5
Livestock Farming Systems, Research and Development Issues

A. Nardone and A. Gibon

Introduction

There is evidence of the husbandry consideration already in ancient civilisations, as can be deducted, for example, from the great detail with which the number of sheep and cattle were annotated on clay tables in the city of Ebla in ancient Persia about 4000 years ago. Those can be considered some of the first documents of husbandry demography of the history. Quite numerous were in the roman and subsequent times the studies carried out on husbandry methods. Nevertheless, until late Middle Age there were more a collection of observations than true investigation methodologies. Consequently, the husbandry systems and their productive capacities depended mostly on the environmental conditions, with few possibilities for man to manipulate them. In the late Middle Age started a new allocation process of the land resources. Defined areas where assigned to different agricultural uses: cultivation, pasture, wood. Rationalisation processes of livestock farming activities began in this period and the premises are founded to switch much later from an animal production closely integrated into the agricultural activity to systems where the agricultural production is in the service of animal production. In the Renaissance, with the first treatises of veterinary anatomy the bases of future animal science were founded. But the animal science began only to develop in the 18th and 19th century.

Between the end of the 1800s and the begin of 1900s, a fruitful integration between animal sciences and other sciences established. But perhaps the major advance in this period is the establishment of principles for animal production recording, which allowed the achievement of paramount results on genetic improvement of productive traits.At the beginning of 1900, when, as consequence of the industrial development, the economic and social situation in many countries leads to an increasing demand for animal proteins, the general interest moves from animals themselves and the multipurpose objectives of their husbandry (from manure as a fertiliser to draught power) to animals food products. Agriculture begins to produce for husbandry. The animal sciences take an important part in this evolution, since they already have a good knowledge of anatomy, morphology, physiology, nutrition and can rely on the acquisitions of chemistry, statistics, genetics etc.

From these times till now, the advances in animal sciences interacted strongly with the society pressures in designing the mutations in Livestock Farming Systems (LFS). New scientific acquisitions in this end of millennium will be such to activate even more technological innovations able to modify deeply the LFS. In this paper we emphasise the main evolution trends in both animal science and LFS, in order to out light the principal aspects of their interactions in the past and to discuss some of the main issues and challenges for the future, with reference to the society demands and pressures. For simplicity, we will refer in the following to the extreme intensive and extensive forms of LFS, and we will distinguish between two groups of developing and developed countries.

Historical trends in the evolution of animal science and of husbandry practice

Transfer of knowledge a major key for the specialisation and the intensification of the livestock farming systems

At the end of the 19th and the beginning of 20th century the productive specialisation for species and for product begins in farms devoted to husbandry in the countries today named "developed". The real forces of reciprocal interaction between the society demand for animal products, the offer of livestock production and the discoveries of research are established. On the technical side, processes for conserving foods for animals, for milking and housing the animals are developed. With the switch from pasteurisation at high to low temperature and with the availability of machinery and electric power begins the expansion of the modern cheese industry, which will be a great stimulus for dairy farming.

Scientific advances determine the possibility to match the increasing demand of product by improving husbandry productivity. They make possible to obtain animals genetically more productive, to feed them more rationally, safeguarding their health and managing them with suitable techniques. Economists, as for example Boutonnet & Martinand (1979), demonstrated that models exploiting this principle can constitute an efficient tool for satisfying increasing quantitative demands for animal products.It is interesting to stress how long the times of in field transfer of some of the principal research discoveries have been, and that outcomes from other disciplines were needed to allow them to be fully exploited and to have an effect on the livestock production systems. The genetic improvement of dairy cattle illustrates well this issue. In the choice of the parents, the milk records marked the passage from the appraisal of animal conformation to the measurement of the quantities produced. This method was introduced 2 centuries ago. But the full exploitation of its potentiality came out only recently, from the outcomes of researches in at least three different disciplines.

The acquisitions of quantitative genetics (Write, Fisher, Lush, Mal,cot) justified the employment of artificial insemination (AI) in order to carry out progeny tests and to distribute the semen of proven bulls. The principles of the genetic indices were formalised by Lush and Hazel around 1940. But they became highly reliable only recently, when electronics and informatics provided computers and software powerful enough to solve the big matrices of BLUP-Animal Models, devised by Henderson and others since the sixties. Artificial insemination, to become fully established at least 150 years after the first experiments, needed the support of knowledge from various areas of physiology and endocrinology in order to determine the time of insemination, and from engineering for the semen deep freeze and conservation. The dairy records dealt only with quantity for a long time. When to the knowledge of chemistry, of physics and of electronics recently summed up, the determination of fat and later proteins has been automated, allowing selection for milk components also. The genetic improvement allowed to obtain highly productive animals and determined the development of research lines on nutrition physiology and feeding techniques. The machine milking technique induced selection of animals for the udder and tits form, which in turn helped the technique to spread. While in Europe machine-milking equipment was present in 3% of the farms in 1950, it was absent in only 3% of them in the seventies.

The green revolution of the fifties, which hugely increased the cereal and fodder availability, boosted the improvement in animal productivity within intensified dairy systems. Similar and more exasperated results have been achieved in the genetic improvement, nutrition and rearing techniques for swine and poultry. The introduction of pharmaceutical additives, together with concentrate based feeding, determined extreme forms of specialisation and intensification in the production systems of these species. The dominant husbandry development mechanism activated till now from the acquisitions of research in 19th century was based on improving animals individual yields, with the aim to satisfy an increasing demand for animal products. It involved three main pivots: genetics, to obtain an animal which presents the interested trait expressed at the biological maximum; nutrition, to supply the animal with the nutrients required to produce at the maximum level; technique, to find the best solution for the animal produces the maximum at the minimum cost.

The joint employment of the knowledge of the three pivots but also the settlement of specialised services for selection, technical assistance and breeder formation determined the establishment of these specialised and intensive husbandry systems. The evolution we described occurred preferentially in some areas, mainly in developed countries. It led to high concentrations of animals in the areas and the farms where the agro-ecological and socio-economical conditions matched the required conditions for such an evolution (Boyazoglu & Flamant, 1991).

A later research interest for other forms of livestock farming systems

Besides the intensive specialised production systems, many other forms of husbandry, of more traditional and/or extensive type, maintained in wide areas, both in slow developing countries and developed countries. Unfavourable soil and environmental conditions limited the recourse to intensive specialised breeding systems in many husbandry zones. But these factors were not the only ones to limit the spreading of the intensive models, as showed in a survey on cattle husbandry systems in Mediterranean Area (Nardone, 1996). Other principal factors are also influent: a) the capacity of each society to acquire scientific information and to transform it into technical services, b) the local suitability of the innovations proposed, and the cultural level of the farmers to understand these innovations, c) the presence of a market system able to pay back improved results, d) a transformation structure suitable to evaluate and manage animal products, e) a socio-economical system able to ease their consumption.

The current forms of husbandry are very diversified depending on various factors: species and breeds reared, soil, climatic conditions, vegetative and productive characteristics of the husbandry areas, socio-economical environment, farmholding conditions and employed technology. In many parts of the world, especially in developing countries, animals are still associated to agriculture in mixed smallholder systems, their feeding being partly provided by agricultural by-products. Some of these traditional systems can be considered as intensive ones (for instance pig production in Chinese smallholdings). The extensive systems all share some principal characteristics: limited number of heads per hectare, low productivity per head and per hectare, limited employment of technology, reduced utilisation of fossil energy (Coop & Devendra, 1982). The fact they exploit low cost vegetable resources allows an important limitation of the husbandry requirement of cereals. Extensive systems nevertheless range from types in which advantage is taken from advanced technical and scientific knowledge for some few phases of the productive process, as for instance in some Australian systems, to systems where the farmer just still acts following behaviours handed down from millennia, based on empirical observations, as for instance in some few nomadic forms.

Regarding the technologies used, all these systems must be considered with specific attention. Many of the "traditional" forms, either extensive, either in smallholding conditions, demonstrate very efficient for benefiting the resource of difficult agro-ecological environments (Ellis et al., 1979). They often also prove to be economically very efficient under their local societies conditions (Coop & Devendra, 1982). When it has been tried to transfer into these systems the research and technology employed in the intensive specialised systems of developed countries, frequent failures were experimented. A lack of necessary presuppositions about innovations efficiency in very constrained environments has been denounced (Flamant, 1991a; Jasioroswki, 1991; Vissac, 1992).

