Breeding for meat sheep in France

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Abstract

Selection of meat sheep in France is based on within breed collective breeding programs. Selection criteria and phenotypes collected in the national performance recording system depend on the type of breeding program. A comprehensive selection scheme includes 3 key steps with genetic evaluations: (1) on-farm evaluation of maternal abilities and meat qualities evaluations based on (2) individual testing and (3) progeny testing. On-farm evaluation of maternal abilities is based on both prolificacy and mothering ability, assessed by one weighing per lamb around 30 days of age. On the whole, 330,212 ewes had on-farm phenotypes in 2016, in 1,230 flocks from 46 different breeds. These figures represent roughly 5% of the whole meat sheep population. Meat qualities are evaluated on young rams in central test stations; the criteria are growth rate and weight at typical age assessed by weighings, fat and muscular development at typical age assessed by ultrasonic measures (fat thickness and muscle depth) and by muscle scoring (shoulders, back-loins and legs). A total of 3,794 rams were evaluated in such stations in 35 breeds in 2016. Finally, 194 rams from 9 breeds were progeny-tested for meat qualities; phenotypes are collected on lambs in fattening unit and at slaughtering at fixed age: growth rate during fattening, conformation assessed by morphological development, carcass conformation and rib eye muscle, dressing percentage, fat (external fat extent, internal fat amount, loins fat amount, back fat depth at last rib). Besides this pattern of breeding schemes and the phenotypes currently collected, different traits are on the way to be included in the selection criteria for some breeds, such as resistance to parasites, behavior, mortality/vigor of the lambs, longevity. One of the main challenges within the prospect of the new zootechnical European regulation is to reinforce the collective organization of meat sheep genetic improvement, especially through efficient breeding organizations.

Keywords: meat sheep, recording, genetics, phenotypes.

Introduction

Sheep production in France represents a total of 5,159,000 reproductive ewes (FGE, 2017). 73% out of them (3,779,000) are meat sheep, the other 27% being dairy sheep. The meat sheep are commonly divided into specialized pure meat breeds (2/3 of all meat sheep), hardy pure meat breeds (1/4) and crossbreds. Selection in France is organized within breed. 47 breeds had at least one flock in performance recording in 2016. 8 specialized meat breeds and 13 hardy meat breeds are

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considered to have a breeding program. Besides this most important breeds, 26 underutilized breeds are either in conservation or with too small population to implement a selection program. The specialized meat breeds are mainly situated in the northern part of France, in flat area, while the hardy breeds are located in the southern part of France, in non favorized mountainous or dry areas.

The organization of a typical selection scheme in French meat sheep can be drawn as follows, with 3 possible stage for the more complete scheme:

- First step: on-farm recording and evaluation (prolificacy, mothering ability, growth) are focused in the nucleus flocks. In this flocks, AI is practiced in some breeds either to produce connection between flocks or (if the AI rate is sufficient) to run a maternal progeny testing program.

- Second step: rams born from assortative matings in the nucleus flocks (sires of sires and dams of sires) enter a central test station for an individual evaluation for growth and meat quality. Only a part of the breeds have central test station.

- Third step: in some breeds, the best rams after massal selection in the central test station are progeny-tested, in order to produce elite rams.

On-farm performance recording of maternal abilities

In 2016, 330,112 ewes were recorded on-farm in 1,267 flocks (Tiphine, 2017). This figures represents 8.6% of the total meat sheep. 85% of the recorded flocks were engaged in a breed society. 149,599 ewes were inseminated by meat rams, ie 3.9% of the French meat sheep.

Three levels or method of on-farm performance recording, designed as a Russian doll system, can be chosen by the breeder. The first design, called reproduction procedure, consists in recording reproduction data and especially prolificacy, both on natural and induced oestrus. The mothering ability procedure is a design where, in addition to reproduction, the viability of the lambs and a weighing at around 30 days of age are phenotyped. Finally, the complete procedure also collects a weighing at around 70 days of age (before weaning), allowing to estimate the growth between 30 and 70 days. 70% of the flocks (increasing number) use the mothering ability procedure, whereas 20% are in reproduction procedure (stable) and 10% only are in the complete procedure (decreasing number).

