New algorithm to plan easier and faster weighing for French breeders and technicians

A. Delpeuch[1], M. Legris[1], G. Augier[2], L. Jeannot[3], D. Delgoulet[3], M. Le Hung[3] and L. Griffon[3]

[1]Institut de l'Elevage, 149 rue de Bercy, 75 595 Paris, France
[2]Eliance, 149 rue de Bercy, 75012 Paris, France
[3]Races De France, 149 rue de Bercy, 75012 Paris, France
Corresponding Author: Arnaud.delpeuch@idele.fr

Abstract

Beef cattle breeding accounted for 3.7 million cows in France in 2022 (1), including 1 million with certified pedigree (CPB), and 435,000 in Beef Cattle Recording (BCR). Each year (2022), more than 1 million calves were weighed up to weaning, giving 331,000 Adjusted Weights at 210 days (AW210). In 2021, the CALPAT project provided new flexible rules for calculating AW and a reliability indicator was developed (2). These recent developments have increased the number of AWs but have heightened the already existing difficulties for technicians and breeders to plan weighing sessions. To solve these problems and facilitate weighing planning, the PATApi project was adopted by «France Genetique Elevage», to provide a high-performance tool for planning weighings up to weaning.

At the beginning, we initially focused on the needs of network advisors with regard to weighing planning. The main features expected from the algorithm are:

- A forecasting tool, able to provide theoretical weight dates based on the previous year's births.
- Regular updates based on actual births and weighings.
- A list of animals with dates of birth and parameters.

At the output, provide optimal passage dates, decision-support elements such as the ratio of animals with AWs, their average reliability, and graphical representations enabling dynamic adjustment by the user.

At the same time, an exploratory analysis of available methods identified the exhaustive search for dates as a solution, particularly for providing dynamic graphical representations. However, this method would involve considering more than 4 billion possible combinations for a 4-month distribution of births and require 4 different passage dates to estimate AWs. An initial optimisation phase enabled us to detect the optimum periods (represented by their median date) rather than the exact dates, and to considerably reduce the number of combinations tested. Finally, the stochastic 'simulated annealing' method completely adapted to this problem, provided the optimum number of weighings and the corresponding weighing dates, with a very significant improvement in calculation times. On the downside, this method does not allow dynamic adjustment by the user. In practice, the performances obtained are satisfying between 3 and 5s for a farm of 60 animals with 3 weighing dates.

Once improved, this algorithm, developed in R language, was packaged and encapsulated in an API. This will interact with any software able to transmit a list of animals and the expected input parameters. Commissioning is expected as from 2024

and it will facilitate the work of technicians and breeders alike from the start of the next birth campaign.

Keywords: algorithm, weighing planning, adjusted weight, beef cattle recording.
Presented at the ICAR Anual Conference 2024 in Bled at the Session 1b: Decision Support Tools of the Future – Promoting Sustainability Farm Management

Introduction

In 2022, Beef Cattle Recording (1) in France accounted for 6,119 breeders and almost 435,000 cows in VA4. The VA4 formula, which combines weighing and scoring around weaning, concerned around 14% of calves born in France. Around 400,000 pre-weaning Adjusted Weights (AW) are calculated each year for just over 1 million weighings, 20% of which are carried out by the farmers themselves. This represents an average of 2.5 weighings for pre-weaning AWs (AW120 days or AW210 days).

Over the last ten years or so, the Beef Cattle Recording business has undergone a threefold change:

- Breeders' expectations of services are increasingly heterogeneous,
- Farms are becoming more specialised, herd sizes are increasing, and labour is becoming scarcer, all of which tends to increase the constraints involved in carrying out the weighing required to obtain technical and genetic results,
- Breeding Societies (BSs), the prime contractors for Beef Cattle Recording, want data collection to be able to meet the selection objectives of their breeds, bringing a new differentiation in process management.

These three points illustrate the major changes underway in Beef Cattle Recording at every level.

Material and methods

The aim of weighing planning on farms is to obtain as many AWs as possible (AW120 days, AW210 days or both), and as reliably as possible (2) with as few weighings as possible, depending on the distribution of births.