In the general scheme where animal science was focusing on improving animal individual yield through intensification, the research on traditional forms of livestock production systems has been quite limited until recent times. Only from the seventies, animal science started upon the use of system approach for the establishment of technologies suited for severely unfavourable areas. Preliminaries studies of the local farming conditions were given emphasis within these works. Peasants and small farmholders objectives and needs where emphasised, together with their own husbandry practice and know-how. Both in developing countries, and in the unfavourable areas of developed countries like Mediterranean European countries, some animal scientists underwent co-operation with other disciplines in order to improve the assessment of the actual potential progress for livestock farming under the local conditions (Flamant, 1989; 1991b). From the emphasis given to extensive and traditional systems, new areas of animal science were developed, as for example grazing and pasture management, effects of nutritional restrictions, and genotype-environment interactions (Coop, 1982; Boyazoglu & Flamant, 1991; Rey & Fitzhugh, 1994). These researches marked the passage from the long time prevailing animal scientists approach to a new era, based on a widened conception of the relation animal-environment. While the priority was previously given to adapting the productive environment to the animals, the adaptation of the animals to their environment emerged as an interesting concern, leading to emphasise the so-called local and hardy breeds interest.

Present trends in animal production

In order to forecast about the near future of LFS, it seems useful to briefly examine the principal trends of animal production in the last three decades on the basis of FAO data (FAO, 1980, 1994, 1995) referred to the more relevant groups of countries. Only the livestock species more important in providing food products and for which data sources are available at world level will be taken into account. Thus we will not deal with some of the species which can nevertheless be important at a regional level, or grown for other products, like draught power, such as camels or donkeys.

Animal production

Cattle. World-wide the size of heads in the period 1961-1994 increased by 36%, the meat production by 90% and the milk one by 47% (Figures1a, 1b, 1c). In developed countries the Figures for 1994 are slightly higher than those of 1961 and that from 1972 begun a progressive process of restriction. The meat production in the thirty years increased by 65% with a slight decrease in the last 11 years, while the milk production in 1994 is higher by one fourth than that of 1961, but is lower by 8% than that of 1983. The effect of milk quotas in EU affects for about a half on the global milk reduction in the developed countries and it causes also a drop in the meat production and in the head number.Conversely, the developing countries show a continuous and consistent expansion of the head number (+52%) and mainly both of meat (+245%) and milk (+280%). Compared with the head Figures, the last numbers bear witness to a strong increase in productivity gained as an average from LFS in those countries. At world wide level, starting from 1972 the ratio of total head number of a year versus the preceding one shows a slight deceleration.

Sheep and goat. There has been an increase of 55% in the developing countries head number and a decrease of 15% in developed countries (+25% world-wide; Figure 2a). The rate of the increase in the developing countries has been nevertheless lower during the last decade than in the previous one. Mutton and lamb meat production had a considerable increase in the period both in absolute value and, lower, in productivity only in developing countries, respectively 230% and 55% (Figure 2b).

Monogastrics. Differences between developed and developing countries appear much higher than for the ruminants.

Swine. The world head numbers is more than doubled (Figure 3a). But, while in the developed countries the increase is less than 30%, in developing countries numbers more than tripled.The meat productivity (meat per head) increased in a surprising amount in developing countries, almost tripling between 61 and 94 (compared with a 37% increase only in developed countries; Figure 3c). In practice the productivity of developed countries that was 3.4 times the one of developing countries in 1961 turned to 1.6 times in 1994. On the basis of the last 10 years trends the gap of the productivity between these two groups tends to shrink. Among the developed countries, the USA maintained almost the same head numbers in 33 years, improving more the productivity in comparison to EU, which conversely almost doubled the swine population.

Poultry. In the comparison developed countries/developing countries a similar trend to that of swine appears, but of a larger extent. In the 1961-1994 period the developed countries showed high productivity, almost doubling the numbers and enhancing four times the meat production (Figure 4a). Eggs increased only by 60% (Figure 4b). In developing countries the size of 1994 are even 5 times those of 1961 and the productions are multiplied by 11 for meat and 7 for eggs. In the USA the amount of eggs produced is almost constant in the last 20 years, while is decreasing in the EU in the last 11 years. These differences like those observed for swine production, can be considered indicative of the possible incidences on livestock production of changes in the dietetic habits of the society.

Buffalo. The species is reared mainly in developing countries. In the period 1979-1992 the population decreased 10% in developed countries and increased 20% in developing countries, where the milk and the meat production increased 60%.

Overall animal protein production. Transforming in proteins all the products yielded by the above considered species help to assess the worldwide change in their respective contribution to human nutrition (Figures 5 & 6). Between 1961 and 1994 monogastrics increased their relative contribution from 24% to 40%, the increase being higher in developing countries than in developed countries (21 to 48 versus 25 to 34). In both the groups of countries ruminants produce most of the proteins, due to the high contribution of milk proteins. They represent 49% and 43% of the animal protein production in developed and developing countries respectively.

Suggestions from the trends

First. The trends clearly show that the process of progressive intensification of livestock production, that occurred after the II World War and that involved a research policy directed to the biological efficiency to maximise the outcomes, widely involved not only developed countries but also the so called developing countries.

Second. Both developed and developing countries prefer swine and poultry husbandry with extremely productive systems, to satisfy their meat needs.

Third. The production surplus of cattle milk in developed countries did not stop the search for maximising the unit return.

Fourth. The cattle number as a whole is decreasing in developed countries. Its expansion in developing countries presents a reducing rate since a few years and it seems to reach progressively a plateau.

Fifth. In some very indicative countries among the developed ones, the husbandry of animals whose products present dietetic properties believed dangerous for the human nutrition, as eggs, is steady if not shrinking.

