RESEARCH AND DEVELOPMENT CHALLENGES FOR ANIMAL BREEDING IN DEVELOPING COUNTRIES

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INTRODUCTION

In animal breeding, major breakthroughs have been achieved in recent decades but, probably more than in other agricultural sub-sectors, the gap between knowledge generated by scientists and its application and impact on the populations of the poorest countries is widening. This raises specific challenges in terms of research and development (R and D). Actions to correct this situation are urgently needed if we keep in mind that :

- the world's population is expected to grow from 6 billion people in 2000 to 7.5 billion people in 2020 and most of the growth will take place in developing countries ;
- over 1200 million people still live below the poverty line. Three quarters of them live in rural areas and roughly two thirds of them keep livestock ;
- 167 million children under the age of five still suffer from malnutrition. One third of all children in Sub-Saharan Africa continue to go to bed hungry and have their mental and physical development compromised by the ravages of hunger (IFPRI 2001a).

In the fight against poverty, the animal breeding scientific community has a special responsibility as all indicators reveal that the next food revolution will be a "livestock revolution". However, technical and scientific answers would have no or only a very limited impact if the context in which animal breeding programs operate is not improved. In addition, animal breeding in developing countries faces specific constraints, which are often overlooked or underestimated. However, major societal changes related to R and D have recently taken place and offer new opportunities and hopes for a greater impact of animal breeding in developing countries.

THE LIVESTOCK REVOLUTION

The term "Livestock Revolution" was coined by Delgado *et al.* (1999) to summarize a complex series of interrelated processes and outcomes. Human population growth, increasing urbanization and rising incomes are fuelling a massive increase in demand for milk, meat and eggs in developing countries. For example, according to FAO (2000), milk imports have roughly trebled since 1970 and per capita meat consumption is expected to double between 1993 and 2020, when some 82 percent of all food and agriculture production will be in what are now developing countries. One important characteristic of this "revolution" is a major increase in the share of developing countries in total livestock production and consumption. Animal breeding will therefore have a major role to play to meet this demand and to alleviate poverty in these regions. However, the answers will not come from science alone but also, to a large extent, from the environment in which animal breeding programs operate.

OVERVIEW OF THE CONTEXT IN WHICH ANIMAL BREEDING PROGRAMS OPERATE IN DEVELOPING COUNTRIES

Developing countries are facing difficulties inherent to their development process or imposed on them by developed countries that, in general, do not favor the success of animal breeding programs. Scientists should be conscious of these particularities as, sometimes, it may be wise not to launch programs, even though they may be fully justified from a technical point of view, if the environment is not conducive.

Research and Development Policies. Two regional seminars held in Sub-Saharan Africa highlighted the lack or weaknesses of livestock policies as a major constraint to development (Hoste, 1999), but the situation is rather similar on other continents. Very few countries have clear, detailed and coherent livestock development and research policies. In fact, in most countries, livestock development policies are only mentioned in the general agriculture sectoral policy document ; very few specific national livestock policy documents exist. This lacuna is even more evident for livestock research policies : national agricultural research master plans are scarcer than national development policy documents and, where they do exist, the livestock sub-sector is usually underestimated.

In addition, several national policies are considered inappropriate or may have a negative effect on agriculture and its livestock sub-sector and need to be corrected. These include, for example, subsidies, taxation on agricultural inputs, price controls that favor consumers, unsustainable services such as free dipping, total reliance on livestock imports and livestock products, and communal land ownership. Among these “counter-productive” policies, land tenure policies were identified as probably the biggest constraint as they could inhibit human and financial investment in the livestock sub-sector.

More has also to be done on a regional level to establish sectoral policies on harmonization of imports, exports and standards. Another priority on a regional level is to facilitate the free flow of information between countries, in particular for the development and promotion of trade. This is particularly critical for the control of livestock movement, quarantine enforcement and epidemiosurveillance, for better understanding of the markets and for the characterization and conservation of animal genetic resources.

Linked to these policies, the legal aspects are becoming increasingly important, not only in terms of intellectual property rights and patenting but also in facilitating or limiting the transboundary exchange of animals or genetic materials.