Collecting user needs and expectations

To identify user expectations, a stakeholder consultation was organised. After that, 5 main principles were retained:

- The algorithm must allow for a predictive simulation of the dates of passages at the start of the campaign, based on the births of animals from the previous year (N-1).
- It must then be possible to adjust the schedules during the season according to the actual births on the farm and any weighings carried out, depending on the date of the scheduling request.
- It must be able to consider the exclusion of periods from the planning (e.g. summer grazing or grassing phase) and early exits of animals.
- It must be able to operate autonomously based on an API that can be used by any application, based on the minimum data transmitted as input.
- It must offer the possibility of weighting the number of weighings required and their positioning according to the situation of the farm and its structure.

Developing the algorithm in R

The algorithm was developed iteratively. Regular exchanges between the teams (development, management, users) meant that progress could be made step by step, considering the expectations and constraints expressed.

Algorithm input

The algorithm needs 3 files to run (Figure 1).

- The first input file concerns the characteristics of the calculation request. It contains the identifier of the farm and the organisation to which it belongs, the season and breed concerned, and the date and group of the calculation request.
- The calculation parameters are contained in the second file. They specify the AWs to be optimised (search for dates to obtain the maximum of AWs) and the minimum level of reliability of the AWs required. It also contains the dates that are potentially forbidden for weighing (unfavourable periods) or those that are desired, the usual exit ages for calves and the number of weighings envisaged (0 lets the algorithm decide). Finally, it also allows to configure the output according to the desired level of detail.
- The last input file concerns the characteristics of the animals on the farm. It contains their birthdate and previous weighing dates, whether they should be excluded from the planning and whether their birth weight can be used in the AW calculation as first weight.

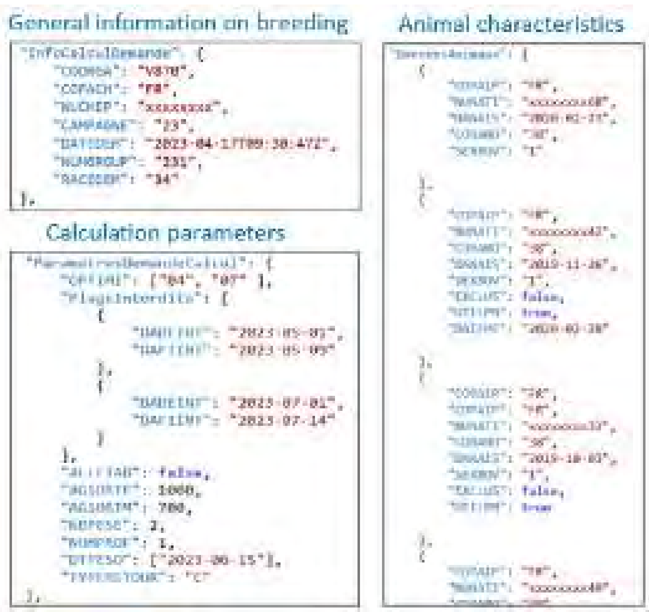

Figure 1. Algorithm input files.

A sorting and selection index

A Sorting and Selection Index (SSI) has been proposed to help objectively choose the best solution. It combines the ratio of AWs obtained, the level of their reliability and the number of weighings required. The SSI is expressed as a value between 0 and 1. Two equations are proposed, depending on whether optimisation of a single or both AWs (AW120 or AW210) is desired:

- For single AW to be optimised:

$$SSI = A * (cC + dD + eE) * \frac{1}{\sqrt{J}}$$

- For two AWs to be optimised

$$SSI = (A * B) * (cC + dD + eE) * (fF + gG + hH) * \frac{1}{\sqrt{J}}$$

With:

A, B: % of AWs (AW120 or AW210) respectively obtained,

C, F: % of these AWs with a high level of reliability,

D, G: % of these AWs with a medium level of reliability,

E, H: % of these AWs with a low level of reliability,

c, d and e: weights applied to each reliability level for AW120,

f, g and h: weights applied to each reliability level for AW210,

J: the number of weighings of the forecasting

Core algorithm

The algorithm has two calculation modes:

1. **Exhaustive and detailed mode**

   In this mode, the calculation is based on a grid containing all solutions according to animal characteristics and demand parameters. The best solution is selected on the basis of the sorting index detailed above. This mode provides more details on the chosen solution, as well as elements for interactive date adjustment. On the other hand, it requires a longer calculation time.