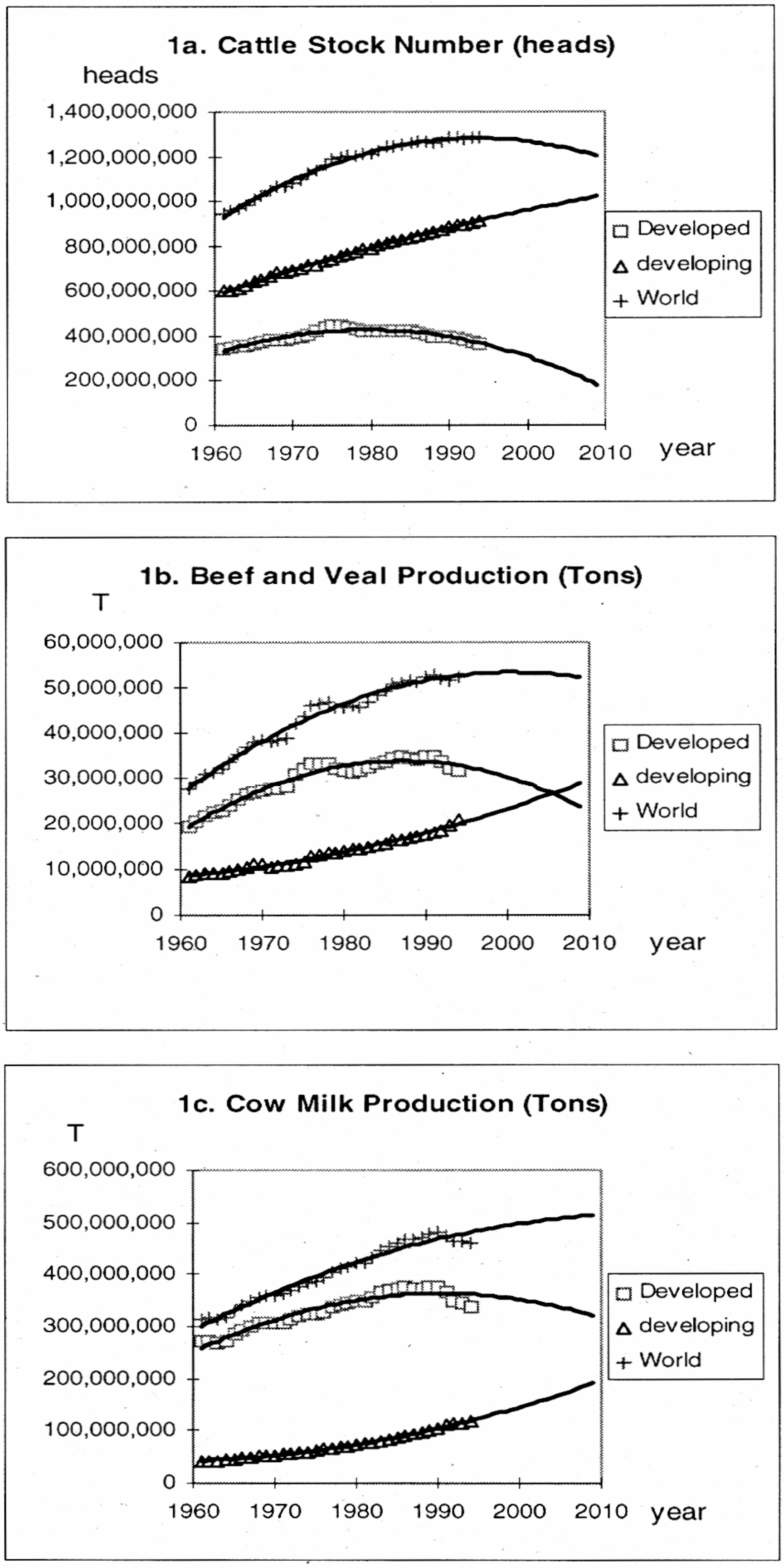


Figure 1: Cattle: trends and projections (Quadratic smooth)

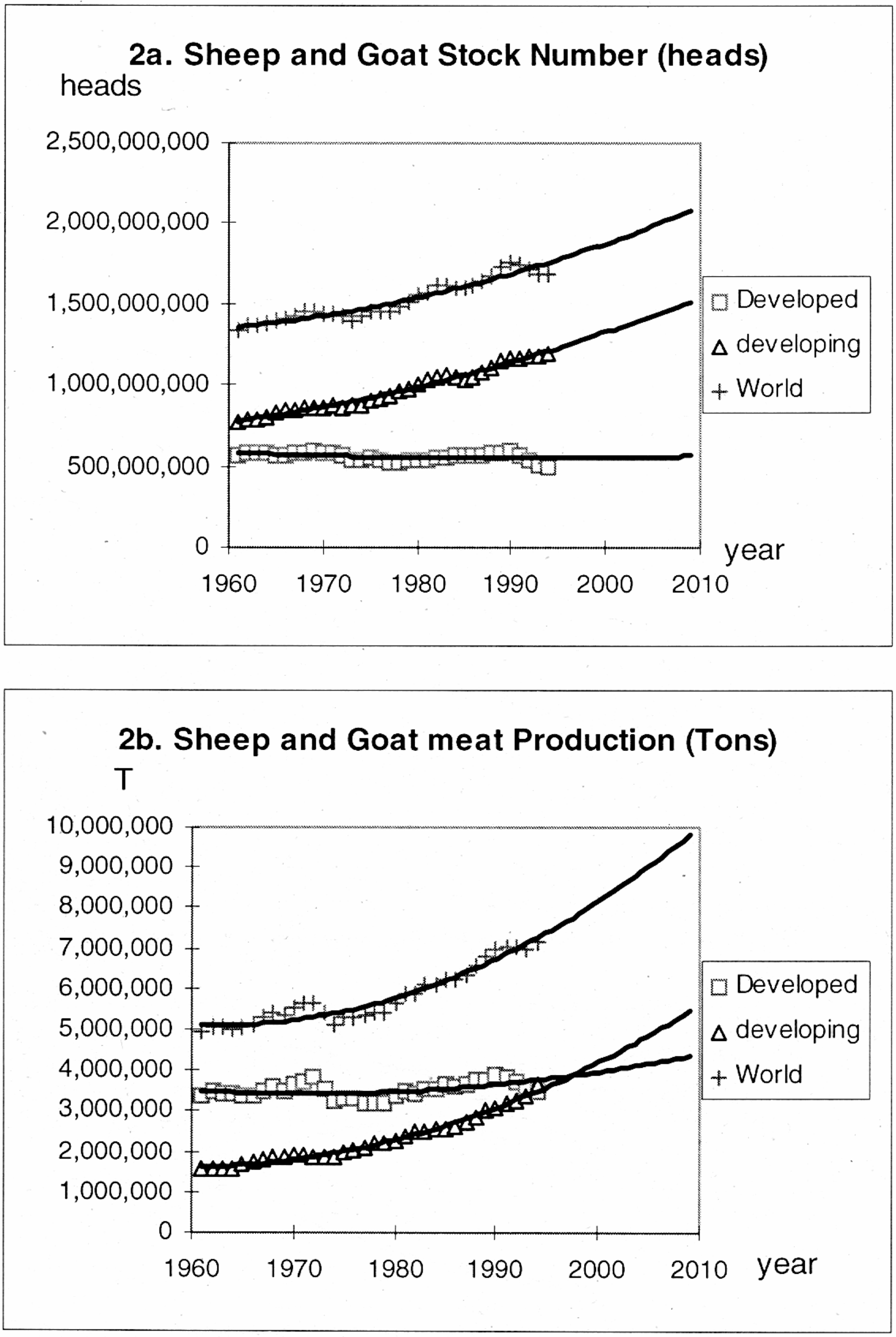
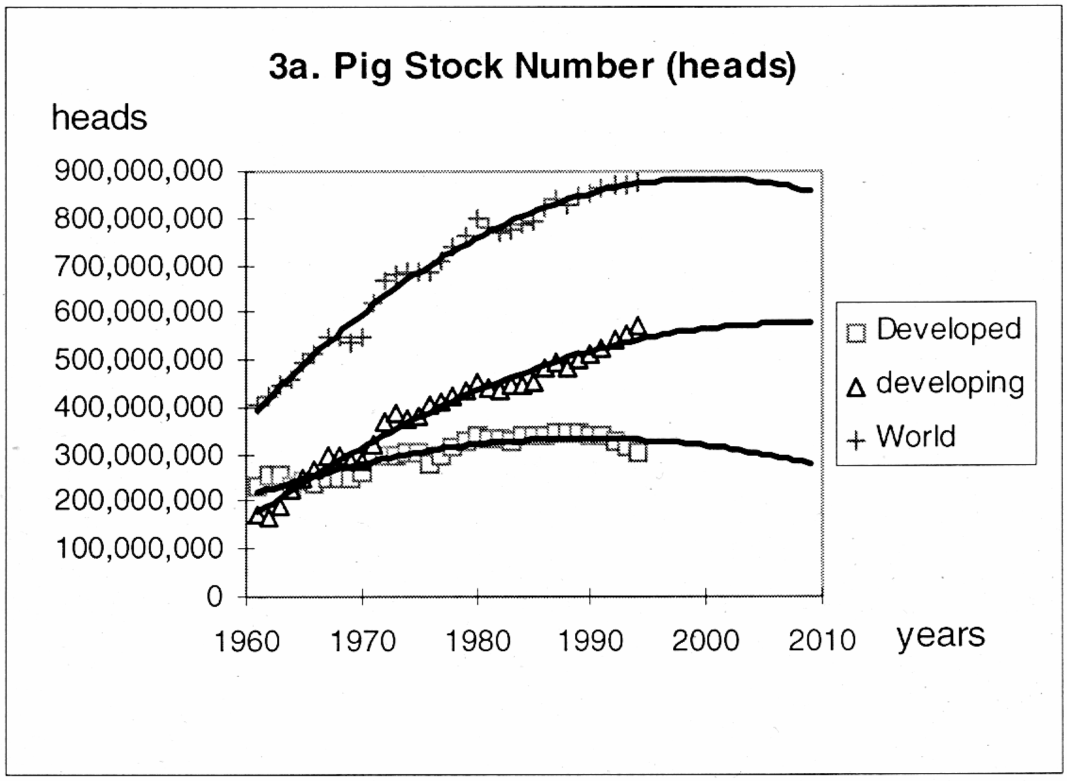