The Economic Context. According to FAO (2000), primary livestock products (meat, milk, eggs, wool, hides, skins) account for approximately 22 % of agricultural Gross Domestic Product (GDP) in the developing regions of Asia, 25 % in Sub-Saharan Africa, 31 % in West Asia and North Africa, 38 % in Latin America and 41 % in Central America. Livestock contributes an average 4 - 7 % to the GDP of developing countries, not to mention the substantial value of draft power and manure, or indirect benefits of animal agriculture.

In spite of this significant contribution to economic growth, the prices of animal products have declined over the past 20 years. For example, between the early 1980s and early 1990s, deflated liquid milk prices fell 37 percent and real meat prices fell 23 - 35 percent (Delgado *et al.,* 1999). This was making food more affordable to consumers of all incomes but also severely penalized producers, especially when, over the same period, purchased inputs such as feedstuffs and medicine became much more expensive due to structural adjustments.

In a globalized economy, developing countries are particularly vulnerable and their producers are usually not protected against imports at highly subsidized prices. For example, who has really estimated the damage caused to the local economies in Sub-Saharan Africa by the European policy to dispose of its meat and butter surplus in the late 1980s ? Furthermore, if traditional trade barriers tend to disappear, there is a great temptation for industrialized countries to use measures under the Agreement for the Implementation of Sanitary and Phyto-Sanitary Measures of the Uruguay Round (SPS Agreement) or to impose new rules (e.g. animal welfare) as a pretext for continuing to protect their domestic markets.

The socio-cultural dimension. In developing countries, the livestock sector is integral to the livelihood of the populations. Each ethnic group tends to have a unique valuation of its animal genetic resources. Their culture may dictate that animals are kept mostly for non-economic reasons such as security, prestige, power, social customs (e.g. coat colors, slaughtering of the best males for funerals), etc. The attachment of livestock owners to their traditional production systems (e.g. Fulani in West and Central Africa) is another limitation to change. It is therefore essential to understand these traditions, habits and selection criteria and to consider them in any animal breeding program to be formulated.

The human resources limitation. In spite of the fact that agriculture is the backbone of the national economies in developing countries, ironically, a majority of people have shifted their attention to other careers creating a vacuum of agriculturists. It is also becoming increasingly difficult to attract the best students to faculties of agriculture or veterinary medicine. Furthermore, often being trained abroad, PhD holders in Africa and in some countries in Asia tend to promote the exotic breeds and sophisticated technologies learned.

Livestock x Environment interaction. The question of environment and management of natural resources is perceived very differently in developed and developing countries. In industrialized countries it becomes a priority as the civil society becomes increasingly concerned by pollution linked to intensification. In developing countries, the poor populations often have no other alternative but to exploit marginal, fragile or protected areas. For them, who are struggling to live, environmental preoccupations may be perceived as a luxury that they cannot afford.

Over the last five years, major efforts have been made to produce evidence that the livestock sector can satisfy future demands while preserving the natural resource base, and is a critical element of sustainable agricultural development. An important milestone in this regard was the study on “Livestock and the Environment” and the international conference which took place in 1997 in Wageningen, The Netherlands (Nell, 1998). These efforts resulted in the

establishment of an inter-institutional "Livestock, Environment and Development (LEAD) Initiative". A "Virtual Research and Development Center" was launched (www.virtualcenter.org) and a toolbox developed to provide, among other things, technical and policy or institutional development options for enhancing positive or mitigating negative effects of livestock on the natural resource base.

The health situation. In addition to their economic consequences, the recent outbreaks of bovine spongiform encephalopathy (BSE) and foot-and-mouth disease (FMD) in Europe had a tremendous psychological impact on civil society and helped to increase awareness of animal health and food safety issues. Several measures taken by different governments to reassure their populations about the "quality" of the animal products they consume will directly affect livestock producers in developing countries, as they may probably be unable to meet the new standards. In addition, as already mentioned, the temptation to use the SPS Agreement to protect some domestic markets may also increase. Another concern for developed countries is the emergence of new diseases, or the re-introduction of animal diseases that were previously eradicated in different countries or regions, due to climatic changes and/or some new technologies used for conservation, processing and transportation of animals and animal products worldwide.

