ABSTRACT: Animal Breeding requires a diverse spectrum of competences, from biology to social sciences and technology, and so does its teaching and training. It results in a collective activity which benefits from moving towards three complementary directions: interdisciplinarity, internationalization, and interculturality. These dimensions open new ways to create and to adapt innovative curricula to the fast evolving needs of the professional sector, but they are also challenging. Recent joint initiatives between European institutions in the field with their successes and pitfalls could be a useful source of experience.

Keywords: Training, Teaching Animal breeding industry, Societies

Introduction

Europe is a region of the world where livestock production is a major economic sector and animal breeding industry is well developed and strongly organized. Many scientists groups, in higher education and/or research institutions, offer training and perform research in this field. Therefore, Europe is a major area for employment in animal breeding and genetics, in both academia and industry.

Animal breeding is a very ancient activity, probably as ancient as domestication (see Clutton-Brock, 1999, for instance). On the opposite, Genetics is a relatively young scientific discipline. When training for animal breeding, one simultaneously faces old questions and new challenges (see Verrier et al., 2005, for instance). The purpose of this paper is to highlight three challenges that we consider of special importance for training in our field, namely interdisciplinarity, internationalization and interculturality. Each of them and in combination, they transform the way knowledge is produced, disseminated, and adapted to the fast evolving relationships of different societies with their domestic animals. After presenting some elements of context, we underline here some of the issues they raise, and suggest some ways to take them up. The present paper is mainly inspired by our experience in our own institution as well as within the framework of some international collaborations.

Elements of context

Animal breeding is linked to evolutionary biology. Animal breeding is an evolutionary force for domestic populations, probably stronger than evolutionary forces met by wild populations. The results obtained by some methodic breeders during the 18th and 19th centuries in several countries in Europe were a source of inspiration for Charles Darwin when conceiving his theory of natural selection, as well as Gregor Mendel when building his experiments which revealed the laws of heredity (Wood and Orel, 2001). Then, an open question for animal breeders deals with the limits of our rights to change living populations. This question includes at least three aspects, not independent each other. From a genetic point of view, to what extent can we select at the expense of the within-population genetic variability? From a physiological point of view, to what extent can we select for animals specialized for a given product (meat, milk, eggs…) at the expense of fertility or other functional traits? From an ethical point of view, should we select for and raise extreme genotypes (e.g., animals with muscle hypertrophy or other morphology leading to a systematic use of caesarean birth, chickens without feathers, blind chickens…)?

Animal breeding has to meet diverse public demands, within mainly urban societies. In Europe, the proportion of people working in agriculture is low: in each country of the European Union (EU), except in the most recent members, this proportion amounts to a few percent only. As a consequence, citizens pay little attention to the way of life of farmers, and their view on the role of animals in our societies is mainly that of people living in more or less large cities. From several decades, the public demands have strongly evolved: a “mass” demand for cheap food still exists but many other services are expected from livestock, such as sanitary food quality, typical or “terroir” products, services for the environment, leisure or sport, work power, etc. The emphasis put on these services differs according to the country (e.g., more emphasis on disease control in the North of Europe, more emphasis on typicity of products in the South). To an extent with no equivalent in the world, EU regulations include specifications intended to respect the animal welfare or to monitor the environmental impact of production. This regulation framework is also the consequence of the evolving views of the public on animals and livestock production, this public image being a matter of concern per se in Europe.

Animal breeding is an international business. In almost all species, the activity of breeding organizations is international. In a commercial context becoming more and more liberal, there are extensive exchanges of genetic material. Some populations are managed at an international level: e.g., the Holstein dairy cattle breed and the Thoroughbred horse breed. The strains of poultry or pig breeding companies are distributed worldwide.

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sanitary and juridical issues are of special importance in these activities. In a competing context, the European animal breeding industry often has a leading position.

