On the importance of diffusion management for local breeds selection

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Introduction

The more widespread model of breeding activities for most of domestic ruminant species in France is based on the separation between the production and the diffusion of the genetic gain. Through this organization, the goal was to conceive and implement an efficient breeding strategy for a whole population, and not for a few solitary breeders (Barillet *et al*, 2001). This model was implemented in the 60's, thanks to the cooperation between the French State, farmers, and scientists, through the Breeding Law in 1966. In this model, *"the population was split into two groups: a selection nucleus (selected population), for which the size needed to range between 10 and 20% of the population to be improved"* (Elsen et Mocquot, 1974), and the rest of the animal population (i.e. commercial flocks). The breeding tools (pedigree recording, official milk recording, artificial insemination, progeny test, assortative matings, etc.) were exclusively or mainly used within the nucleus farms, firstly to create genetic gain, and secondly to organize its diffusion by artificial insemination (AI) or natural mating towards the other farms (Barillet, 1997; Barillet *et al*, 2001). There is an exception to this organizational and technical model: the case of dairy cattle where the diffusion of artificial insemination and milk recording over almost the whole population has allowed not to separating the production and the diffusion of genetic gain between nucleus and commercial flocks. Since practices and performances of breeding flocks are recorded, the way in which genetic gain is produced is very well known. How it is afterwards spread in all dairy farms is mainly studied through modelling: the main questions explored are "what breeding practices in the nucleus flocks could provide enough genetic gain to the base population? How could we predict the annual genetic gain of the whole population?". The objective of such modelling efforts is to define an "optimal diffusion plan", "a good diffusion method" (Elsen, 1993). But the answers to such questions rely on several hypotheses on how is used the genetic gain produced in the nucleus flocks: mainly toward sales of artificial insemination and of breeding animals from breeding centres and breeders toward "ordinary farmers" (commercial flocks). Moreover, while artificial insemination has been designed in the 1920s and 1930s, this conceptive technology was transformed into an essential method for reproducing dairy cattle (Wilmot, 2007). Despite it never replaces natural mating, AI is now considered by research programs and agricultural extension as the most efficient and profitable method to diffuse genetic gain. Several questions remain under investigated the "diffusion" side of breeding activities: what are the actual practices of the farmers from the commercial flocks and their uses of the genetic gain produced by breeding schemes? What are their criterions for a "good" genetic gain supply? How do they choose between artificial insemination and others means of genetic gain access? How does the market of males work? How is constructed the prices of breeding products?

The case of local breeds exacerbates on the problem related to the diffusion of genetic gain. Indeed, researches on local breeds have mainly focused on the production of genetic gain, while its diffusion used to be taken for granted, or considered as obvious as the State was subsidizing official breeding schemes. However, nowadays diffusion and sustainability of small local breeding schemes are threatened by current changes in breeding activities and

organizations - diversification of breeding objectives, liberalization of public policies, decrease in public support. Local breeds are particularly concerned, since:

- they are threatened by more competitive and widespread ones;
- their breeding schemes are usually small sized and have economic difficulties;
- artificial insemination cannot be the unique way of diffusion, breeding animals exchanges are necessary as there is no AI return, i.e. second artificial insemination if the first one did not work (at least for sheep, goats and beef cattle).

The management of diffusion of genetic gain in breeding activities gets a greater importance, putting forward the need for a better understanding of genetic gain market and the strategies of its participants. We will take as example dairy sheep breeding to develop this analysis.

Material and method

The massive use of artificial insemination as the major way of diffusion in the the Lacaune breed must be considered as an exception. In other cases, artificial insemination is not (or cannot) be the principal way of diffusion toward commercial flocks, for several reasons that we tried to determine subtly in our case study. We studied the case of the management of three local dairy sheep breeds (Manech Red Face, Manech Black Face, Basco-Béarnaise) raised in the Western Pyrenees mountains to produce PDO cheese (Ossau-Iraty). Thanks to both research work and to the active participation of local breeders, a breeding centre and breeding schemes have been implemented in order to increase breed efficiency and farmers' incomes as a result.