In developing countries, the poor populations in contact with livestock are highly exposed to zoonoses that are chronic and debilitating, such as gastro-intestinal parasites, and affect the development of children for the rest of their lives. The incidence of HIV/AIDS has also to be considered, as it reduces the labor forces and changes agricultural practices including the type of stock kept by smallholders. As far as animal populations are concerned, it should be emphasized that imported exotic breeds are usually not adapted to their new environment and are often highly susceptible to tropical diseases. This limitation to their use in any improvement scheme is often overlooked.

R and D funding. Most of the information provided below is taken from a report recently published by IFPRI (2001b) which tracks trends in agricultural R and D over the last few decades. Comments can be made on four topics :
(i) The level of funding. During the 1990s, public spending shrank in Africa and stalled in the rich countries, while many aid agencies reduced their support for agricultural R and D for Southern agriculture. For example, agriculture's share of total lending by the World Bank declined from an average of 26 percent during the first half of the 1980s to only 10 percent in 2000. A drastic decline of 75 percent was observed in the amount of funding USAID directed toward agricultural research in less-developed countries from the mid-1980s to 1996. Since then, USAID funding for agriculture has failed to regain the ground it lost, and this is also probably true for agricultural R and D.
(ii) The type of research funded. According to this IFPRI study, another consequence of the downward trend in funding is that : "growth in the stock of publicly generated knowledge in the North is slowing, thereby limiting the pool of science and technologies than can spill over to the South. It also has less relevance for the South now that much public research in rich countries is focused not on traditional agricultural production technologies but on local environmental and food-safety concerns and on the quality of foods preferred by richer people.

Moreover, the slowdown of science in the South limits the potential of poor countries to develop locally relevant technologies and tap into Northern knowledge stocks".
(iii) The origin of the funds. In spite of the difficulties in estimating the contributions of the private sector to agricultural research, IFPRI considers that, by the mid-1990s, about one third of the $33 billion total investment in agricultural research worldwide was private. But in the less-developed countries, the private share of research is just 5.5 percent and public funds are still the major source of support.
(iv) Attribution arrangements. Another point emphasized in the report is the need for continuity due to the considerable lag between investing in innovation and reaping the rewards. This is especially true for biologically based sciences like agriculture. For animal breeding research, project cycles are usually inadequate with a maximum duration of 3 to 5 years and, often, highly damaging interruptions between them. A lack of donor coordination can still be found, even if significant progress has been made over the last decade. Finally, most donors face great difficulties or impossibilities in supporting sub-regional or regional projects, which are increasingly becoming the most appropriate and efficient scale of intervention.

SOME SCIENTIFIC AND TECHNICAL CHALLENGES FOR ANIMAL BREEDING IN DEVELOPING COUNTRIES

This paper argues in favor of a specific R and D approach. What follows is in no way exhaustive but raises some basic questions and illustrates the type of research that is urgently needed in the field of animal breeding in developing countries. For all the other domains, an overview of the implications of livestock development for rural poverty, the environment and global food security has recently been published and can be referred to (World Bank, 2001).

How to win the "Livestock Revolution". As already mentioned, the livestock revolution will mainly take place in developing countries, not only due to the massive increase in demand but also in terms of production. If this revolution is to have any chance of succeeding, three strategic questions have to be addressed by all stakeholders. The scientific community has a major role and a clear responsibility in feeding the debate with information, facts and results :

- What kind of genetic material will have to be used ? Which model of animals should be promoted : fish-farming, short-cycle species such as rabbits, chickens, pigs ? What could be the role of game ranching and non-conventional species ? In this context, what would be the future of large farm animals ?
- What are the respective roles of public and private research ? The private sector is mainly interested by near-term profit to the exclusion of research on less profitable species or traits. At the same time, there has been limited public investment in animal biotechnology in most developing countries and only modest support for more conventional livestock research and development to improve productivity, nutrition and the health of farm animals. As suggested by FAO (2000), governments need to consider how best to support private-public sector collaboration in animal biotechnology research, especially for research geared towards non-commercial markets to generate public goods.
- What kind of actors would be able to re-establish the dialogue between researchers and the end-users of their results ?

