TRAINING GRADUATE STUDENTS FOR THE CHANGING FUTURE OF ANIMAL BREEDING

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INTRODUCTION
The purpose of animal breeding is to change the genetic merit of animals so they produce more efficiently under future economic and social circumstances. To meet such objective, the society needs skilled practitioners to both determine optimal directions of genetic changes and to design and implement sound breeding programs. But, society has changed over the last years and production goals have broadened to include issues on animal welfare, environment, and food safety. Advances in science have allowed for greater sophistication in the tools available to animal breeders and geneticists. Therefore, new approaches are needed to teach the entirety of so many different production systems. The challenge is to identify areas in modern animal breeding valuable for the future and to find teaching methods adequate to today’s student, following the evolutionary Red Queen principle that it takes ‘all the running you can do, to keep in the same place’ (Lewis Carrol, 1871).

To fulfill the objectives of teaching, it is important to emphasize not only the scientific content but also the teaching methods. Training in problem solving, communication skills, and ability to work in groups and independently, are essential. The face of education is changing rapidly as a direct result of innovative computer technology and most teachers have readily available a wide variety of technological resources they can use to make their lectures more beneficial to the students (e.g., quality visuals, multimedia, software). In each of the subsequent sections, we will emphasize the use of innovation in education to teach animal breeding.

MODERN ANIMAL BREEDING
During the evolution of animal production systems, breeding goals were successively for subsistence and immediate needs of the family (pioneering), for production, for productivity or efficiency of production, and, nowadays, for persistency and sustainability of the production. Indeed, it was necessary for the whole context of animal production to adapt itself to globalisation, reduction in production subsidies, decreasing commodity prices, and increased emphasis on health, food safety, animal welfare and environment. Many of the potential animal breeding strategies proposed to approach problems for future production systems refer to a broader definition of breeding goals balancing animal higher productivity with improved functional traits such as health, fertility, and environment friendly feed intake capacity. For example, in dairy cows, the need is to improve fertility, disease resistance, fitness and longevity of cows, to reduce metabolic stress and increase the quality, safety and health qualities of milk. In pigs, eating quality, suitability for special production (e.g., lipid light poultry and pig meat), disease resistance, and food safety are new traits added to the main objective of production efficiency (RASE and BSAS, 2000).
While targeting to durable production, breeding goals must also be adjusted to the local, natural, and social production systems. In well-supplied and affluent regions of the world, priority is no longer solely for volumes of cheaper food but for associations connected with safety, traceability, nutritional value, taste, environment and animal welfare (RASE and BSAS, 2000). It is thus not culturally and socially acceptable simply to transfer such high input systems to developing countries together with the breeding stock, as it was emphasized in a round table on the future of the livestock sector in the light of the recent crises in Europe (EAAP, 2001). Even within the single EU community, future farming will develop under 3 different paths: the conventional path (continued use of present-day farms with breeding objectives to produce high food quality at reasonable cost), the alternative path (moderate productivity, small farms with breeding focus on nice-market products, such as organic and regional foodstuffs, and on animal welfare), and the low cost path (with large farms aiming to produce cheap animal products efficiently), each with different objective. Note however that co-operation between production systems of different countries intensifies, with the well-known example of Interbull in dairy cattle, and this co-operation opens the door to harmonization of goals across countries.

A final note on future animal breeding relates to the increased use of breeding programs in sport animals, exemplified by the Interstallion project for evaluating sport stallions across Europe and in pets, in face of governmental treats and media pressure to insure genetic welfare of pedigree animals (e.g., Breeding value assessment program for hip dysplasia in Germany). Modern animal breeding calls for promoting exchange between students so they understand the global and specific issues. Many student exchange programs exist such as Socrates/Erasmus, ISEP, or the Fullbright, that give students the opportunity to be a part of a host institution and to be immerged into new realities. A more flexible way to exchange ideas is through distance education programs, using interactive technologies (e.g., videoconference, teleconference, CD-ROMs) or internet-based resources. But distance learning has also some drawbacks (e.g., student passivity, hardware limitations and learner isolation) that need to be resolved. A solution may be the procedure used in the Global Seminar (http://www.globalseminar.org/), an online community web site promoting global discussion on environmental and sustainable food systems between students of various educational institutions, with videoconferences and case studies to feed the discussion. Distance learning may also be on the form of list server, as the well-known Animal Breeders Discussion Group (http://ansci.colostate.edu/res/breed/), or through online genetic course with lab exercises and discussion with faculty and other students via email or web-based discussion board (http://www.anisci.cornell.edu/cat/cg01/cg01.html). Distance learning and teaching requires that diploma be recognized across institutions. The European Commission has developed a European Credit Transfer System (ECTS) that provides a way of measuring and comparing learning achievements, and transferring them from one institution to another, creating curricular transparency and facilitating academic recognition (http://europa.eu.int/comm/education/socrates/ects.html). This system necessitates a careful examination of courses taught in each institution. For this purpose, the working group on higher education within the EAAP maintains a web page (http://cemu10.fnv.ulg.ac.be/_Vienne/) with curriculum information on animal science, including animal breeding.
ANIMAL BREEDING SYLLABUS

Available methods to reach breeding objectives have also evolved rapidly. Evidently, students should be aware of the technical advances in these various topics, without forgetting previous progress.