2. **Optimized mode**

   This mode speeds up the process of finding only the best solution (and results around +- 7 days) adapted to the input parameters. It is based on the simulated annealing method (1).

Algorithm outputs

The algorithm output comes in 3 different forms, adapted to the expectations and parameters transmitted at the time of the request. In the “optimized” calculation mode (Figure 2), the optimal date(s) of passages associated with their SSI are returned. In addition, a table of animal frequencies by AW and by level is provided. Finally, results +/- 7 days from the optimal dates are provided to help the technician to adjust the final choice.

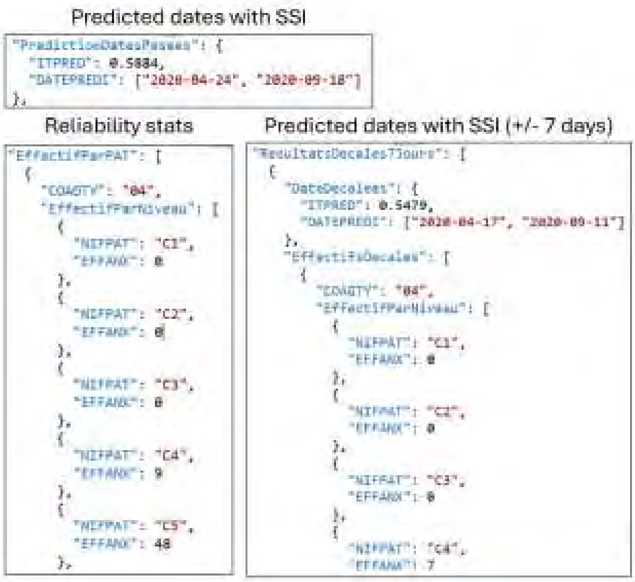

Figure 2. Optimized outputs.

The exhaustive mode (Figure 3) provides an additional output which contains an extraction of the calculation grid (left of figure) enabling the reconstruction of the PAT frequency curves obtained according to the date on which the weighings were carried out.

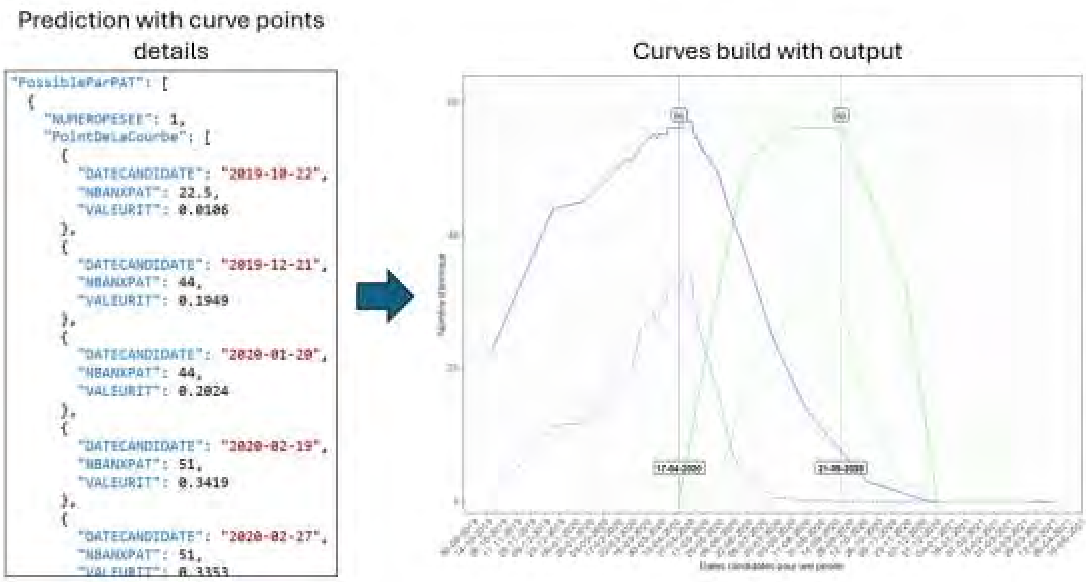

Figure 3. Specific output exhaustive mode.