Figure 2: Sheep and goat: trends and projections (Quadratic smooth)



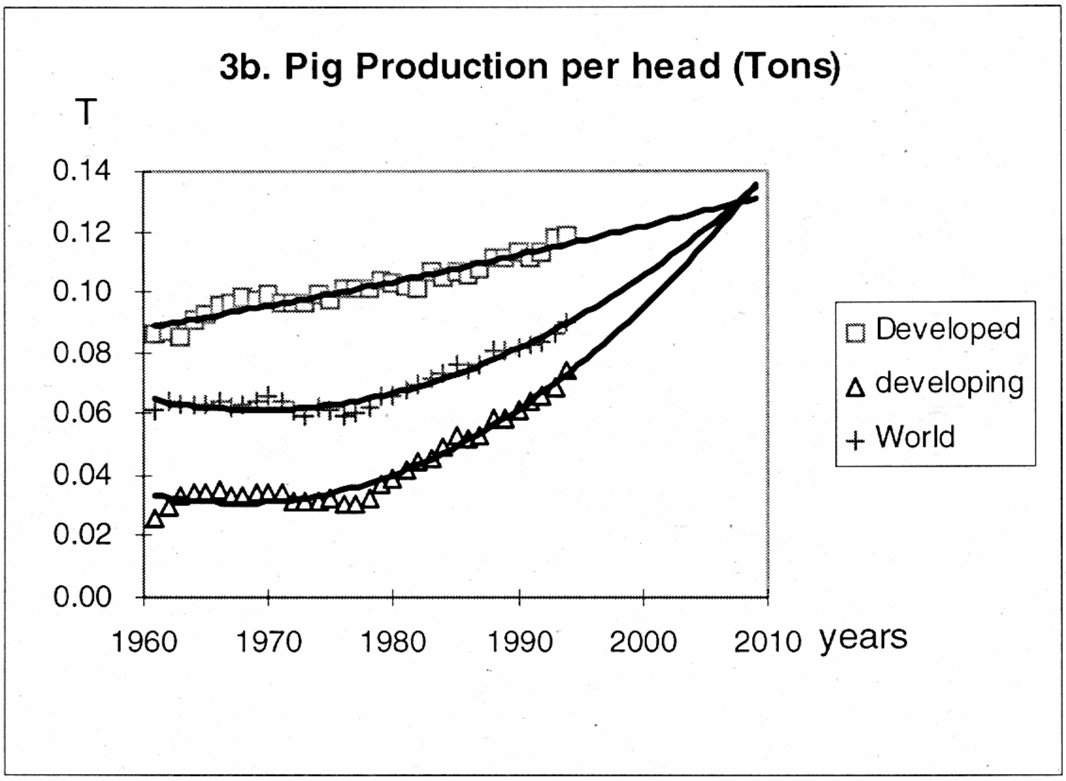
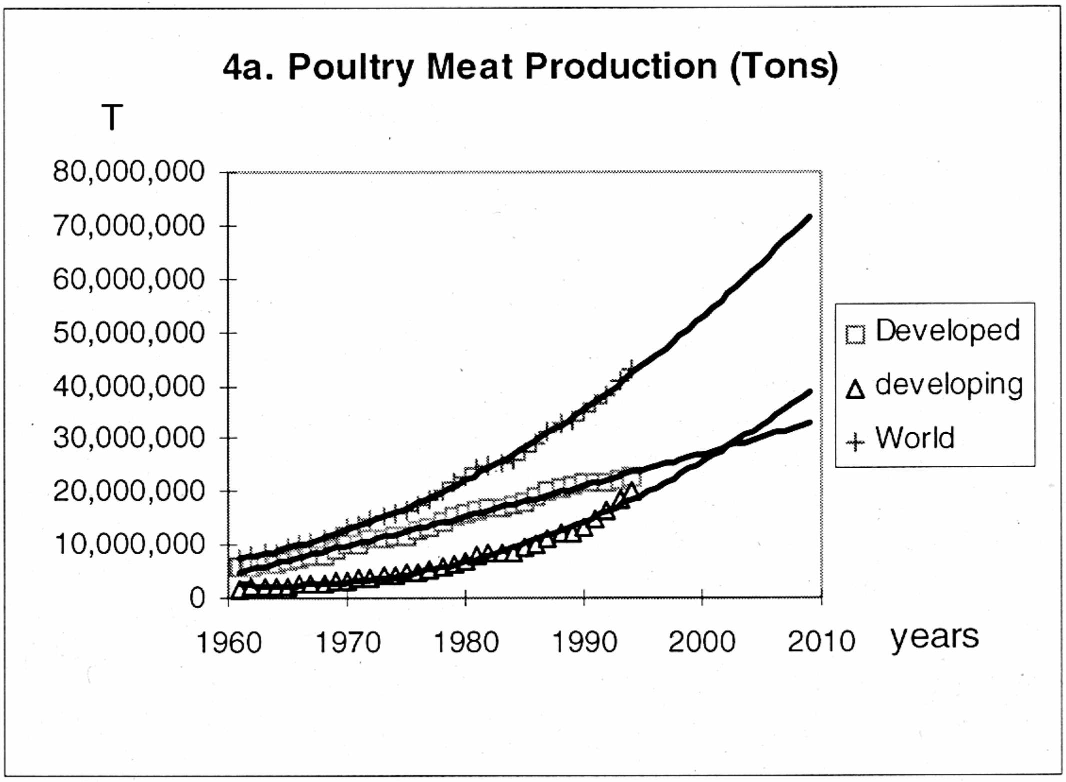


Figure 3: Pigs: trends and projections (Quadratic smooth)



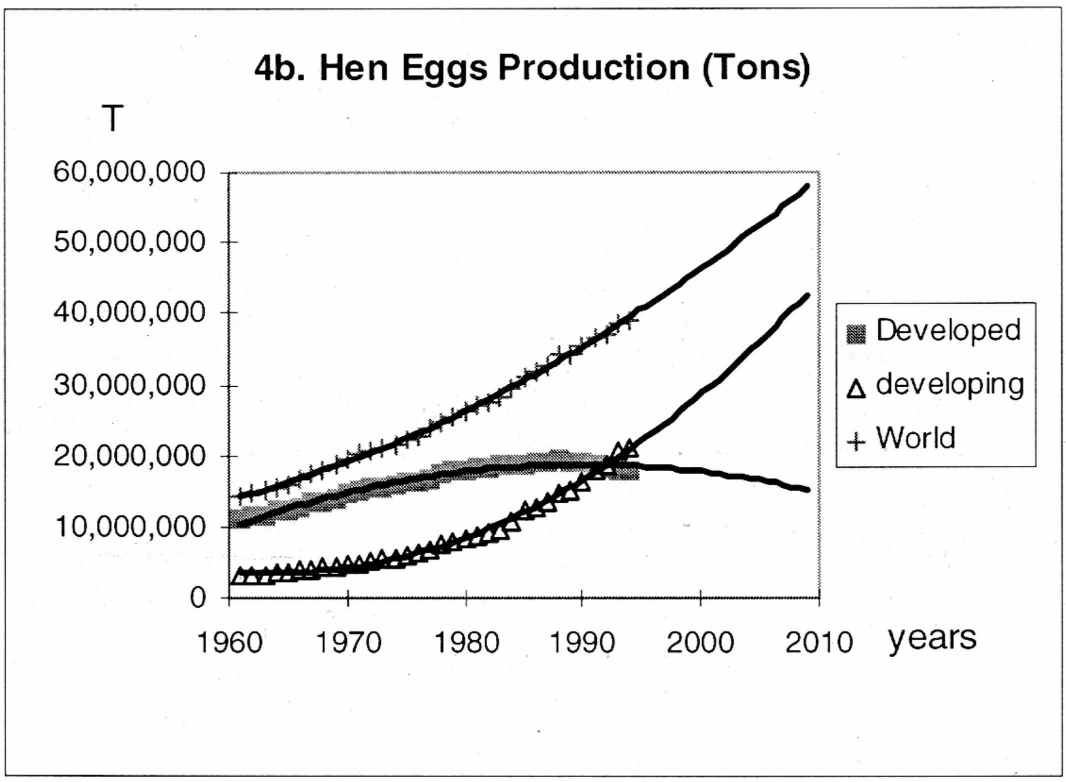


Figure 4: Poultry: trends and projections (Quadratic smooth)

Are these indications useful to forecast the future of LFS?

