# New French Genetic Evaluations of Fertility and Productive Life of Beef Cows

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## Abstract

Since beginning 2000's, all herd inventory, animal movements between herds and animal insemination are uploaded in the French national database for genetic evaluation. Two major breeders' wishes can now be addressed with regards to female reproductive performance: heifer fertility and cow productive life. This paper covers the different steps realized for the implementation of two new national genetic evaluations concerning these traits. Female fertility is evaluated with heifer calving success after first AI. Cow productive life is assessed by the number of calvings at 78 months of age.

For both traits, heritabilities were estimated at low values: 1.5% for fertility and 4% for productive life. Reliabilities of estimated breeding values for these traits are therefore low. The results of these new genetic evaluations will thus be mainly interesting for selecting bull and cow sires in breeding programs.

**Keywords:** beef cattle, genetic evaluation, fertility, productive life

## 1. Introduction

Since these last two decades, the number of traits taken into account in French on-farm national genetic evaluations of beef cattle has continuously increased. The first national genetic evaluation with BLUP animal model was implemented in 1993 for birth weight and weaning traits (210 adjusted weaning weight and 19 type traits). Birth ease has been added in 2003 in a bi-variate model with birth weight. The next traits evaluated were then relatives to post-weaning traits: carcass traits (slaughter age, carcass weight and conformation) in 2008, post-weaning growth (2 year adjusted weaning weight) in 2010 and 5 type traits in 2013.

Fertility and productive life are also of major concern for beef cattle breeders but until recently, the amount of data available was not large enough to carry out a genetic evaluation of these traits.

This article gives a general overview of the different steps to implement official genetic evaluation of fertility and productive life for French beef cattle.

## 2. Trait definitions

### 2.1 Fertility

Because reproduction events by natural mating are not recorded exhaustively in French beef cattle herds and because animal insemination is rather used on heifers than on cows, heifer calving success after first AI (HCS) was chosen as the trait of interest for fertility. To enhance the accuracy of HCS genetic evaluation, primiparous calving success after first AI (PCS) was also integrated in a bi-variate analysis.

An AI was said successful if the difference between first AI date and calving date equals to the breed specific average gestation length more or less 19 days.

### 2.2 Productive life

Preliminary studies have been realized to determine the best trait definition for routine genetic evaluation of productive life. Two complementary ways can be considered to assess cow productive life:

- longevity that refers to cow ability to achieve a long career, either in terms of length of reproductive life or number of calvings,
- productive efficiency assessed by the number of calvings at a target age.

Phocas *et al.* (2006) showed that survival analysis of longevity in terms of lifespan or number of calvings were almost equivalent for beef cattle with the example of Charolais breed. Martinez *et al.* (2004) concluded that prediction of life productivity can be made early in cow's life, based on the high genetic correlations found between measures of life production at different ages. Following their conclusions it has been decided to study the number of calvings (NC) at two different target ages to assess productive efficiency in terms of ability to reproduce and produce regularly. In the short term, the target age was 78 months (NC78) which corresponds in average to the opportunity for a cow to reach four calvings given an age of first calving of three years old (average of first calving age observed in French beef production systems (idele, 2013)). In the long term, the target age was 150 months (NC150) corresponding in average to the opportunity for a cow to reach ten calvings.

Genetic parameter estimation for NC78 and NC150 has been conducted in order to define the best trait for the genetic evaluation of cow productive life.

## 3. Data

### 3.1 Date Source

Pedigree, animal insemination (AI), calving information and animal movements between herds were extracted from the French national database which gathers animal information recorded on French farms for all cattle breeds. 9 breeds are considered in French national beef cattle genetic evaluations: Charolais, Limousine, Blonde d'Aquitaine, Salers, Aubrac, Rouge des Prés, Parthenaise, Gasconne and Bazadaise. Due to a limited population size and limited use of AI, the two last ones couldn't be included in fertility evaluation.