An RShiny application for testing and visualization

Right from the start of the project, we realised that we needed to develop an

RShiny application. First, it enabled us to understand the need and its context. It was then very useful for considering the various parameters and constraints expressed by the stakeholders. Finally, it was used to test and demonstrate how the algorithm worked as its development progressed.

Results

To evaluate the algorithm’s performance, we randomly selected 45 farms from the 1465 available in the test database. This sample included farms with 40 to 150 calvings and a birth spread of up to 10 months (Figure 5).

Next, the algorithm was called upon 10 times for each mode and each of the selected farms. Then we calculate the median time for each farm, considering only the iterations with the same number of weighings.

Average performance is satisfying, particularly in “optimized” mode. Some farms take a long median calculation time to obtain results (up to 9s) with a large variability range. These are very often large farms with very spread-out birth distributions (up to 180 days). On the other hand, the median calculation time for medium-sized farms, even with an extended birth period, is less than 5s (2.4s vs 4.9s). These tests were carried out on a standard computer and not on a server dedicated to computing (Figure 6).

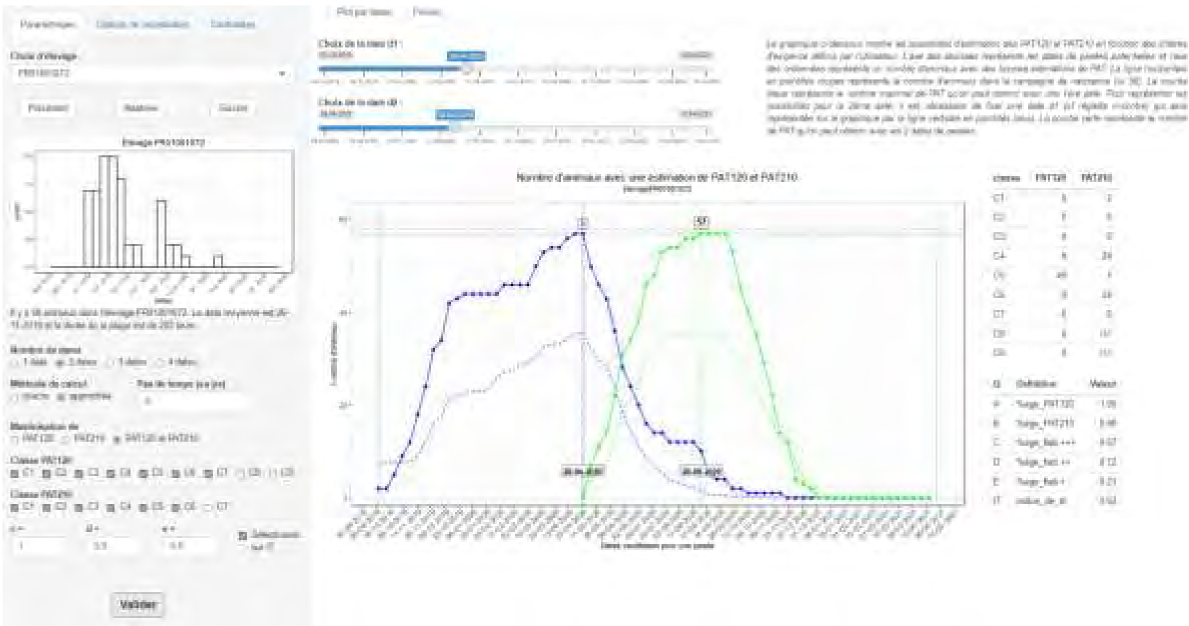

Figure 4. RShiny interface.