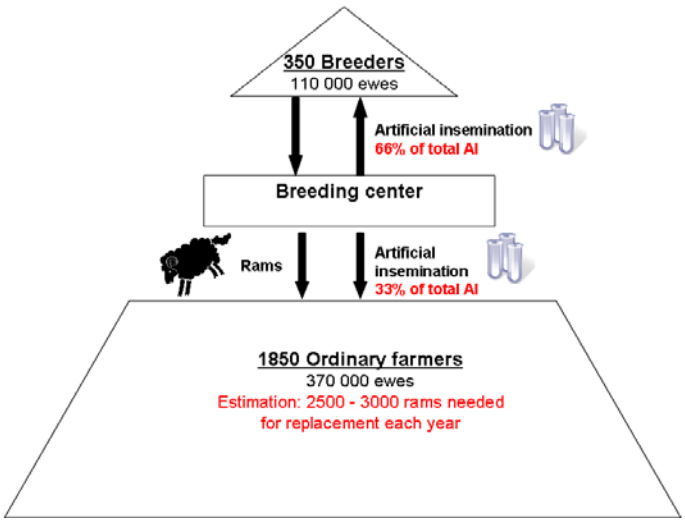

Figure 1 : Organization of the breeding schemes in Western-Pyrenees

Genetic improvement has been successful (Barillet *et al*, 2009), but cooperation between farmers and R&D organisations is difficult to maintain at this time (Labatut *et al*, 2007), threatening the sustainability of these local breeds.

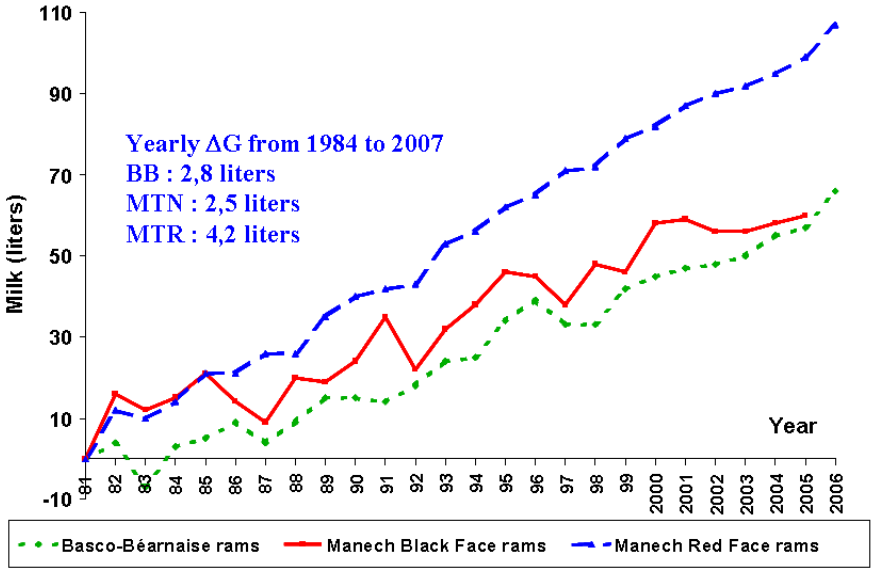

Figure 2 : Evolutions of the breeding values of Manech and Basco-Béarnaise , rams (average milk breeding value 2008) (from JM Astruc, Technical report of the genetic session of the CNBL October 2008 provided by official EBV)

There are controversies on breeding objectives and on the quality of breeding products, and an apparently low level of diffusion of genetic gain through artificial insemination and collective rams. In this area, the use of artificial insemination outside nucleus flocks is weak. The diffusion is mainly based on the exchanges of live breeding animals (especially rams), but the number and substance of the exchanges are unknown. We identified several paradoxes in the functioning of the market of genetic gain in this case. Firstly, the breeding centre uses to sell rams left over. However, while there is a shortage of breeding rams in the region, not all the rams from the breeding centres are sold, even if they have very good estimated breeding values. Secondly, a parallel market of rams seems to be more important than the one provided by the breeding centre: breeders in the nucleus flocks use to sell rams to the base population. Until now this parallel market has not been precisely evaluated. Thirdly, breeding rams produced outside of the breeding scheme, by the farmers from the base population, are sold at a higher price (sometimes twice more) than the ones from the breeding scheme, while their performance is not evaluated thanks to breeding values.

To investigate the diffusion of genetic gain and the market of breeding animals in this case, we studied qualitatively the genetic market in our studied case. We analyzed two types of markets set up: the official sale of breeding animals, organized by the breeding centre; the parallel market of rams' exchanges by mutual agreement between farmers. We interviewed 35 farmers, both members and non-members of the collective breeding organization, and formalized their "realized strategies" (Mintzberg et Waters, 1985) using an innovative categorisation method (Girard N. *et al*, 2001; Girard N. *et al*, 2007). This method focuses on the categorisation of farming practices instead of evaluating technical and economic variables. It then expresses the qualitative nature of these practices without reducing them to quantitative parameters (Girard *et al*, 2007). The interest of such a qualitative method for studying the diffusion of genetic gain in our case is two fold. First, for a better understanding of the motivations of farmers for their breeding strategy (artificial insemination, breeding

animals, scientifically evaluated or not, etc.) and second, for a better knowledge of the market of breeding animals and its dynamics (social networks, price construction of breeding animals, etc.). This method is also linked to local specific practices in order to build a specific typology rather than a generic one. The objective is to reformulate these issues through a deep understanding of husbandry practices (Girard *et al*, 2007). An important part of the work was to choose objectively 35 farmers to be interviewed. Our aim was not to build a representative sample in statistical terms (which is quite impossible with only 35 interviews), but to interview representative farmers in terms of their diversity. We chose several criteria to favour a wide variety of cases (location, age of farmers, farming system, breed reared, farming practices such as summer grazing or not, pluriactivity, farm cheese production or not, etc.).