Students should understand molecular genetic technologies and their use in the genetic improvement of livestock. Indeed, markers and major genes provide opportunities for breeders to increase production via marker-assisted or genotype-assisted selection and increase in the probability of fixation of advantageous alleles. Transgenic technology is also promising although it has not received the expected success as it is not yet adapted to farm animals and because of the fear of legal and ethical objections as indicated by the latest Eurobarometer survey.

Students should appreciate the theoretical improvements in the prediction of genetic parameters under the additive infinitesimal assumption such as random regression and test-day models, or from models that exploit information from mitochondria inheritance or marker genes. Models used for analysing GxE interaction in plant breeding, such as additive main effects multiplicative interactions models may also be of interest for future breeders. Students should recognize the various statistical methods available in animal breeding: bayesian and maximum likelihood approaches to inference and techniques to analyse longitudinal or discrete data. There has been also considerable progress in computing algorithms indispensable to solve genetic equations helpful in predicting genetic parameters.

Students should be able to evaluate the impact on breeding programs of novel reproductive techniques, even if artificial insemination will probably remain the main reproduction method applied in animal breeding schemes across species. They must know procedures to formulate clear breeding objectives and to maximize profit of the producer, in the short and long terms. They should be aware of the techniques to manage biological resources in animal population (e.g., by limitation of inbreeding) and to estimate the nature of natural selection on any measurable suite of characters. Future students need also to be aware of the legal developments (e.g., patenting process), ethical issues (e.g., animal welfare and integrity) and consumer aspects (e.g., opinion and behaviour) of animal breeding. They need to have a sound knowledge of breeding systems in traditional (e.g., cattle, pig, sheep, farmed fish) and new species (e.g., exotic breeds, sport and pet animals).

Last but not least, students need to be aware of progresses in epidemiology (e.g., genetic-epidemiological models) and ecology (e.g., models of host-parasite co-evolution) in face of the growing interest from livestock breeders for animals resistant to disease. Indeed, actual breeding methods to improve productivity are not adequate to improve animal health because disease does not depend only on the host characteristics but on the interaction between the host, its pathogen and its environment.

Given the diversity of areas of study in animal breeding, graduate students will usually focus on few fields of expertise, depending upon their carrier objective. For example, interest for genetic mapping has increased quasi-exponentially with 4, 15, 46, and 73 contributions presented during the last four WCGALP. Today, molecular animal breeding is the most attractive with its highest impact factor (Nature Genetics : 38.9) and industry demand (patenting prospect). But, tomorrow, wind will change direction as the need for exploiting molecular data increases. As stated by Walsh (2001), ‘modifications of classical genetic
models will provide the natural framework for handling both phenotypic and genotypic information’ and much work is needed on how to integrate and use new information for genetic improvement.

The complexity and novelty of the techniques means also that graduate students, each specialized in their field of expertise are increasingly distanced from the work of others. It seems important that at least one course give students a flavour of all relevant techniques so they can be in a position to judge the appropriate tool for their own work and have a solid grounding for more detailed study and research. The course outline should be defined with partners from the industry, government agencies, and consumer groups. Educational institutions have usually teachers/researchers highly specialized in several but not all aspects of animal breeding. To enhance their technical skills, teachers may assist to meetings and symposia or they may take sabbatical leaves to interact with peers. An interesting alternative comes from AFANet, a EU SOCRATES thematic network. The idea is to share, via an Internet page, teaching materials from European institutes with animal breeding and genetics in their curriculum (http://www.clues.abdn.ac.uk:8080/afanet/). Another source of material is interactive exchange between researchers through discussion forum (http://www.ulg.ac.be/fmv/resistance/index.htm) or online defence of thesis in animal breeding which will make the bridge between countries in compatible hourly network and be of interest for French- or Spanish-speaking countries without direct contact with the USA.

As a final note, keep in mind the many teaching resources available in numerous web sites with different software (e.g., genup, pedigree, populus), educational materials (e.g., http://www.webct.com/), course notes and links to breeder sites.

CONCLUSION
Animal breeding has a long history of being multidimensional and many new possibilities have appeared in the teaching materials and techniques. The future may be the virtual reality classrooms in which students could find themselves in Henderson’s shoes when he was dealing with the mixed model equations. Whatever the evolution, teachers will continue to look at something akin to what R. Leblanc was stating in his Good teaching : top ten requirements, i.e. ‘good teaching is about having fun, experiencing pleasure and intrinsic rewards like locking eyes with a student in the back row and seeing the synapses and neurons connecting, thoughts being formed, the person becoming better, and a smile cracking across a face as learning all of a sudden happens’.

REFERENCES
This paper is not a review of current advances and future prospects in animal breeding and the list of scientific contributors would be too exhaustive, so we have chosen not to reference the work of researchers in animal breeding but we hope they will recognize themselves.

EAAP, Round Table, 52nd EAAP Annual Meeting, Budapest, 26th August 2001
Lewis Carrol, (1871) Through the Looking-Glass