiments and the whole problem should be looked into further, remembering also that other breeds of Indian origin have a fertility problem.

Heritability for growth rate from birth to slaughter weight for beef cattle is usually in the order of 0.3–0.5. Little is known about heritability under tropical conditions, but as the environmental variation often is very large (seasonal droughts, variation in disease and parasite occurrence) heritability should be expected to be fairly low. TRAIL, SACKER and FISHER 1971, in a large-scale crossbreeding experiment in Uganda estimated heritabilities for weights at 12 months and 24 months at 0.08 and 0.19 respectively, heritabilities well below the usual values from the temperate zones.

Hybrid vigour has been shown to be an important factor in the overall economy of beef production, both through the superior growth rate and viability of the crossbred calf and the improved fertility and mothering ability of the crossbred cow. Under the harsh environments of the tropics, heterosis in growth rate of F_1 calves can be quite stunning. In the large-scale crossbreeding experiment in Uganda, referred to above, the overall heterosis effect for the liveweight of steers at 24 and 36 months was 11 and 13% respectively (TRAIL, SACKER and FISHER 1971). In another experiment involving Boran and Red Poll the liveweights of the F_1 were 26% above the mid-parent value at 12 months and as much as 15% above the better of the two parental strains, the Boran (SACKER, TRAIL and FISHER 1971).

Future research

Comparisons between various breeds, both indigenous and exotic, with regard to growth and adaptability should be carried out on a much larger scale than heretofore. As with the dairy breed comparisons, it is essential that some common denominator breed be included to facilitate comparisons between experiments.

Much more work is required on tolerance to environmental stress. The immunological and physiological reasons for the genetic differences in resistance to ticks need to be looked into further. In Australia, with only one major tick (*Boophilus microplus*), breeding for resistance to ticks may be an attractive alternative to dipping, as the ticks develop resistance against the acaricides which are being used. But what about Africa with a great number of different ticks, two of which transmit the protozoa *Theileria parva* causing East Coast Fever? The present accepted policy is to dip regularly once (or twice) per week to control the ticks. Can existing genetic differences in tick resistance replace the use of acaricides?

Trypanosomiasis, a protozoal disease spread through the tsetse fly, makes cattle production impossible within large areas of Africa. There are certain West African cattle breeds, N'Dama for instance, which are tolerant to the trypanosomes. The causes of the tolerance are, however, not known. Due to the immense economic importance of the trypanosomiasis problem, it is surprising indeed, that so little has been done to explore this genetic variation in tolerance and to study in depth its physiological background.

Breeding programs for hot climates

Any breeding program will have to consider the general social and economic level of development in the country concerned and make use of (a) the superior adaptability of zebu-type cattle and other breeds indigenous to the tropics, and (b) the marked effect of hybrid vigour on growth rate, viability and mothering ability. A suitable breeding program should, therefore, be based on selection for growth and viability within well-adapted strains (e.g., Boran and Africander cattle) which in themselves might have originated from breed crosses. Bulls from the two improved strains should thereafter be used in alteration in the beef producing herds. Another alternative would be to develop new strains from crosses between European-type cattle and zebu strains and subsequent vigorous selection in much the same way as has been so successfully explored in the Rockhampton experiments in Australia. Unfortunately, this kind of work takes considerable time and resources. The superior zebu cross strains developed in Rockhampton and elsewhere may, however, be utilized as a basis for rotational crossing or further "pure" breeding also in other countries.

Other livestock and poultry

The problems of sheep breeding in the developing countries are in many ways similar to those for beef cattle, although sheep are usually kept under even more extreme environmental conditions. To get the breeding animals and their lambs to survive during seasonal droughts or cold spells is often the main concern. Local sheep breeds show a high degree of adaptation to existing environmental conditions. Under the traditional management system, flock fertility and growth rate of the lambs are low. However, several studies (e.g., DEMIRÜREN 1972) show that native sheep breeds respond well to improved feeding and management. Measures such as organization of feed reserves on the ranges or semi-intensive fattening combined with an early offtake of lambs therefore deserve priority, in

most cases, over improvement through breeding. However, in special cases such as for the improvement of wool quality, selection is essential. Crossbreeding for hybrid vigour may also have its place under certain conditions.