Results

Thanks to this method, we identified six types of individual breeding strategies of farmers at the farm level, ranging from an intensive use of genetic services (type 2 "Producing good ewe lambs using genetic gain produced by breeding scheme and accelerating flock replacement"), a moderate use aiming at improving steadily the genetic level of the flock (type 3 "Increasing progressively the genetic level of the flock, using collective genetic gain while using summer pasture"), to other strategies whose driving forces are not directly genetic improvement but territory use or cheese production (type 4 "Using mountain pasture and producing cheese while simplifying flock management and using rams born from artificial insemination", as artificial insemination is sometimes a constraint when animals are summer grazing during the reproductive period, and type 5 "Having simple and natural breeding practices while using moderately collective genetic gain"). Other farmers put forward in their strategy the individual control of breeding for sanitarian and genetic reasons (type 1 "Controlling flock breeding on farm and improving its genetic level only by artificial insemination") or the animal standard (type 6 "Having a nice-looking flock without using collective breeding tools, and using mountain pasture as much as possible").

Type	Description
Type 1: "Controlling flock breeding on farm and improving its genetic level only by artificial insemination"	Type 1 raises Manech Red Face breed, sells milk to milk plants, has a high milk production level. This breeder manages individually his flock on private pastures close to his farm. He increases the genetic level of his flock using artificial insemination and rams produced exclusively on his farm through artificial insemination. He practices late one-year lambing to match the heat cycle of his ewes.
Type 2: "Producing good ewe lambs using genetic gain produced by breeding scheme and accelerating flock replacement"	Type 2 breeder is young, owning a Manech Red Face flock of medium size. His aim is to improve the genetic level of his flock producing good ewes. In this purpose, he uses artificial insemination on at least 20% of his flock to produce replacement ewes. He buys exclusively rams born from artificial insemination in official recorded flocks. He practices one-year lambing and he decides to speed up the first lambing of his ewe lambs using melatonin implants or artificial insemination on one-year old ewes to group the lambings.
Type 3: "Increasing progressively the genetic level of the flock, using collective genetic gain while using summer pasture"	Type 3 breeder has a medium size Manech Black Face flock. His objective is to improve the genetic level of his flock using artificial insemination and producing on his farm good rams from artificial insemination. He does two-year lambing because he wants his ewe lambs to finish their growth before reproducing. For this type of breeders, the practice of summer mountain grazing is very important, allowing them to be autonomous in forage.
Type 4: "Using mountain pasture and producing cheese while simplifying flock management and using rams from artificial insemination"	Type 4 breeder produces on-farm cheese and raises Basco-Béarnaise. For him, the practice of summer mountain grazing is necessary because of shortage of forage on farm. Moreover, summer grazing gives him the opportunity to produce a high quality cheese with low investment. He seeks to simplify the management of his flock in order to have enough time for cheese processing.

	He does late one-year lambing. This type also tries to improve the genetic level of his flock: he buys rams at breeders involved in official milk-recording or produces rams on his farm thanks to artificial insemination.
Type 5: "Having simple and natural breeding practices while using moderately collective genetic gain"	Type 5 breeder is a pluriactive breeder with Manech Red Face of Manech Black Face ewes. He tries to simplify the management of his flock in order to save more time for other activities. He does not use artificial reproductive methods in order to preserve the natural rhythm of his ewes. However, he seeks to improve the genetic level of his flock but with the minimum of investment: he buys rams to official milk-recording flocks but also keeps rams from his farm because rams from official milk-recording flocks are expensive.
Type 6: "Having a nice-looking flock without using collective breeding tools, and using mountain pasture as much as possible"	Type 6 breeder is a Manech Black Face breeder. He seeks a compromise between milk performance and morphological and aesthetic aspects of his flock. He chooses ewe lambs thanks to their morphological standard but also to the milk performance of their dams. This breeder does exclusively natural mating. He produces his rams on his farm or buys sometimes his rams to "old farmers" breeding animals on aesthetic criteria. He tries to use as much as possible the natural resources of his environment through a long stay in summer grazing pastures.