The results presented in this paper focus on two specific breeds: Charolais, a specialized breed with short cow productive life and larger AI use (28% of Charolais calves born in France are from AI) vs Aubrac, a hardy breed with longer cow productive life and lower AI use (10%) (idele, 2013).

Results of previous survival analysis showed that half life in terms of number of calvings corresponds to 4 calvings for the Charolais breed and 8.5 calvings for the Aubrac breed.

### 3.2 Fertility data editing

For fertility, only AI performed between August 2001 and December 2012 were considered. Editing concerns AI for embryo transfer, AI realized before 240 days of age or second AI done before 3 days after a previous AI that were excluded from the analysis. A consistency check was also applied on the difference between AI date and next calving date: if the difference between these two dates was greater than the maximum gestation length of the breed more or less a common interval between 2 reproductive periods within herd (interval fixed at 180 days for all breeds), then this AI was excluded.

849 998 Charolais and 45 893 Aubrac animals were evaluated (67 908 and 6 656 sires respectively) based on 445 420 HCS for Charolais and 13 687 HCS for Aubrac (152 774 PCS and 3 526 PCS respectively).

### 3.3. Productive life data editing

Only first calvings after 1st of August 1990 were taken into account for pure bred females with birth date and sire known. Calvings from embryo transfer were also excluded. All calving intervals for each cow had to be between 280 and 810 days, otherwise the cow was not considered in the analysis.

1 491 920 Charolais and 153 536 Aubrac animals were evaluated (108 444 and 11 057

sires respectively) based on 1 065 886 NC78 for Charolais and 112 795 NC78 for Aubrac.

## 4. Censoring

One of the main difficulties inherent in the analysis of productive life is that a proportion of cows are still alive at the end of the studied period. These cows have ‘censored’ observations, *i.e.* we only know that their final number of calvings will exceed the observed number of calvings at the time of analysis. Table 1 shows the censoring rate for Aubrac and Charolais breeds at the 2 target ages.

**Table 1.** Censoring rate at 78 and 150 months for Aubrac and Charolais breeds.

| | Censoring rate | |
|---|---|---|
| **Breed** | **Aubrac** | **Charolais** |
| **at 78 months** | 56 % | 26 % |
| **at 150 months** | 35% | 19 % |

For cows that completed their productive life at their target ages (*i.e.* uncensored observations), NC78 and NC150 were defined as the observed number of calvings at 78 and 150 months of age, respectively. For cows that were still alive at the end of the study period and that did not reach the target age (*i.e.* censored observations), NC78 and NC150 were predicted using the formula developed by Brotherstone *et al.* (1997). Information needed for the prediction were average calving intervals and probabilities of survival from one calving to the next one. These parameters were calculated from the data set with only uncensored data (Table 2). The expected number of calvings (*Ec*) still possible to achieve at 78 or 150 months of age given the observed number of calvings for a given cow was calculated as:

$$Ec=(c-d)/CI$$

where $c$ was the target age (78 or 150 months) expressed in days, $d$ is the age at the last observed calving expressed in days and $CI$ is the average calving interval for the corresponding last observed calving expressed in days. The predicted number of calving ($NC$) at 78 or 150 months for a given female still alive was calculated as (for $Ec$ >0):

$$NC = r + \left( \sum_{i=1}^{Ec} \prod_{k=1}^{i} p_{r+k-1} \right)$$

where $r$ is the rank of the last observed calving for a given cow and $p_j$ is the probability of survival from the $j^{th}$ calving to the next one.

**Table 2.** Parameters used to predict the number of calvings at 78 and 150 months of age for censored records (average calving intervals (in days) and survival probabilities from the $i^{th}$ calving to the next one) in Aubrac and Charolais breeds .