The corresponding genetic evaluation and selection criteria to the different procedure are:

- Reproduction procedure:
  - The selection objective is prolificacy.
  - The EBVs are prolificacy on natural oestrus ($PROL_{NO}$) and prolificacy on induced oestrus ($PROL_{IO}$).
  - The selection criterion is $PROL = a\,PROL_{NO} + b\,PROL_{IO}$, with weightings a and b depending on the breed.

- Mothering ability procedure:
  - The selection objective is both prolificacy and ewe ability.
  - The EBVs are (in addition to prolificacy): viability of the lambs (or total weaned weight of lambs per dam) (VIAB) and weight at 30 days (WEIGHT).

- The selection criterion for ewe ability is: EWAB = a (1/2 WEIGHTdir + WEIGHTmat) + b VIAB, with weightings a and b depending on the breed.

- Complete procedure:

  - The selection objective is prolificacy, ewe ability and growth.

  - The EBVs are (in addition to prolificacy and ewe ability): growth between 30 and 70 days (ADG_{30-70}) and weight at 70 days ($WEIGHT_{70}$).

  - The selection criterion for growth is GROW = 1/2 ADG_{30-70} + ½ $WEIGHT_{70}$.

Performance recording of growth and meat quality in central test station

Individual selection for growth and meat quality is undertaken in central test station which are flock or station gathering the best young rams born from assortative matings. 35 breeds have a station where at least one batch per year is phenotyped. 13 breeds submit the rams to the whole protocol which is described below, 22 breeds are submitted to a lighter protocol.

The central test station is a major tool for the collective management of the breed with a triple objective: genetic management of the rams, sanitary control of the rams, collective and participatory dynamics of the breeders. Only scrapie-resistant rams, born from the best rams and dams, enter the station. Almost 3,500 young rams are evaluated each year.

In the complete protocol, rams enter the station just after weaning, at 70 days. After an adaptation period of 2 weeks, the rams are tested during 8 weeks, with a bunch of phenotypings, including weighing, ultrasonic scan and scoring. At the end of the test period, a transition period during which evaluations of the rams are produced and results diffused, results in the mass selection of the rams. The bottom 20% are eliminated, the top one are selected for AI, and the other are qualified as recommended rams for natural mating and diffused in both the selection and commercial flocks.

The table 1 describes the main measurements collected during the test period, as well as the criteria calculated and evaluated (Tiphine *et al*, 2011). An index is produced as a linear combination of growth, weight, fat and muscle, the weightings depending on the choice of the breed.

Table 1. Measurements collected and criteria evaluated on the rams in central test station.

Measurements	Criteria
Weighing	Growth rate
	Weight at typical age
Ultrasound (fat depth and rib eye area)	Fat at typical age
	Muscle at typical age
Scoring (shoulders, back-loins, legs)	Muscle at typical age

Progeny testing of meat quality

A few breeds are involved in a progeny testing for meat qualities. This progeny test has a dual objective:

- Assessing the meat quality of the lambs and improving the carcass quality (more muscularity and less fat).

- Decreasing the production costs, by reducing the age at selling. This leads indirectly to an increase of feed efficiency through growth and fat.

Protocol and phenotypes

The top 10 or 15 rams from the central test station enter AI center. They are inseminated with 35 to 50 females, either suckling or dairy females, in order to produce at least 30 progeny. The lambs born from the AI are gathered in a fattening station at weaning (30 days for the lamb born from dairy ewes, 70 days for the lambs born from meat ewes). There are 4 fattening station in France (figure 1). The lambs are fattened until a fixed age (33 kg for the female lambs, 39 kg for the male lambs) where they are slaughtered. This corresponds to an average age of 110 days. During the period of fattening, the lambs are measured (weekly weighings) and scored. Different appraisal and measures are realized on the carcass:

- Carcass weight.
- Conformation score.
- Fat score (external).
- Fat score (internal).
- Amount of loins fat.
- Back fat depth.
- Shoulder width.
- Rump width.
- Carcass length.
- Rib eye area.
- Muscle depth.