Of the world's meat supply, about 30% comes from the pig, and 13% from poultry. In the Far East the proportions of pig meat among all meats consumed is as high as 45%. As pigs and poultry require grain feeds which to a high degree can be used also by man, the size of the pig and poultry industries in the developing countries depends on the demand for grain for human consumption. This competition has often made governments reluctant to undertake measures to stimulate pig and poultry production. Breeding problems for pigs and poultry in developing countries were discussed recently in two FAO meetings on animal genetic resources (for pigs, FAO 1970 and for poultry, FAO 1973). With regard to pigs, a gradual transfer and adaptation to developing countries is likely to take place. Since the production system as such will be taken over, no great efforts will be required to adapt the pigs through selection to a new and very different environment. The methods of freezing boar sperm and of artificial insemination which are now in an advanced stage of development will facilitate the transfer of genetic material to the developing countries. Intensive pig production systems, making use of genetically improved breeds are likely to become established initially in peri-urban areas of developing countries as basic services can be met more easily there than out in the rural areas. Once intensive production systems have been established in a developing country, the need for some testing facilities as a base for selection may arise. However, in the initial phase of production development, there is largely a need for transfer of breeding stock and for the build-up of an organizational structure which allows good use to be made of the improved breeding material.

Poultry production in most developing countries is divided into two quite different sectors, backyard production and large-scale intensive production. Even though backyard production in many countries still is much more important than the modern sector, very little can be done to its improvement by breeding, due to lack of organization. The commercial sector is based on continuous imports of breeding material (grandparent stock) from large poultry enterprises in Europe or North America. These imports have certainly contributed considerably to the level of poultry production in the developing countries, but they make a constant drain on scarce resources of foreign exchange. As the standards of poultry feeding, housing and management are likely to lag behind conditions in the highly industrialized countries for quite some time and as there appears to be a considerable genotype-environmental interaction for overall productivity, it may be time to reconsider import policies in at least the large developing countries. As a matter of fact, India and Malaysia have already started national large-scale breeding programs based on pools from imported strains (FAO 1973). India has announced that it will discontinue imports of breeding stock soon.

Infrastructure and training of animal breeding staff

As resources are scarce in the developing countries, it is most essential that

available funds for livestock improvement be used at strategic points in the overall national development programs. It was pointed out in previous sections that improvement through breeding will, in many cases, require importations of genetic material and techniques, for instance, dairy bull semen, pigs and poultry stock from industrialized countries, or trypanosome-tolerant cattle from West Africa to other parts of Africa. It is important, therefore, that the developing countries build up units and organizations by which imported genetic material can be tested for adaptation and, when required, multiplied and disseminated. The organization of small but efficient A.I. services capable of handling imported frozen cattle semen should be given high priority in most countries and the same applies to the development of governmental stations for breed comparisons, multiplication and practical investigations. However, extensive production recording among private livestock owners which has proved so useful in the highly developed countries may have to wait until these more basic facilities have been developed.

It goes without saying that research in the developing countries should be oriented towards the particular needs of the countries concerned. However, the developed countries have a great role and even obligation in assisting students from the developing countries in their research training. A considerable amount of good work has been done in this sector but in many cases, there is a lack of understanding in the scientific community for the type of training required by students from the developing countries. Research problems should be assigned to them which have relevance to the overall livestock development of their home countries. The development of some kind of sisterhood relationship between universities in the developing and developed countries could go a long way towards meeting the needs for training of future research staff. The graduate students could then have most of their training in their home countries. Periodic visits of staff from the sister university in the more developed country would have the double purpose of guiding the student in his research work *and* make the visiting staff better acquainted with the particular needs of the country where the student is going to work.

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