**Animal breeding is a multi-actors process.** A breeding program implies several steps corresponding to different kinds of job: definition of the breeding goals; recording performances, pedigrees and genotypes at markers; processing all information and genetic evaluation; selection of the best animals; spreading the genes of the best animals into the whole population. In poultry and fish, and to some extent in pigs, all these steps are managed by private breeding companies. In ruminants, the different steps can be under the responsibility of different farmers', public or semi-public organizations, involving a huge number of actors. This collective way to manage a breeding program requires strong coordination efforts.

Moreover, animal breeding requires the input of other stakeholders than breeders. For instance, in France, what is called “Organisme de Sélection” (OS) is in charge, among others, to define the breeding goals of a given breed. This organization comprises different categories of stakeholders: (i) individual breeders, (ii) breeding companies (AI Centers), (iii) representatives of the food chains using the breed (e.g., the inter-professional organization for a given product), and (iv) representatives of territorial collectivities where the breed is raised (e.g., a natural park). Then, a French OS typically represents what social scientists call an “arena”, where different and sometimes competing points of view can be expressed before to take a decision.

**Animal breeding involves sophisticated tools and methods.** Even before the extensive use of genomic data, elaborated statistical methods were required to analyze variation and for genetic evaluation. With the development of genomic tools, the availability of data on a huge number of SNP markers, and the development of the use of DNA sequences, methods to be used are more and more sophisticated, requiring specialized skills in the fields of data processing, bio-informatics, machine learning, bio-statistics and computer programming.

**Animal Breeding is then at the crossroads between biological sciences, social concerns that turn into politics, and techno-economical issues.** As such, it is a form of biopolitics, i.e., an activity where application of biological knowledge and rational goals from socio-political origins is the driver of social evolutions. But in this case, this is a multilayer biopolitics, because it impacts not only humans, but also domestic animals, and the complex set of interactions between them. Thus, teaching and training in Animal Breeding is not only, and by far, a technical question. On the one hand, teaching is an agent of knowledge dissemination, a classic instrument of biopolitics. On the other hand, it deserves accurate skills and up-to-date knowledge, but demands various inputs, in order to provide adapted skills and know-how in a complex and changing world. This makes interdisciplinarity, internationalization, and interculturality three key elements for achieving these goals.

**A multiple-discipline and interdisciplinary training**

**The need for a wide and multiple-discipline background.** As many other disciplines directly linked to a well-defined professional sector, teaching animal breeding and genetics generally starts during the last year of Bachelor and specialized trainings are available in Master only, with some differences across countries in the year of Master (1st or 2nd) when specialization occurs (Verrier et al., 2002). In order to build an adequate background before specialization, four pillars are well identified: (i) Biology, because animals are not machines traversed by flows of raw materials and products, and because considering the genome as a black box is effective but not sufficient; (ii) Tools and methods to collect, process and analyze data of diverse nature, and to model biological processes; (iii) Technologies, including crop, animal and food sciences; (iv) Economic and social sciences, because animal breeding is at the top of food chains and has to face with diverse public demands (see above).

**The value of an interdisciplinary training during specialization.** Indeed, advanced courses in animal breeding and genetics constitute the hearth of a specialized training. We consider that it is also very important to include interdisciplinary subjects in Master or PhD courses, as well as in continuing education. As a matter of fact, in both academia and industry, most of the issues to be addressed are at the interface between disciplines: genetics and physiology, genetics and immunology, animal breeding and social sciences, etc. Taking interdisciplinary subjects allows students to acquire the concepts and to manipulate and combine the tools and methods from different fields, which is often a key to find practical solutions to complex questions. The value of interdisciplinarity is conditioned by a truly joint conception and management of courses by scientists from the concerned fields: interdisciplinarity is not a juxtaposition of specialized areas of knowledge.