Evaluation and diffusion of the results

The different phenotypes are evaluated and combined in indexes:

- Growth from birth to slaughter: ADG0-slaughter

- Fat index: FAT = linear combination of fat score[external], fat score[internal], amount of loins fat, back fat depth

- Conformation index: CONFORMATION = linear combination of shoulder width, rump width, carcass length, conformation score, rib eye area, muscle depth.

A total merit index is diffused with weightings *a,b,c* depending on the breed:

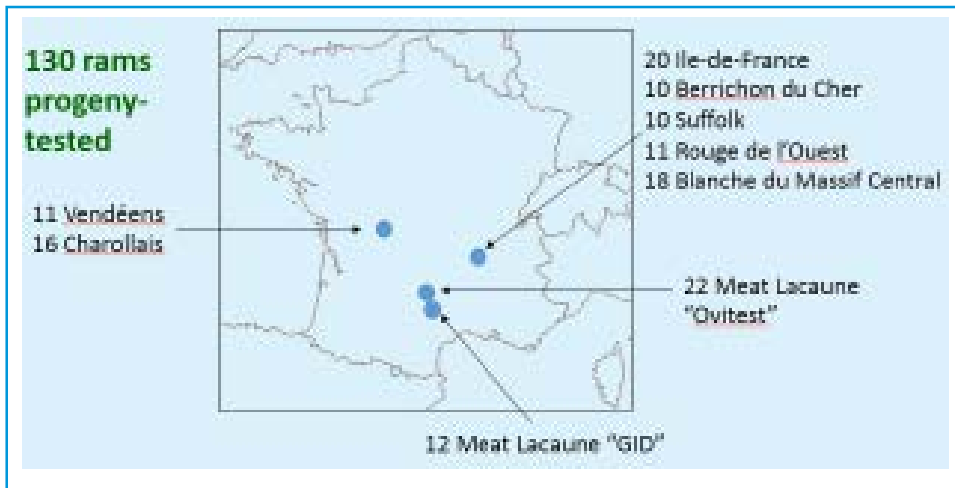$$\text{TMI} = a \text{ ADG0-slaughter} + b \text{ FAT} + c \text{ CONFORMATION}$$

Figure 1. Progeny testing for meat qualities: fattening stations and breeds involved.

On the whole, 130 rams are progeny tested each year in 8 breeds (Cheype, 2017) as shown in the figure 1.

The different EBVs are represented in a spider chart (Cheype *et al.*, 2016) as illustrated in the figure 2.
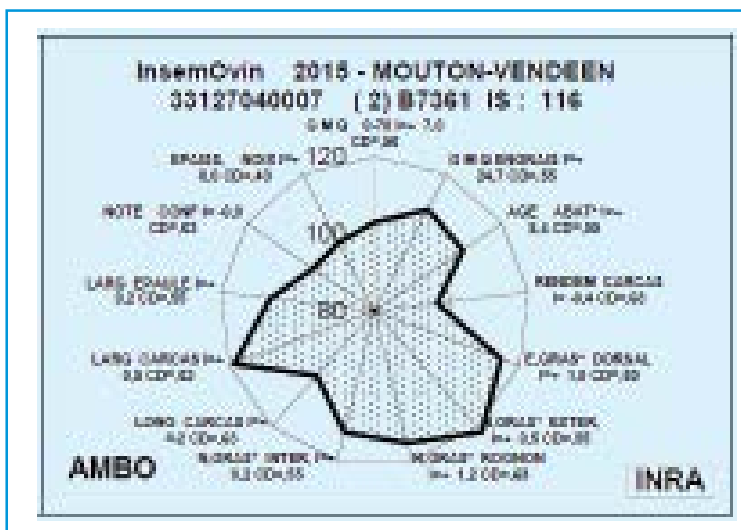

Figure 2. Spider chart of the EBVs of a ram after progeny testing for meat qualities.