Animal breeding research priorities. Many scientific disciplines contribute to livestock production and have their own research specificities and priorities in developing countries. Only animal breeding research priorities are reviewed here. In 2001, the French scientific community founded GENATROP, a group to deal specifically with animal breeding in the tropics. Based on the wide and long French experience in the tropics and extensive discussions with scientists from the South, this group has identified four broad priorities that are briefly presented.

Characterization of the biodiversity in domestic and wild species of economic interest. The importance of animal biodiversity cannot be overemphasized. Currently, indigenous breeds of domesticated animals are neglected and approximately 30 % of them are in danger of extinction. Nowadays, with the tools provided by molecular biotechnologies, it is possible to estimate the genetic characteristics of individuals and, through them, the genetic diversity, the differentiation and the structure of animal populations. An overall priority is to increase knowledge of the different animal genetic resources, both domestic and wild, through exhaustive inventories, characterization, productivity estimates, adaptability to different environments, identification of genes for genetic resistance to diseases and/or production trait improvement. With this improved knowledge, it will then be possible to design new production systems based on different species and breeds, facilitate access to the genetic resources needed, and establish *in situ* and *ex situ* programs for the conservation and sustainable use of these resources. A special mention should be made of the major contributions of FAO in this field with the formulation of a "Global Strategy for the Management of Farm Animal Genetic Resources" (FAO, 1999), the launching of the "Initiative for Domestic Animal Diversity" and the establishment of a "Domestic Animal Diversity Information System".

Quantitative genetics. The efficacy of selection techniques has been greatly improved by the use of sophisticated statistical methods such as BLUP. Marker-assisted selection schemes are also a very promising avenue. In spite of this progress, there will always be a need to monitor populations, record performance and build pedigrees. In developing countries, there are very few situations in which such data can be collected due to the production systems in place (e.g. transhumance). Furthermore, the small size of herds makes it difficult to effect selective breeding at the herd level and there are almost no community-level breeding programs to pool small herds. Additional difficulties are the lack of easily-implemented recording systems, the inability to control sires and the high mortality rates which limit the contribution of any genetically superior animals. To address some of these questions, CIRAD has developed a software called "Laser" which facilitates individual recording in traditional livestock systems in Africa (Juanes and Faye, 2001), and is working with INRA, France, on the adaptation of selection methods to an environment in which the sires are unknown.
Another challenging research topic is the introduction of high potential genes in animal populations well adapted to their local environment according to the level of intensification and the production system. Adaptive genetics is becoming an important component of this research theme.
A prerequisite to any genetic improvement scheme, either through the use of reproductive biotechnologies or the introduction of exotic genes, is in-depth knowledge of the reproductive physiology of the indigenous breeds in developing countries. In addition to the difficulties

linked to their use in harsh conditions, the results of simple technologies such as artificial insemination or embryo transfer are still significantly lower in indigenous breeds than those obtained in developed countries. Much more needs to be known about the reproductive physiology of these well adapted local breeds but it is a fact that this does not greatly mobilize the scientific community.

Functional genetics approach in resistance to diseases based on marker-assisted selection. This is one of the most promising avenues in animal breeding and a probable future breakthrough in livestock research. Whilst viral and bacterial diseases are usually well controlled by immuno - and/or chemio - prophylaxy (vaccines, antibiotic therapies), it is totally different for parasitic diseases, which are much more difficult to control. The wide diversity of parasites, of their biological cycles, of their vectors and of their hosts may explain why it is still difficult to control these pathologies. In addition, the substantial antigenic variability that often characterizes them allows these parasites to escape natural defenses. This also results in major difficulties in producing antiparasitic vaccines both for human and animal populations. All these constraints fully justify investments in research on genetic control as a good alternative. The priority programs are related to dermatophilosis, trypanosomosis, internal parasites, pleuropneumonia and tick attractiveness. The same approach can also be used for the improvement of productive traits.