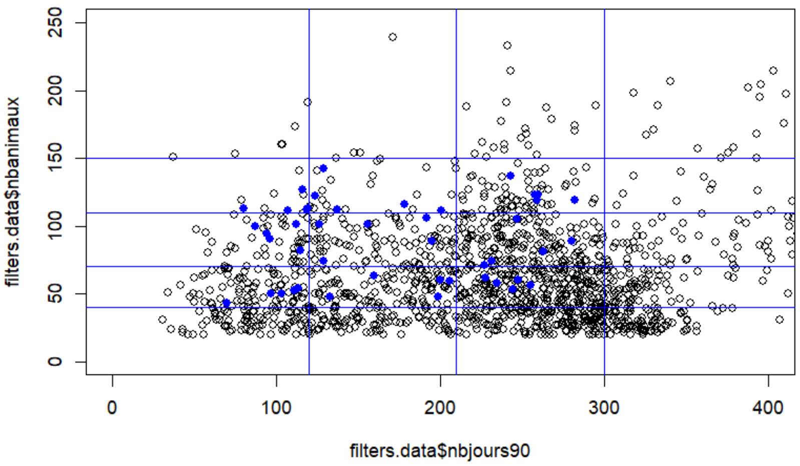

Figure 5. Sampling of test farms.

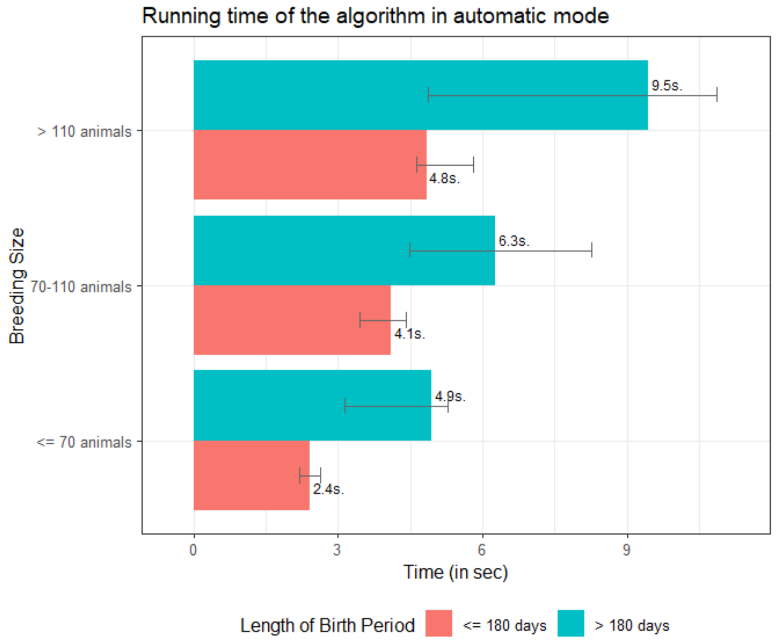

Figure 6. Algorithm runtime in optimised mode comparison.

Discussion and conclusion

We have produced an algorithm (encapsulated in an API) that uses a livestock inventory to determine the ideal weighing dates. This algorithm meets the expectations of professionals. Its flexibility means it can be adapted to a wide range of uses. Some options have not been implemented in this first version, but its modular construction will enable its evolution in the future. The use of parallelized calculations could boost performance and reduce response times. This will certainly be implemented in a 2nd version of the algorithm.

The service is currently being implemented by FGE. The API encapsulating the algorithm should soon be made available to users so that their software can exploit it.

List of references

M. Foucault, 2023, Institut de l'Elevage, "Résultats du contrôle de performances des bovins allaitants - France - Campagne 2022", https://idele.fr/detail-article/resultats-du-controle-de-performances-des-bovins-allaitants-france-campagne-2022

A. Delpeuch, 2021, Institut de l'Elevage, "Prise en compte de la qualité des données de naissance dans le calcul des PAT et des index IBOVAL", https://idele.fr/detail-article/prise-en-compte-de-la-qualite-des-donnees-de-naissance-dans-le-calcul-des-pat-et-des-index-iboval

S. Kirkpatrick, C. D. Gelatt et M. P. Vecchi 1983 « Optimization by Simulated Annealing », Science, vol. 220, no 4598, p. 671–680 (ISSN 0036-8075 et 1095-9203, DOI 10.1126/science.220.4598.671