| | **Aubrac** | | **Charolais** | |
|---|---|---|---|---|
| ***i*** | **CI*i*** | **p*i*** | **CI*i*** | **p*i*** |
| 1 | 398 | 0.76 | 405 | 0.66 |
| 2 | 381 | 0.75 | 385 | 0.67 |
| 3 | 376 | 0.83 | 379 | 0.74 |
| 4 | 376 | 0.85 | 379 | 0.77 |
| 5 | 377 | 0.87 | 380 | 0.77 |
| 6 | 378 | 0.88 | 381 | 0.75 |
| 7 | 379 | 0.84 | 382 | 0.69 |
| 8 | 381 | 0.88 | 384 | 0.62 |
| 9 | 382 | 0.80 | 387 | 0.55 |
| 10 | 387 | 0.72 | 385 | 0.48 |
| 11 | 387 | 0.69 | 396 | 0.44 |
| 12 | 387 | 0.59 | 396 | 0.33 |

$i$ = transition from $i$ to the $i^{th}$ +1 calving; $CI_i$= average calving interval in days; $p_i$= average probability of survival to the next calving.

## 5. Models and software used

### 5.1 Fertility

Fertility was analysed with a bi-trait linear animal model including HCS and PCS. Fixed effect definition for HCS included contemporary group (combining AI herd, AI campaign and AI subgroup within herd), age at AI in classes (before 17 months, between 18 and 28 months and after 29 months), AI season (6 classes) and day. The same fixed effects were selected for PCS along with other effects relatives to first calving (time between first calving and AI, calving ease and calf sex).

Three random effects were considered in this analysis: AI mating bull, AI technician and animal effect.

### 5.2 Productive life

Number of calvings at 78 months and at 150 months were analysed with animal linear mixed model with the following fixed effects: age and herd year effect at first calving, average of calving ease along the cow career.

For both fertility and productive life, genetic parameter estimations were run with ASREML software and genetic evaluation with genekit developed by Ducrocq.

## 6. Genetic parameters

### 6.1 Fertility

HCS and PCS genetic parameters were very similar for the different breeds considered with heritabilities of 1.5%. Proportions of phenotypic variance explained by AI sire or AI technician were limited with respectively 0.2% and 0.4%. Genetic correlation between HCS and PCS was estimated at 0.5.

### 6.2 Productive life

Table 3 shows the estimated genetic parameters of NC78 and NC150 for Aubrac and Charolais breeds: heritabilities were equal for the two breeds and NC150 heritability was slightly higher than NC78 one.

**Table 3.** Genetic parameters for number of calvings at 78 or 150 months.

| Breed | Aubrac | Charolais |
|---|---|---|
| NC78 heritability | 0.04 | 0.04 |
| NC150 heritability | 0.06 | 0.06 |
| Genetic correlation between NC78 and NC150 | 0.92 | 0.95 |

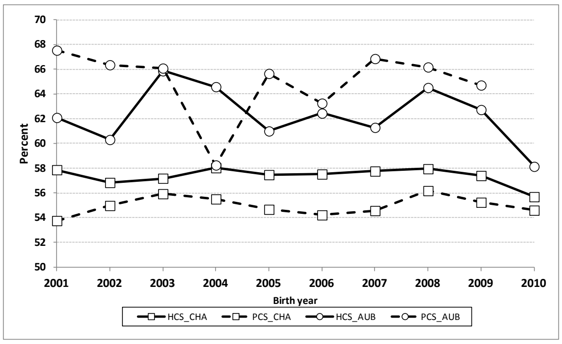
Genetic correlation estimated between NC78 and NC150 were close to 1. Therefore, selection for productive efficiency in early life (NC78) is similar to selection in later life (NC150). Since it can be measured earlier with less cows censored, NC78 was chosen for the genetic evaluation of cow productive life.