**An attitude towards interdisciplinarity.** Teachers must be trained to interdisciplinarity, in addition to keeping up-to-date on their skills and knowledge in their own field. For that prospect, good opportunities are offered by interdisciplinarity research projects or PhD projects jointly supervised by two scientists from different fields. Such activities are time-consuming, due to the required mutual learning. Working with colleagues from social sciences is of special value: (i) it offers us a possibility to renew our views on a complex reality, (ii) it allows us to be well prepared to answer some questions challenging the limits or even the legitimacy of livestock production, which are not uncommon today from both students and the general public, and (iii) such interactions fuel our position papers on
societal issues [1], that we consider to be part of our duties as teachers-researchers.

One could stress that it is also a direct outcome of our agronomical education system: both biological sciences and agronomical sciences, two of its pillars, are complex and multilevel disciplines, involving dense networks of actors, where permanent interfacing with disciplines at their boundaries is a prerequisite for high-quality standards of teaching. This implies a collective approach in designing our curricula, which paves the way for broader, international collaborations.

Interdisciplinarity is also challenging per se. First it deserves a very accurate coordination of the disciplines. Moreover, the ever increasing need for technological information and sophisticate mathematical formalizations in Animal Breeding is time consuming from a teaching point of view: making room for other disciplines, as important as it indeed is, can be a difficult task.

International exchanges and curricula

The necessary international dimension of national curricula. Needless to say that our lectures valorize the results of international research, the need to provide international information also impacts illustrations and concrete case studies. First, since the employment area for our students is at least at the European level, as far as possible, illustrations are given for the whole EU. Second, we have to let the students see the diversity of situations across the world. Indeed, it is less easy to collect technical information worldwide than to have access to the most recent scientific papers. To invite scientists who have a concrete experience of breeding programs, for instance, in a foreign country, is a good way to overcome this difficulty.

International exchanges and networks. Historically, internships abroad were the first way to let the students benefit from an international experience. Next, the Erasmus program, funded by EU, gave to European students the opportunity to spend a long stay (typically one semester) to take courses in another EU-member than their own country, on one hand, and allowed staff exchanges between European higher education institutions, on the other hand.

In parallel, many bilateral exchanges agreements have been developed between EU and non-EU institutions. International networks of European University have been developed to share experiences and pool courses offered to students: a convincing example is provided by the Nordic network NOVA [2].

Distance learning and online training resources can also be managed by international networks. One may highlight the relevance of two networks, each involving both European and African institutions, providing training resources to students and young scientists from developing countries: one is intended for English speaking people and is focused on animal breeding and management of animal genetic resources, namely AGTR [3]; the other one is intended for French speaking people and deals with all branches of Genetics, namely GeNet [4].

Joint international curricula. With the Erasmus-Mundus (EM) program, EU promotes not only exchanges but joint international curricula, at the Master level from 2004, and at the PhD level from 2009. The principle is that higher education institutions from several EU countries jointly conceive and manage a Master Course (EMMC) or a Joint Doctorate (EMJD). These programs are open to both EU and non-EU students, and they involve geographical mobility between at least two countries. When they succeed, students are awarded with a double diploma (i.e., two diplomas separately delivered by two institutions) or a joint diploma (i.e., a single diploma jointly delivered by the concerned institutions).

Our institution is involved in two EM programs in the field of animal breeding and genetics, namely, the European Master in Animal Breeding and Genetics (EMABG) [3] coordinated by Wageningen University, and the European Graduate School in Animal Breeding and Genetics (EGS-ABG) [4] coordinated by AgroParisTech (our institution). The Master course involves a total of 5 higher education institutions, in the Netherlands, Sweden, Norway, Austria and France. The Doctoral program involves a total of 4 higher education institutions, in France, the Netherlands, Denmark and Sweden. Both programs use English as education language.

From its beginning, in 2007, EMABG enrolled a total of 120 students, from all around the world, for a 2-year course. From its beginning, in 2010, EGS-ABG enrolled 32 doctoral candidates, from 22 different countries (Figure 1), for a 4-year program. After several years of implementation in each case, with regular evaluation by students or doctoral candidates, added values of such programs are clearly identified: (i) the definition of harmonized and stringent rules for selection, supervision and awarding of degrees, intended to warrant the high quality of both training and research, (ii) the mobility, which allows candidates to benefit from a wide range of expertise, and (iii) a definitive multicultural touch with good networking opportunities (Van Arendonk et al., 2010; Verrier et al., 2013).