Genomics. Much progress has been made in this discipline over the last ten years. With new biotechnological tools, genotyping programs and gene - expression studies, using micro-arrays, have been launched in many species. However, due to the technologies involved and the very high cost of this type of research, the research teams pool their resources within "genopoles" such as the one in Montpellier to accelerate host/vector/pathogen genome sequencing. The cross-organism comparison of linkage, physical and comparative genetic maps and DNA sequences will significantly reduce the time needed for identification and selection of potentially useful genes. However, the major research projects on genomics are mainly focusing on breeds in developed countries and greater effort should be made to gain a better understanding of tropical breeds and identify potentially useful genes.

MAJOR SOCIETAL CHANGES IN R and D

The perception of research by the different stakeholders and their increasing involvement in the design and implementation of research programs is a major societal change that has occurred in the last decade. This is noticeable at four different levels.

Organization of livestock owners. In developing countries, there is still a large gap between modern, large-scale, mainly milk producers who are usually well organized within national breeders associations, and voiceless smallholders. However, promising signs can be seen in terms of smallholder organization. This is particularly true in the agricultural sub-sector in which farmers' organizations are emerging, on both national and regional levels, and are beginning to be heard by politicians. Probably the best example is the recent establishment of ROPPA, a network of farmer and producer organizations in West Africa, which has now gained direct access to the highest level of decision - making in the region. In the livestock sector, the geographical distribution maps of poor livestock keepers and the assessment of their

likely changes in the coming decades published by Thorton *et al*. (2001) will be a very useful tool for future priority-setting exercises. Another very important change that can be noted is that the scientific community is beginning to recognize the value of "indigenous knowledge" and significant efforts are currently being made to combine indigenous and modern knowledge. New associations such as the "All Africa Society for Animal Production" are trying to reflect this new dimension in their membership.

The building of National Agricultural Research Systems (NARS) and the strengthening of regional cooperation. The concept of NARS emerged in the early 1990s when developing countries realized the benefits they could gain from better coordination of all their resources in the agricultural sector, in particular their human resources. The first priority was to bridge the gap between universities and national agricultural research institutions, and the livestock situation in Africa was analyzed in more detail by Hoste (1995). The next step was to integrate Non-Governmental Organizations and Farmers' Organizations in the NARS. The last step is now to mobilize the emerging private sector of small and medium-size agro-industrial enterprises. Here again, new opportunities are offered to the livestock sector to make its voice heard and have its priorities considered. A recent organizational change initiated by the NARS is the establishment and/or the strengthening of sub-regional and regional fora to improve South-South dialogue and collaboration.

Launching of the Global Forum on Agricultural Research (GFAR). GFAR was officially established in October 1996 but started its operations in mid - 1998 with the opening of its Secretariat hosted by FAO in Rome. Three sets of keywords characterize the GFAR mode of operation : subsidiarity – complementarity – added value ; partnership – mobilization of all stakeholders – participatory decision-making ; openness - adaptability – transparency. In three years, the "bottom-up" dynamics generated by GFAR have contributed to the emergence of a Global Agricultural Research System based on strong NARS and their sub-regional and regional fora. More information about GFAR can be found on their website : http://www.egfar.org.

The emergence of Global Programs. Based on regional research priorities, GFAR stakeholders have identified a few "Global Partnership Programs", one of which deals with animal trypanosomosis. More recently, and as part of its reform process, the Consultative Group on International Agricultural Research (CGIAR) developed the concept of "Challenge Programs". Currently, there is only one challenge program in the pipeline in the livestock sector but it also deals with animal diseases. There is probably a unique opportunity for the animal breeding scientific community to join forces and propose a global program to contribute to the success of the livestock revolution.

CONCLUSION

The animal breeding scientific community needs to be galvanized into addressing the specific R and D challenges faced by developing countries in meeting the increasing demand generated by the livestock revolution. The overall goal is to make livestock production in developing countries more competitive. Considering the existing situation, this implies an important scientific shift towards breeding programs which minimize costs rather than maximizing

production system productivity. Public awareness, education and information on the benefits and risks of new biotechnologies and their potential role in the management and use of animal genetic resources are also key pillars of the strategy that needs to be put in place. The new partnerships that are emerging offer a unique opportunity to the animal breeding scientific community to take up the challenge of the ongoing livestock revolution.

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