## 7. Results

### 7.1 Fertility

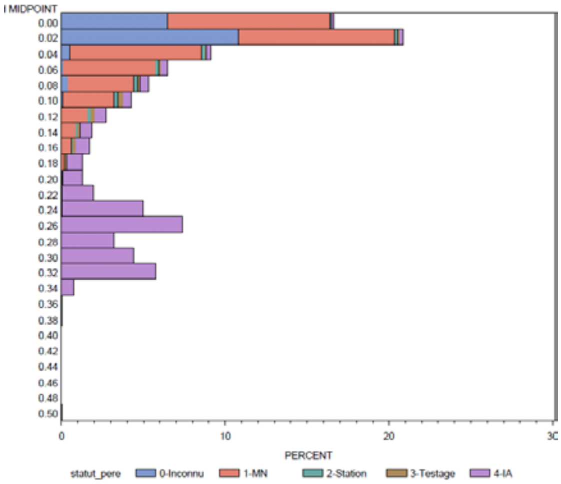
Figure 1 presents heifer and primiparous raw calving successes after first AI for Charolais and Aubrac breeds. In average between 2001 and 2010, Aubrac HCS and PCS were 63% and 65% respectively, while Charolais HCS and PCS were 57% and 55%, respectively.

**Figure 1.** Heifer and Primiparous calving success after first AI for Charolais and Aubrac breeds.



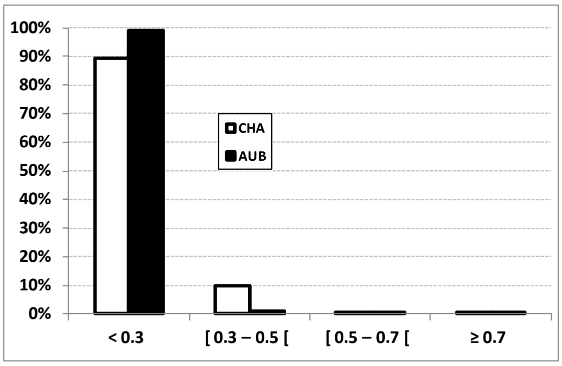

Due to low heritabilities, EBV value range is limited and reliabilities are low. Figure 2 gives the example of the Charolais reliability distribution: a bimodale distribution can be observed with a large majority of the evaluated animals (cows and calves) with very low reliability and a second population with reliability around 0.27: this second animal group corresponds to bull population bred by AI sire. The same pattern can be observed for Aubrac breed with lower average reliability level.

**Figure 2.** Charolais HCS reliability distribution with sire origin detail (0=unknown, 1=Natural Mating sire, 2=sire from test station, 3=sire tested on farm, 4=AI sire).



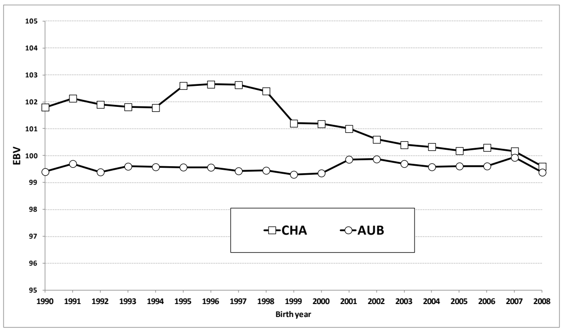

Regarding only sire reliabilities, only 1% for Aubrac and 11% for Charolais of the evaluated sires have reliability above 0.3 (Figure 3).

**Figure 3.** HCS Charolais sire reliability distribution.




Since 2000, no genetic trends can be observed for both Charolais and Aubrac breeds on Figure 4.

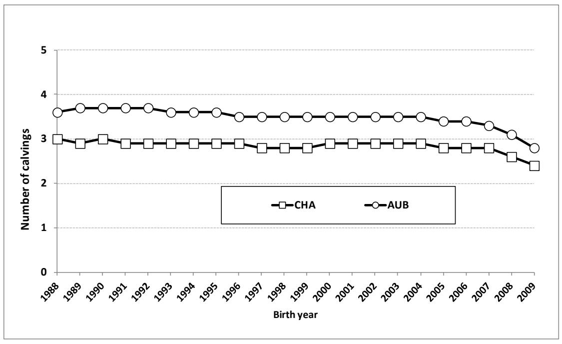
**Figure 4.** HCS estimated genetic trends for Charolais and Aubrac breeds *(EBV were standardized with mean of 100 and genetic standard deviation set to 10).*