Swine and poultry numbers and also swine, poultry and dairy cattle productivity are strongly increasing on the one hand. On the other hand, a consistent increase in human population in the next decades is foreseeable in developing countries (Alexandratos, 1995), with a corresponding enhanced need for animal protein (Matassino et al., 1991). For both these reasons, we believe that, in the next future, more and more productive intensive systems will continue to develop world-wide for the three species mentioned, if new factors will not come out. This will be facilitated from the fact that when the specialisation of a production system becomes so advanced as to reach a standard in the employment of the different components, then it can be implanted almost everywhere provided that the standards are complied.

Issues and problems to solve

Assuming such a likely evolution, some main questions arise at level of husbandry, research and also society as a whole.

A first issue regards the consequences of intensification of the productive systems. The intensification, despite the advantage of its high unit returns determines some drawbacks, which are increasingly denounced, especially in developed countries:

A) pollution risks of soil, water, air, due to the concentration of great amounts of waste.

B) negative effects on the quality of products due to the husbandry techniques, nutrition, animal genetic types, residues of pharmaceutical treatments (including some molecules from recombinant organisms).

C) risks for the animal health and welfare; due to the concentration, keeping techniques, feeding, treatments and high production stresses.

D) reduction of the animal genetic variability due to the necessity to utilise very productive and uniform animals, which belong to a few highly selected breeds.

E) cumbersome productive surplus in developed countries due to market policies.

F) world-wide increase in animal consumption of cereals.

A second issue is the attitude to have towards the "traditional" and "extensive" livestock systems, as we qualified them. Should these systems be spread as widely as possible because they are able to solve the problems arising from the intensive systems?

In developed countries, a limitation of the intensive systems and a greater spread of the extensive ones are increasingly evoked, due to ecologist and economic motivations of various kind. In these countries, where the intensification process has been particularly strong, the drawbacks we mentioned upper led to big changes both in society attitudes and in agricultural policies. This evolution is to a large extent responsible for the growing feeling that for facing the current problems "intensive" equal "bad" and "traditional or extensive" equal "good". But do really and everywhere these last types of system have the characteristics suited for the so called "sustainable agriculture", towards which a vast support opinion is building up? There is not an immediate and universal response to such a question. In developed countries, where the extensification process is nevertheless limited by the actual economic-productive system, differential extensification can lead to other environmental or societal detrimental effects, as the current evolution in some disadvantaged areas illustrates it. It can lead to environmental problems regarding landscape quality and pasture resource preservation, or again to societal ones, as the animal welfare problems linked to some very limited level of care to the animals. In developing countries, where the feeling is also supported by the failures of previous unsuited attempts of technology transfer from developed countries, even if more attention has obviously to be paid to the traditional systems and to their potential, the improvement of these last systems will not be sufficient to face the fast growing human needs.

Since there is an undoubting different capacity to provide large amounts of animal protein between the two forms of systems, the importance to balance them will depend also on the alimentary needs of humankind and on the human nutrition advances. That leads to a third issue regarding human nutrition. Will the developed countries continue to eat an amount of animal proteins 2-3 times over the average recommended requirement and will this attitude be shared also by the developing countries once they will improve their economy? What weight should be given to the consumer behaviour in some developed countries, particularly in USA, who tends to reduce for dietary reasons the consumption of some products (eggs, butter, pork) or to reject animal products for ethical reasons, concerning for instance animal welfare? Which modifications will happen in the ethnic-demographic structure of human populations, and how much they will influence the needs and alimentary habits? Which consequences will have the future changes in dietetics recommendations linked to the medical research advances?

Interactive researches and actions

Animal research can have a paramount role to solve the large problems we face now, provided of course that the ruling powers: politics and economy, will allow it. Some of the objectives and methods of research have been revised and widened, mainly in the last years, and sound researches dealing with some of the principal mentioned problems have been carried out. There is a growing awareness that the error to be avoided now is that these researches develop each independently from the others, searching for the solution of each problem as if it was the only one, since the animal science issues interact with a multiplicity of disciplines.

Research privileged for a long time progress in basic biological and technical knowledge about animal production processes, in order to maximise animal yield. We are now entering a time where the knowledge gained, and the changes in socio-economic objectives bearing on production bring not only a reorientation for research priorities but also in methods of research approach in animal production (Milligan et al., 1995). Growing efforts are currently put into theoretical and simulation modelling in order to provide integrated models of biological systems, for example on the regulation of nutritional function (Danfaer, 1990; Sauvant, 1992), or again on the plant-animal interaction and intake at grazing (Demment & Greenwood, 1988; Hyer et al, 1991. The basic knowledge necessary to rear the single animal and to manage the herd and the livestock farm is more and more evolving towards the prediction of the consequences of management alternatives. Under this scope, animal science interacts with many basic disciplines: Biology, Chemistry, Mathematics, Physics, Genetics, Anatomy, Physiology, and with others, of more technical type, mainly the Agronomical and Engineering Sciences.

Parallel, an increasing number of animal scientists realise that the production systems they were trying to improve are part of a larger system interesting global environment and society (Van der Zijpp, 1993). Sustainability of development becomes one of their main key-words. Research in developing countries and unfavoured areas, but also growing pressures on intensive systems in developed countries like France (Beranger & Vissac, 1994) or Denmark (Sorensen & Thysen 1992), pushed an increasing number of animal scientists to look for a more integrated approach to livestock farming systems. The general aim is to help the farmers and the others actors of animal industries to make decisions under increasingly constrained environments where a growing number of objectives is pursued (Gibon & Matheron, 1992; Gibon & Flamant, 1994; Dent et al., 1996). Such approaches focus on the overall livestock farm management, on the production chains from producer to consumer (Gerhardy, 1996), or again on land use aspects of livestock farming (Havet et al., 1994; Sibbald & Hutchings, 1994). Systemic modelling of the livestock farm, considered as a dual entity, associating both a human activity system and a livestock production process, is at the heart of the approaches (Gibon et al., 1996). Most of the works are developed in strong co-operation with scientists in other disciplines like Ecology, Agronomy, Sociology and Economics, etc., and a part of them are run within rural or agricultural system research frameworks (Brossier et al., 1990; 1995).

This second level of concerns in animal science takes into account the socio-economical aspects of production and insert the LFS in the productive context of the whole social reality. Under that scope, further knowledge belonging to Social and Economical Sciences, Human Nutrition, Communication, Transportation, Environment, Energy are required. Therefore, theoretically speaking, animal science field nowadays extends to two main levels of knowledge. Both call for a systemic approach and a close co-operation with others disciplines for meeting the current challenges in LFS.

* For pollution, the animal scientist in collaboration with the microbiologist contributes already to reduce the residues by acting on the livestock feeding, by engineering the rumen micro-flora or by using micro-organisms to treat the forages (Tamminga, 1992). He endeavours to do even better with the help of both animal and vegetal geneticists (Oldham & Tamminga, 1995). The knowledge of the agronomist, the chemist, the physicist, the engineer, is as well necessary to take the problem under control with the help of the ecologist, as for example in animal waste management (Hall, 1994). There is also a need for further studies on the effects of the residues of growth factors or antibiotics, which are still largely unknown, in order to assess their real implications on the soil biology and eventually on the human health (Navarotto, 1995).

* Regarding the quality of the products, animal scientists already deepen their co-operation with economists for assessing the production chains in a wide scope from the producer to the consumer (Gherardy, 1996), and they emphasise increasingly both the biological and social aspects of the animal products quality (Kemp, 1994; Edwards & Casabianca, 1996). But we want to stress the general weakness of the existent relationship between animal science and human nutrition science. Points of joined evaluation could be the food composition versus the risk factors for the human health and the residues arising from pharmacological treatments of various kind.