Table 1 : Six types of individual breeding strategies (from Boisseau, 2007)

Moreover, beyond these individual strategies within the coherence of farm management, describing individual practices such as "ways of obtaining rams" or "use of collective breeding tools" allowed us to characterize the relationship chosen by each farmer with the collective level, i.e. the breeding scheme or local networks of farmers. These data revealed unexpected results on the functioning of the market of breeding rams. Firstly, even though artificial insemination is not very much used in the commercial flocks, only the type 6 does not use at all the genetic gain produced by the breeding scheme (based on AI rams in the nucleus flocks). The majority of rams' purchases are directly or indirectly linked to the breeding scheme. Thus, despite controversies on breeding objectives, the genetic gain produced by the breeding scheme is diffused regardless to a large part of the base population, mainly thanks to the parallel market of breeding animals. Secondly, we also identified the existence of a second-hand market for rams, which allows a return on investment for farmers who buy to breeders in the nucleus flock expensive rams.

Thirdly, we analyzed how farmers choose the place where they buy their breeding rams. They give various reasons to explain why they prefer to buy private breeder rams (born in the nucleus flocks) rather than rams sold by the breeding centre (also born in the nucleus flock):

- the morphology and standard of rams, which is not suitable enough for some farmers when rams come from the breeding centre;
- the capacity of the rams to resist to summer grazing: as rams from the breeding centre are reared indoor, with sufficient food, they sometimes do not resist to the difficult conditions of mountain pasture.

The choice of the breeder whom they buy breeding rams depends mainly on their own social network: family, neighbourhood, friends. They are usually faithful to the same provider of rams every year. One of their criteria is thus the similarity between their farming practices and the ones of the seller. For example, if the buyer practices summer grazing, he would better seek a breeder who has the same practice.

Our study also gave us indications on the construction of the prices of breeding animals. We identify that the diversity of prices on the market can not be explained only according to official and scientific evaluation of animals (including traits corresponding to the collective breeding objectives) and that aesthetic criteria and social networks of farmers are also taken into account. For example, rams from the Manech black-faced produced outside of the

breeding scheme can be sold up to 1000€ for a high standard ones, which are not genetically evaluated according to scientific standards (i.e. official EBV), while the average price for rams evaluated through breeding values in the breeding scheme is 250€.
Another unexpected result was that breeding rams production and sales are not so much sought-after by breeders in the breeding scheme even if it is economically profitable. For them, producing rams for sales requires a specific organization, and involve risks of mortality before sale and of bad quality of the progeny as rams are not progeny-tested before sale.

Discussion

Even if there are stowaways, i.e. individual breeders who sell the collective genetic gain produced in the breeding scheme, the collective action of breeding is efficient: genetic gain is produced and diffused. But the economical equilibrium of the breeding scheme is uncertain, as the benefit of private sales of collective genetic gain does not return at least partly to the collective organization. The only solution considered by breeding scheme managers is often to increase sales of artificial insemination. Since they are focused only on artificial insemination, they have poor knowledge of the market of breeding animals. Several ways of investigation may be proposed. First, there is a need for quantitative data management of breeding animals' exchanges: how many, who are the sellers, who are the buyers, what are the prices, what are the criteria, where the natural mating rams come from, etc. Implementation of the follow-up of rams sales from the breeders during on-farm milk recording. Different local organizations own part of the data concerning rams' exchanges out of the breeding schemes, such as inter professional and veterinary organizations. But these data are diverse and not centralized in a unique system. Indeed, today, it is no possible to have knowledge of animal movements for sheep as it is feasible in cattle with generalized identification. Secondly, how to provide a return on investment to the collective breeding scheme? Two types of solutions can be imagined: one about collective property-rights, such as the "droit d'obtention animal" or the creation of taxes on rams sold by breeders from the nucleus flocks, taxes which would participate to the funding of the collective breeding scheme. But both tools are already questioned in terms of social acceptability… There are also organizational solutions. Some have already been implemented:

- the collective property of rams like for one of the breeding centre of the Lacaune breed in Roquefort: all the breeding rams are the property of the breeding centres;
- the creation of an activity of breeding rams production on the breeding centre, to meet the specific demands of farmers according to criteria such as morphological quality and hardiness.

In conclusion, we argue that when artificial insemination is not widely used, breeding organisations should give more importance on the market of breeding animals. This study opens a field of investigation on the market of genetic gain, the organizational aspects of breeding schemes and the practices of farmers. Our results confirm the necessity of taking into account not only the genetic aspects of breeding schemes (producing genetic gain is not sufficient to insure its diffusion), but also their organizational dimension. For example, organizing a data bank between sellers and buyers on the animals provided by the nucleus flocks toward the commercial flocks and a system of contributions to provide and access to these information could be one of the solutions to investigate. This kind of study is out of the classical approaches of genetic selection, but reveals the interest of interdisciplinary work between genetic science and management science in the analysis of breeding activities.

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