## 7.2 Productive life

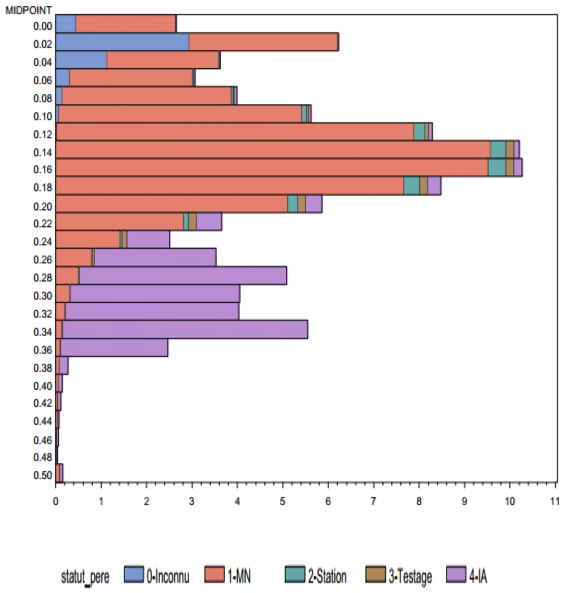
The average numbers of calvings at 78 months have been estimated to 2.8 ± 1.2 for Charolais and 3.4 ± 1.0 for Aubrac. They are stable between 1988 and 2009 (Figure 5).

**Figure 5.** Average number of calvings for Charolais and Aubrac breeds at 78 months.



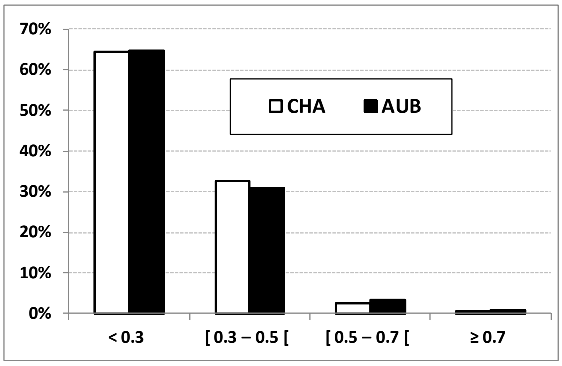

Due to the fact that NC78 heritability is higher than HCS one, the EBV range and reliability values are larger but stay low for both breeds. Figure 6 shows the same reliability pattern than for HCS.

**Figure 6.** NC78 Charolais reliability distribution.



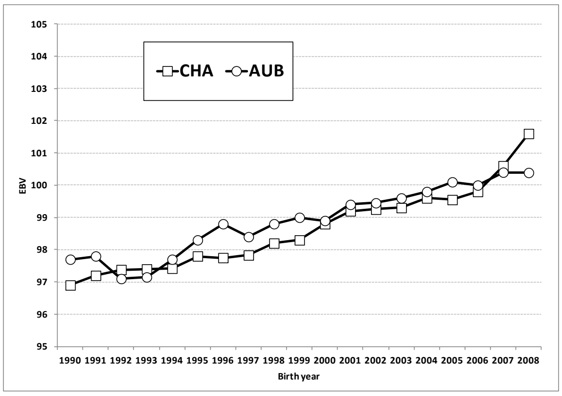

In case of NC78, Aubrac reliability is about of the same level than the Charolais one. Sire reliability distributions for both breeds are equivalent with around 36% of the sires with reliability above 0.3 (2,898 Aubrac sires and 25,502 Charolais sires).

**Figure 7.** NC78 Charolais sire reliability distribution.




In terms of genetic trends for NC78, an increase of half a genetic standard deviation can be observed between 1990 and 2008 for both breeds (Figure 8).

**Figure 8.** NC78 estimated genetic trends for Charolais and Aubrac breeds *(EBV were standardized with mean of 100 and genetic standard deviation set to 10).*




## 6. Conclusion

All ingredients are available now to implement national genetic evaluation of fertility and productive life.

However, low heritabilities associated with low reliabilities for both traits will restrict in practice the use of the evaluation results mainly to selection of bull and cow sires.

## 7. References

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