* The genetic diversity of reared animals is a growing concern for the animal scientist. Within the general issue of biodiversity preservation, he envisages the safeguard of the so called local breeds (Hammond & Leitch, 1996) and considers relevant to focus jointly on the regarding

farming systems. These breeds are frequently associated to traditional systems, which present very particular characteristics regarding various factors: natural environmental conditions, pathogen agents, available feeding resources, production characteristics (products of particular quality), land preservation, farmers management know-how, maintenance of cultural traditions etc. Many other aspects are taken under consideration in the current works about livestock breed biodiversity preservation (Maijala, 1986). Studies concentrate on the risk that can arise from the increase in homozigosity in highly selected breeds, frequently associated with the outcome of negative traits, and also from the disappearance of genes coding for particular traits not yet discovered, which could be useful in the future (Hall & Bradley, 1995).

* For Biotechnology, some areas of research should deal with the impact that the application of new fast growing biotechnologies will have on LFS and their actual problems. For example the new biotechnologies of reproduction (ovum pick up, IVF, ET, clonation, sex pre-determination) bear characteristics potentially able to radically transform the livestock systems and their productivity (Courot & Volland-Nail, 1991).

The sex predetermination, although not yet completely achieved, when completed, could give such a justification to the other biotechnologies of reproduction to let them expand tremendously in husbandry. This biotechnology can transform a dairy farm into a farm which also produces beef veal intensively (Nardone, 1992); and can also allow a beef cow herd to produce only embryos. New economical models should be set, a new background will be necessary to deal with.Even more innovative will be the knowledge acquired with the possibility to enlighten the functions of single genes and of transgenesis. All this can not only completely modify the methods of genetic improvement, but also overthrow the methods of control of animal diseases, the transformation industry of the products (from classical alimentary ones to organs for human transplantation) fulfilling multiple needs for human health.

The transgenesis bio techniques will require from the animal scientist a dialogue opened to all the human society, which, with just right, takes care of bio ethic problems. There are issues of concrete nature like those of safeguard of the life in the earth, first of all the human life, but also of ethical nature. How should the whole genetic resources (alleles) existing in the earth be considered? Can man, as he did with other natural resources, value them for his real, or presumed, needs? In this case the animal scientist is not alone, nor he could be. Besides the biologist, the physician, the naturalist, he will have to interact with the specialist of ethics (Mepham, 1994).

Final consideration on behalf of an integrated assessment of LFS

In the last decade, an important change occurred in the animal science, questioning its classical assumptions on the way to contribute to enhance the efficiency of animal production. Such a change has been induced by four main phenomena, i.e. the accumulative side affects of the previously dominant livestock intensive model, the general change of society attitudes towards scientific progress in biology, the issues related to livestock farming development in developing countries and the agricultural policies for limiting production volumes in developed countries.

In the previous section, we discussed some of the new major research issues animal scientists try to face. We would like here to come to the question of an overall evaluation of livestock farming systems and of the general attitude animal scientist can have in the future for helping their adaptation. Since the classical assumptions of animal science regarding the promotion of intensive systems are questioned, there is a need for undergoing a deep re-examination of the traditional and extensive systems, mainly based on ruminants. Another reason for it could be found into their current contribution to the world-wide supply of animal protein. Though the trends of the 30 last years suggest there is a decrease in their relative contribution over the period, they still actually provide 44% of the overall current production of animal protein according to the rough estimates we could derive from the FAO Figures (Table 2). Ruminants contribute three quarters of this total, and monogastrics the last quarter. For developing countries, their overall contribution is still of the most importance, with 70% of the total supply.

Emphasis should be put into getting better bases for assessing their respective interests compared with intensive systems, since, as previously said, there will be a need in the future to better balance these different types both in developed and developing countries. It is worthwhile to remind that most of these systems take mainly advantage of land resource that would be lost without them and that their replacement by intensive systems would require an increase in world cereal production. There is first a need to put effort into evaluating their respective cost/benefit ratio and into providing guides to politicians in order to avoid unbalanced and uncontrolled development induced by unsuited economical pressures on livestock farmers. In the production cost for intensive systems shouldn't be fair to consider also the expenditure of the (public) research which develops the techniques employed in these systems? and to add as well the costs of the direct and indirect pollution or those of the modification of the soil fertility? The cost of the maintenance of genetic diversity, being a consequence also of the diffusion of intensive systems, shouldn't be accounted to them?

Considering the extensive systems, shouldn't they be given a value for the control of the environment, for the preservation of the territory, as well as for the conservation of cultural traditions? What kind of new research, and with which methods, should be carried out for obtaining a relevant evaluation? The second question is to think about the possibilities of enhancing knowledge transfer efficiency. There is a lot of knowledge already transferred in some zones and in others not. Such an objective leads to try to evaluate which knowledge is suitable for transfer according to the systems, trying to avoid to repeat some of the past errors. An effort considerably greater than in the past should be put in the time spanning from the discoveries to the applications. The acceleration existing today in the human activities requires more timeliness than what happened for example with milk recording, AI and ET. Particularly, the research should evaluate what knowledge already acquired can be transferred with advantage in the types of traditional-extensive systems more represented world-wide.

Conclusion

1) The objective to maximise the economical return of the three basic factors of the agronomical system: land, capital and labour, pushed up, in a large amount, towards a specialisation and intensification of livestock farming and to the employment of animals with high yield. Some husbandry systems do not have any more a direct relationship with the land factor.

2) These intensive systems continue to spread, and appear as the main immediate answer to cover humankind increasing needs in animal proteins.

3) In these systems the following is often managed in an unbalanced way: the animal in relation to its biological and physiological needs, the livestock farm in relation to the external environment.

4) The animal, as an open biological system, should be put at the centre of LFS and LFS should be managed in equilibrium with the ecosystem.

5) It is necessary to analyse the capacity of each LFS to satisfy the following points, in different environmental and social realities:

- to supply sufficient protein, and/or other products, for the population worldwide;
- to preserve the land resource and the environment;
- to produce with a good quality standard;
- to be careful about animal welfare;
- to preserve animal genetic diversity;
- to produce with low costs;
-.to improve the socio-economical condition of the livestock farmers

Then, it will be necessary to individualise:

- the impact of new knowledge (i.e. biotechnology) in LFS;
- which kind of actions are to improve or eventually to correct the current systems.

6) There is a large quantity of knowledge waiting to be transferred in the field world-wide.

7) The LFS are part of a larger system, where they interact with many other systems, and it is necessary to integrate the advances in different disciplines to better satisfy the several society requirements.

8) A renewal in Animal science concerns is under progress. Within this widening range of issues, the relationships are evolving towards an increasing interaction between science discoveries and management issues regarding LFS and related systems. The use of systemic methodologies, and the co-operation with an enlarged range of disciplines appear as the best way to secure improved results.

Acknowledgments

The authors wish to thank Prof. B. Ronchi and Prof. A. Valentini for their collaboration, and also Prof. J.C. Flamant, Prof. M. Roux and Prof. J.L. Tisserand for their comments which helped them to improve the paper.

References

Alexandratos, N. (ed.) (1995): Agriculture mondiale: Horizon 2010, tude de la FAO. Polytechnica Paris et FAO Rome.

Béranger, C., Vissac, B. (1994): An holistic approach to livestock farming systems: theoretical and methodological aspects. In: Gibon, A., Flamant, J.C. (eds.) 1994 (ibid). 5-17

Boutonnet, J.P., Martinand, P. (1979): Intensification de la production et march, mondial de la viande ovine. Contradictions propres … la France. Et. & Rech. Economie et Sociologie Rurales, INRA Montpellier, Ed., Nø47.

Boyazoglu, J., Flamant, J.C. (1990): Mediterranean systems of animal production. In: Galaty, J.G and Johnson, D.L. (eds.): The world of pastoralism. The Guildford Press, New York.

Boyazoglu, J., Flamant, J.C. (1991): The actual state and the future of animal production in the Mediterranean rangelands. In: Proc. IVth Int. Rangelands Congress. Montpellier, France, Avr. 1991. CIRAD Publ., Montpellier, Vol. 3: 1017-1025.