To build and manage international curricula is challenging. Being given a large autonomy in defining our pedagogical goals and methods is of the highest interest, but sometimes leads to unescapable conundrums. For instance, Erasmus Mundus rules give opportunity to raise our collective standards by sticking to the highest one across a consortium. However, these rules are sometimes incompatible with the minimal common standard across the different institutions of a consortium. This deserves organizational and educational engineering skills and creativity that may sometimes be out of our competences, and/or almost impossible to solve at our level (e.g., to fix the rules to award a joint diploma). Similarly, different administrative rules and paces between national institutions may restrict our autonomy in designing curricula fully.

1Numbers within brackets refer to the list of referenced websites, at the end of the paper.
focused on the students and candidates interest, which is the outcome expected from us by the same institutions. One could hope that given the innovative ways we have overcome some of these hurdles, and the insolvability of others, would be taken in careful consideration as a learning-by-doing process when future programs aiming at curricula convergence in Europe will be designed.

Intercultural experiences

Teaching activities “in the real life”. In any European institution offering training in animal breeding and genetics, emphasis is put on ways of teaching that let the students be in the real life: short visits, study trips, internships on farm, internship in a company, etc. From our point of view a value of such activities, more important than learning the practice, is to let the students (a majority of them being of urban origin) in situations where they have to adapt them-selves to a social context generally different than their familial and educational context.

The diversity of educators. By nature, teachers are the main actors of training. Fortunately, they are not the only ones: practitioners are regularly invited to give lectures and, during internships (see above), they are the main actors. This diversity is of high value in primary education as well as in continuing education, because it forces students to pay attention to a diversity of points of view, to balance them and to form their own opinion.

Interculturality within international curricula. In many aspects, interculturality is a by-product of internationalization. When engaged in an international exchange, students are first facing cultural differences in the real life, which may require several weeks or months for adaptation. In the academic context, they experiment diverse ways of thinking, which will be very beneficial some years after when working in an international context, as it is often the case in the animal breeding industry.

When participating in an international training program, teachers have to manage multi-national groups of students. By experience, the point which deserves the main attention is to promote a true multicultural life of the whole group. The main trap is that the group splits into two sub-groups, one with national students and one with non-national students. This is all the more true in countries where English (which is supposed to be the common language of all students) is not the native tongue: in that case, when teaching activities are finished, the national students spontaneously come back to their native tongue, which is generally not spoken by foreign students. Then, when teaching involves work in pairs or small groups, it is highly important to form “mixed” groups (i.e., with both national and non-national students).

This internationalization of curricula is highly rewarding and strategic. We strongly believe that building an international network of young animal breeders from different countries of origin and various cultures is a decisive added value for our field, because their future relations will not be reducible to scientific or commercial competition but will include collaborations rooted in their common curriculum and shared experiences.

Conclusion

We choose to focus our paper on three challenges that are not strictly of scientific or technical nature. Indeed, we are facing other challenges: for instance, how to balance a general background and advanced skills; how to combine an expertise in molecular biology, on the one hand, and quantitative and population genetics, bio-informatics, etc., on the other hand; how to avoid a growing gap between top level research and practices on farm, especially in an international context; etc. These challenges deserve attention: both the contents of the courses and the ways of teaching them must necessarily evolve in Bachelor-Master curricula, in PhD programs as well as in continuing education. However, we consider that interdisciplinarity, internationalization and interculturality are even more important for the future employability of European students. Incidentally, to go towards these directions is a way to maintain or renew the enthusiasm of teachers.

Referenced websites

[2] NOVA, the Nordic Forestry, Veterinary and Agricultural University Network: http://www.nova-university.org

Literature Cited

Figure 1: Geographical origin of the 32 doctoral candidates enrolled in the European Joint Doctorate ‘EGS-ABG’.