Perspectives

Novel traits investigated

The current situation of meat sheep selection allows to select for reproduction traits, growth traits and meat quality traits.

Several novel traits are investigated in research & development programs with the purpose to include them as quick as possible in the breeding objectives.

- Resistance to internal parasites (nematodes). The phenotypes is collected through an experimental infestation with *Haemonchus contortus* applied on rams in central test station. 5 breeds are concerned so far. Genetic parameters are still to be estimated.

- Maternal behavior. Different in-progress study are undertaken in experimental farms with different tests (handling test, arena test) to assess the maternal behavior of the ewes. The traits have a moderate to high heritability. The interesting point is that litter survival increases as maternal behavior score increases.

- Lamb survival. Within different programs including 2 breeds, the aim is to define a common way of registration for lamb survival, before extending to the collection of the phenotypes to all breeds (Cheype *et al.*, 2016).

- Functional longevity. The breeders are more and more concerned with what they called rusticity or robustness. Functional longevity, assessed by the productive lifespan (date of last lambing – date of first lambing) is an overall trait which can synthesize all functional abilities of the ewes and thus increase the rusticity. An in-progress program aims at producing EBVs of functional longevity (Talouarn *et al.*, 2018).

- Semen production has been already collected in 9 AI centers for several years. EBVs on volume, motility, concentration and number of spermatozoa are released once a year. EBVs are used by the AI center to select the rams.

Besides these novel traits, various major genes are genotyped, collected and managed. The more important is the PrP gene (resistance/susceptibility to scrapie). More than one million animals have been genotyped since 1999 (30,990 in the year 2017). Different major genes related to prolificacy are genotyped: the mutations $FecX^L$ (gene BMP15), $FecL^L$ (gene B4GALNT2) and $FecB^B$ (gene BMPR1B). The mutation $FecL^L$ is managed in one of the two strain of the Lacaune breed where 3,900 rams and ewe lamb are genotyped each year. Finally, the second strain of the Lacaune breed has introduced the double-muscling mutation (gene GDF-8) from the Belgian Texel sheep.

Organizational issues

French selection of meat sheep is based on a large number of organizations:

- 18 breeds societies

- 63 performance recording organizations

- 9 AI centers

- Genetic evaluation was so far run by INRA whereas diffusion of EBVs were run by the French Livestock Institute.

The main features to draw meat sheep selection is the collective side of the breeding programs, which allows an actual efficiency of the selection.

The EU Animal Breeding Regulations (2016/1012) will deeply change the organization: breed societies will manage all aspects of selection, including performance recording and genetic evaluation which is new in France.

This new rule is the main **challenge** of the upcoming years, regarding the sustainability of collective breeding programs, their efficiency and their economic model.

Conclusion

Performance recording of meat sheep in France is widespread, with 330,000 ewes recorded each year, even though the trend over the last decade is a steady decrease. Moreover, it appears difficult to maintain AI and the number of inseminated ewes also decreases, rendering more fragile the programs of connection and on-farm progeny test. The central test station are at the heart of the collective breeding programs and are reinforced. So far the different selection tools have been efficient to respond to urgent matters such as resistance to scrapie issue. The "breed approach" is a king of French specificity. The commitment of both the breeders and the administration to maintain the breeds is a way to keep a strong level of biodiversity.

Regarding ICAR concerns, France Génétique Elevage (the French ICAR member) has obtained the ICAR Certificate of Quality for meat sheep in 2017. This is an acknowledgement of the quality of the tools and methods implemented in French meat sheep selection.

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