Brossier, J., de Bonneval, L., Landais, E. (eds.) (1994): Systems studies in agriculture and rural development. A selection of papers published by researchers in the Agrarian Systems and Development Department of INRA (1990-1994). INRA Publ., Versailles, 415 p.

Brossier, J., Vissac, B., Le Moigne, J.L. (eds.) (1990): Modélisation syst,mique et système agraire. INRA Publications, Versailles, 1990, 365 p.

Coop, I.E. (ed.) (1982): World animal science. Production system approach: Sheep and goat production. Elsevier, Amsterdam, 492 p.

Coop, I E., Devendra, C. (1982): Systems, biological and economical efficiencies. In: Coop, I.E. (ed.) (Ibid)

Courot, M., Volland-Nail P. (1991): Management of reproduction in farm animals: present and future. In: Rossier, E. (comp.): On the eve of the third millenium, the European challenge for animal production. EAAP Publ. Nø 48, Pudoc, Wageningen, 23-37.

Danfaer, A. (1990): A dynamic model of nutrient digestion and metabolism in lactating dairy cows. Beretning fra Satens Husdyrburgsforsig, 511 p. Copenhagen, 511 p.

Demment, M W., Greenwood, G.B. (1988): Forage ingestion: effect of sward characteristics and body size. J. Anim. Sci., 66: 2380-2392.

Dent, J.B., McGregor, M. and Sibbald, A.R. (eds.) (1996): Livestock Farming Systems: Research, Development, Socio-economics & the Land Manager. Proc. 3rd Int. Symp. On Livestock Farming Systems, MLURI, Aberdeen, 2-3 September 1994. Wageningen Pers., EAAP Publication Nø79. (Under press).

Edwards, S.A., Casabianca, F. (1996): Perception and reality of product quality from outdoor pig systems in Northern and Southern Europe. Invited paper at the 4th International Symposium on Livestock Farming Systems, Foulum, Denmark, 22-23 August 1996. 12 p.

Ellis, J.E., Jennings, C.H., Swift, D.M. (1979): A comparison of energy flows among the grazing animals of different societies. Human Ecology, 7(2) 135-149.

FAO (1980): Yearbook Production.

FAO (1994): Yearbook Production.

FAO (1995): The state of food and agriculture.

Flamant, J.C. (1989): Systèmes d',levage et utilisation de l'espace dans le bassin méditerran. In: Proc. of the Symposium on "The constraints and possibilities of ruminant production in the dry subtropics". Cairo, Egypt, 5-7 Nov. 1988. PUDOC, Wageningen, 27-38.

Flamant, J.C. (1991a): Problems associated with the transfer of genetic material from temperate to warm Mediterranean regions: Consequences on the equilibrium of the animal production systems. In: Ronchi, B., Nardone, A. and Boyazoglu (eds.): Animal husbandry in warm climates, PUDOC, Wageningen publ. EAAP Publ. Nø 55, 48-54.

Flamant, J.C. (1991b): Considering the social aspects of sheep breeding programmes. In: Maijala, K. (ed.): Genetic resource of pig, sheep and goat. World Animal Science (B8), Elsevier, Amsterdam, 379-390.

Gherardy, H. (1996): Integration of livestock farming system into a beef marketing system. In. Dent, B. and McGregor, M. (eds.) 1996 (ibid).

Gibon, A., Flamant, J.C. (eds) (1994): The study of livestock farming systems in the scope of Research/Development. Proc. 2nd Int. Symposium on Livestock Farming Systems, CIHEAM-JAMZ, Saragosa, 11-12 July 1992. Wageningen Pers., EAAP Publication Nø 63, 449 pages.

Gibon, A., Matheron, G. (eds.) (1992): Global appraisal of livestock farming systems and study of their organisational levels: Concepts, methodology and results. Proc. 1rst Int Symposium on Livestock Farming Systems, INRA, Toulouse, 7 July 1990. Office for Official Publications of the European Communities, Pub. EUR 14479, 510 p.

Gibon, A., Rubino R., Sibbald A.R., Sorensen J.T., Flamant J.C., Lhoste, P., Revilla R. (1996): A review of current approaches to livestock farming systems in Europe: towards a common understanding. In: Dent, J.B., McGregor, M. and Sibbald, A.R. (eds.) 1996 (ibid).

Hall, J.E. (ed.) (1994): Animal waste management. FAO regional Office for Europe, Reur Technical series 34, 391 p.

Hall, S.J.G., Bradley, D.G. (1995): Conserving livestock breed biodiversity. TREE, 7: 267-270.

Hammond, K., Leitch, H. (1996): The FAO Global Programme for the Management of Farm Animal Genetic Resources. American Journal of Animal Science (in press).

Havet A., Hubert B., Gibon A., Roux M. (1994): Méthodologie d'étude des relations élevage-environnement. Quatre exemples de recherches pour l'action en France. In: Gibon, A., Flamant, J.C. (eds.) 1994 (ibid). 101-105.

Hyer, J.C., Oltjen, J.W., Galyean, M.L. (1991): Development of a model to predict forage intake by grazing cattle. J. Anim. Sci., 69: 823-835.

Jamison, W.V. (1993): Social concerns and responses in animal agriculture. In: Garnsworthy, P.C. and Cole, D.J.A. (eds.) Recent advances in animal nutrition. Nottingham University Press, 76-96.

Jasiorowski, H. (1991): European animal husbandry: a model to adopt or reject by developing countries. In: Rossier, E (comp.) On the eve of the third millenium, the European challenge for animal production. EAAP Publ. Nø 48, Pudoc, Wageningen, 127-141.

Kemp, R.A. (1994): Genetics of meat quality in cattle. In: Proc. 5th Congress of Genetics applied to livestock production. Guelph, Ontario, August 1994. Smith C. Et al. Ed., Vol. 19: 439-445.

Maijala; K. (1987): Possible role of animal gene resource in production, natural environment, conservation, human pleasure and recreation. In: "Animal Genetic Resources". Proc. of the 2nd meeting of the FAO/UNEP expert panel, Varsaw, Poland, June 1986. FAO, Rome, Italy, 205-215.

Matassino, D., Zucchi, G., di Berardino, D. (1991): Management of consumption demand, supply and exchange. In: Rossier, E (comp.) On the eve of the third millennium, the European challenge for animal production. EAAP Publ. Nø 48, Pudoc, Wageningen, 105-127.

Mepham, T.B. (1994): Approaches to the ethical evaluation of animal biotechnologies. Anim. Prod., 57: 353-361.

Milligan; L.P., Journet; M., Maeng; W.J. (1995): Future areas of research and expected advances in the nutrition of herbivores. In: Journet, M. et al. (eds.): Recent developments in the nutrition of herbivores. Proc. of the Ivth Intern. Symp. on the Nutrition of Herbivores. INRA Editions, Paris, 587-610.

Nardone, A. (1992): La zootecnia italiana di fronte alle sfide del prossimo futuro.Atti Convegno "Quale foraggicoltura per la zootecnia di domani". Piacenza.

Nardone, A. (1996): Production systems analysis of cattle breeding in the Mediterranean area. EAAP Publication n. 86, 5-26.

Navarotto, P. (1995): Rapporto tra territorio e allevamenti; trattamento e utilizzo agronomico delle deiezioni. Quaderno Assalzoo n. 63/95, 7-21.

Oldham, J.D., Tamminga, S. (1995): Changes in the nutrition and management of herbivores in the temperate zone: economic and social influences. In: Journet, M. et al (eds.): Recent developments in the nutrition of herbivores. Proc. of the IVth Intern. Symp. on the Nutrition of Herbivores. INRA Editions, Paris, 41-65.

Rey, B., Fithzug, H.K. (1994): Systems approach to livestock development oriented research: the ILCA's experience. In: Gibon, A., Flamant, J.C. (eds) 1994 (ibid): 120-129.

Sauvant, D. (1992): Systemic modelling in nutrition. Reprod., Nutr., Develop. 32: 217-230.

Sibbald, A.R., Hutchings, N.J. (1994): The integration of environmental requirements into livestock systems based on grazed pastures in the european community. In: Gibon, A., Flamant, J.C. (eds.) 1994 (ibid). 86-100.

Sorensen, J.T., Kristensen, S.E. (1992): Systemic modelling: a research methodology in livestock farming. In Gibon A., Matheron G. (eds.) 1992 (ibid): 45-57.

Tamminga, S. (1992): Feeding management for dairy cows as a mean to contribute to environmental pollution control. J. Dairy Science, 75: 345-357.

van der Zijpp, A. (1993): Science and sustainability in animal production systems in the developed world. Proc. World Conference on Animal production, Edmonton, Canada. 33-39.

Vissac, B. (1992): Livestock farming Systems Research, Development, Action: from the developed to the developing countries. EAAP 43rd Annual Meeting, Madrid Sept. 1992. 15 p. + ann.

Annexes

Table 1: Some of the main scientific progresses in Animal Science during the 18th century and the beginning of the 19th Century. (Dates mentioned refer to their publication)

Backewell (1750)
First principles for genetic improvement, from study of cattle breeds
Collins brothers (1750)
First use of inbreeding for selection purposes
1750-1800
Lavoisier (1770)
Assessment of the respiratory process in animals
Spallanzani (1875)
First experiments on artificial insemination
Weatherby (1791)
Establishment of the first official stud book (Thouroughbred)
Thaer (1809)
First evaluation of content of digestible substances in forages; principle of "ÿhay equivalentsÿ" for the estimation of nutritive value; principles of separation between maintenance and production requirements.
1822
Establishment of the first Herd book for cattle (Shorthorn)
Liebig (1840)
First Application of principles of organic chemistry to animal physiology
Regnault & Reiset (1849)
First measurement of gas exchanges in animals
1800-1900
Voit (1857)
Methodology for assessing N-balance in animals
Mendel (1860)
Discovery of laws of heredity and bases of quantitative genetics
Henneberg & Stohmann (1864)
Dissemination of Weende methods for the analysis of animal foods
Wolff (1876)
Principles of ruminant feeding from forages
Heape (1890)
First embryo transfer in rabbit

Table 1 continued …

Armsby (1898)	First calorimeter device for the study of animal energetic metabolism; determination of metabolizable and net energy of foods.
Lindstrom, Babcock & Gerber (1900-1905)	First methods for rapid determination of milk fat contents
Kellner (1905)	First studies on nitrogen catabolism; principles for estimation of the nutritive value in starch equivalents (bases of the modern technique of animal feeding)
1990-1914	
de Vries (1900)	Rediscovery of heredity laws in Plants
Hopkins (1906)	Identification of the role of the tryptophane
Morgan (1910)	Rediscovery of heredity laws in Animals (drosophiles)
Funk (1912)	First proposal of the vitamin concept

Table 2: Animal protein production: percentage distribution between ruminants (cattle, buffalo, sheep, goats) and monogastrics (pigs, poultry) in developed and developing countries.

	Intensive Systems	Extensive Systems	Total
Developed countries	43	13	56
Ruminants	25	12	37
Monogastrics	18	1	19
Developing countries	13	31	44
Ruminants	2	21	23
Monogastrics	11	10	21
World	56	44	100

(Reformulated from FAO data, 1994,1995)

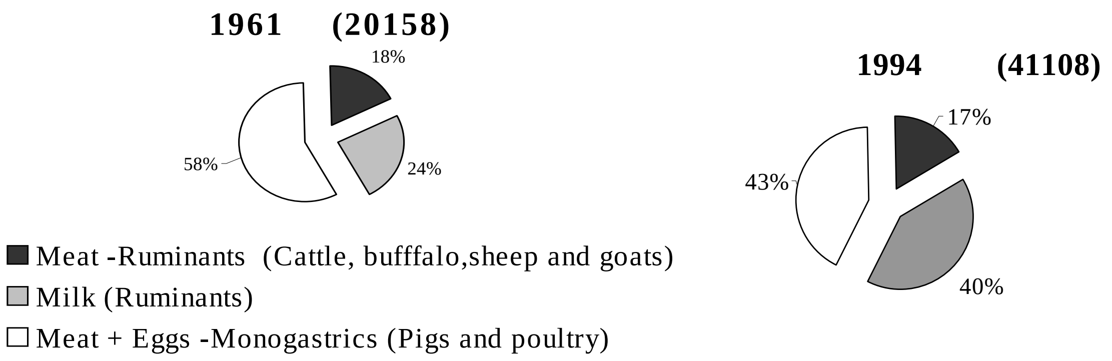


Figure 5: Animal protein production in the world (T 000) (reformulated from FAO data, 1995)

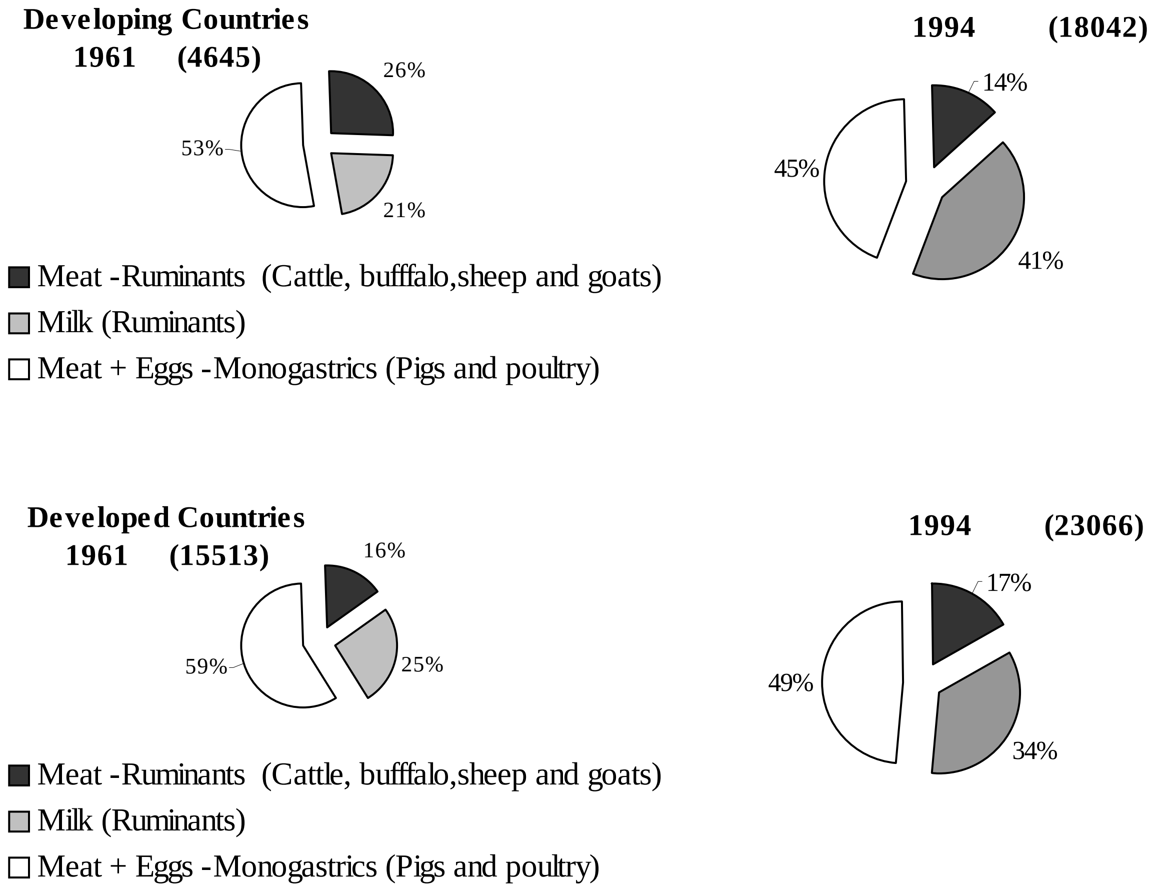


Figure 6: Animal protein production in developing and developed countries (T 000) reformulated from FAO data, data)