Underlying factors influencing the technical parameters of organic rabbit farms in France

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MSc Thesis

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ORGANIC RABBIT FARMS IN FRANCE

The underlying factors influencing the technical parameters.

Based on 9 study-cases

Figure 1 : Example of maternity system in an organic rabbit farm located in the North of France

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Abstract

The organic rabbit production was unknown and few researches were carried out. In this exploratory study, the first aim was to describe the organic rabbit production systems in France and characterize their technical parameters. Secondly, we researched the main factors influencing these parameters. To reach these goals, data from 2012 to 2017 from 9 organic rabbit farms were compared with data from 2014 from conventional rabbit farms. The organic farmers were interviewed twice.

Mainly located in the North-West of France, 22% the organic rabbit production and 33% of the conventional ones bred only rabbits: It is a secondary production. Organic rabbit production was a new developing niche market, with about 30 farmers in France in 2017 and 66% of them settled after 2013. Their systems were extensive with 4 to 10 adults/ha compared to 20 rabbits/ha of the conventional farms. Unlike rabbits in organic systems, conventional rabbits were kept in a highly controlled environment in closed buildings (>99%). In 89% of the organic farms, does were kept in movable cages and 100% of the meat rabbits in parks.

The reproduction management was flexible in organic farms. The technical performances were lower than in conventional farms. All farms had different technical performances but none of the farm was significantly performing better than the others. Overall, fertility rate was 57% for organic farms. Per parturition, 8.8 kits were born, among them 8.0 were alive and 6.2 weaned. In conventional farms, numbers were higher: 10.7 total born, 10.1 born alive and 8.6 weaned. Mortality rates were a lot higher in organic litters than in conventional.

Multiple factors influencing the technical performances have been identified in organic farms. The genetic potential (fertility, prolificacy, meat conformation, growth rate) seemed to be the most important. Then the sanitary issues (diseases, parasites and predators) were an important concern due to sudden and irregular episodes with heavy consequences. Other factors pointed out were the working time, the feed quality and quantity, the farmer experience and the access to information.

Keywords:

Organic

Rabbit farms

France

Exploratory study

Technical parameters

Influencing factors

Table of acronyms and abbreviations

%: percentage
$\bar{x}$: average
€: euros
ADG: Average daily gains
AELBF: French organic rabbit farmers association
ANOVA: Analysis of variance
AW: Age of weaning
conv: conventional
DOF: Degrees of freedom
g: grams
h: hours
ha: hectares
IA: artificial insemination
IA+: farms using artificial insemination with 400-650 does
ID: identification
IKK: Interval between two kindles
IKS: Interval between kindle and the next service
INRA: French agronomic research center
ITAVI: Technical institute of poultry, rabbit and fish productions
KBA: Kits born alive (per kindle)
KBT: Kits born in total (per kindle)
kg: kilograms
KS : Kits weaned (per kindle)
KSL: Kits starting the lactation period (per kindle)
LSD (Least significant difference method
n: number of data of the sample
PB: Production time of bucks
PD: Production time of does
Q-Q: Quantile-Quantile
R^2: Coefficient of determination
RENACEP: French rabbit farmers association for productions managed in batches
RENALAP: French rabbit farmers association for productions managed individually
SWOT: strengths, weaknesses, opportunities and threats
UAA: Utilized Agricultural Area
VHD: Viral hemorrhagic disease
vs: versus
y: year
s: standard deviation

Preface

This work was part of the EURAMA (European Animal Management) Master which was a partnership between Ecole d'Ingénieurs de Purpan (Toulouse, France) and Wageningen University (Wageningen, The Netherlands). My specialization was APS (Animal Production Systems) and I did my minor thesis in FSE (Farming Systems Ecology).

Firstly, I would like to thank Fokje who supported me all the way long. I liked your supervision. Your advices and comments were very interesting and allowed me to end up with a very satisfying report. Thank you a lot.

Then, I would like to thank Thierry. I enjoyed the time spent at the INRA center and I really liked the organic rabbit production. For sure, I'll include this into my future farm!

Thank you Davi for your help on the statistics and Lucie for your reviews.

Also, I would like to thank my parents who made this study program possible. This was the end of my studies and the beginning of a very new life that I'm impatient to start.

Finally, I would like to thank Sophia who was always there for me.

1. Introduction

1.1 Rabbit production and consumption

World rabbit meat production was about 1.8 million tons/y, corresponding to 100 million animals (Dalle Zotte, 2014). 49% of this production was in Asia, 28% in Europe, 18% in America and 5% in Africa. Rabbit meat in France represented around 600 million euros per year, which was about 37 million animals, including 15 000 to 20 000 organic rabbits (CLIPP, 2017a). There were 1 200 French farms with more than 200 reproductive females (CLIPP, 2017a).

Even if rabbit meat was part of French culture (CLIPP, 2017a), the overall consumption decreased over years (Braine and Coutelet, 2012). It progressively went from 1.1 kg/capita/y in 2009 (Lecerf and Clerc, 2009) down to 0.8 kg/capita/y in 2015 (Hurand *et al.*, 2015). It was less than the worldwide average consumption of 2.3 kg/capita/y (Dalle Zotte, 2014). However, the organic rabbit market increased from 19 French organic farmers known in 2011 (Roinsard *et al.*, 2016) to 30 rabbit organic farmers with 10 to 90 does in 2017 (Gidenne, pers. comm.). To continue and strengthen the development of this promising market, organic farmers created a farmer association (AELBF) (www.aelbf.fr).

Since the 90s, conventional production methods in France have changed from small and traditional ways of farming to bigger farms with automatic systems, artificial insemination, and management in batches (Fortun-Lamothe and Gidenne, 2008). Evolution had been driven by two main traits of the rabbit: its high prolificacy and high health fragility (CLIPP, 2017a ; Dalle Zotte, 2014). Since the 80s, the factors influencing the technical parameters in conventional farms have been studied. It led to considerable improvement of the performances of conventional farms (Braine and Coutelet, 2012). Animals were usually kept in closed buildings with dynamic ventilation and sometimes heating and cooling systems (ITAVI, 2015b). In 2014 and still in 2017, 93% of conventional farms were organized with a single batch of does every 6 weeks (42d) as described in Figure 2 (ITAVI, 2015a, Gidenne, pers.comm). 77% of the conventional farms applied the all in / all out procedure: one room or building is completely emptied in order to disinfect and clean the facilities.

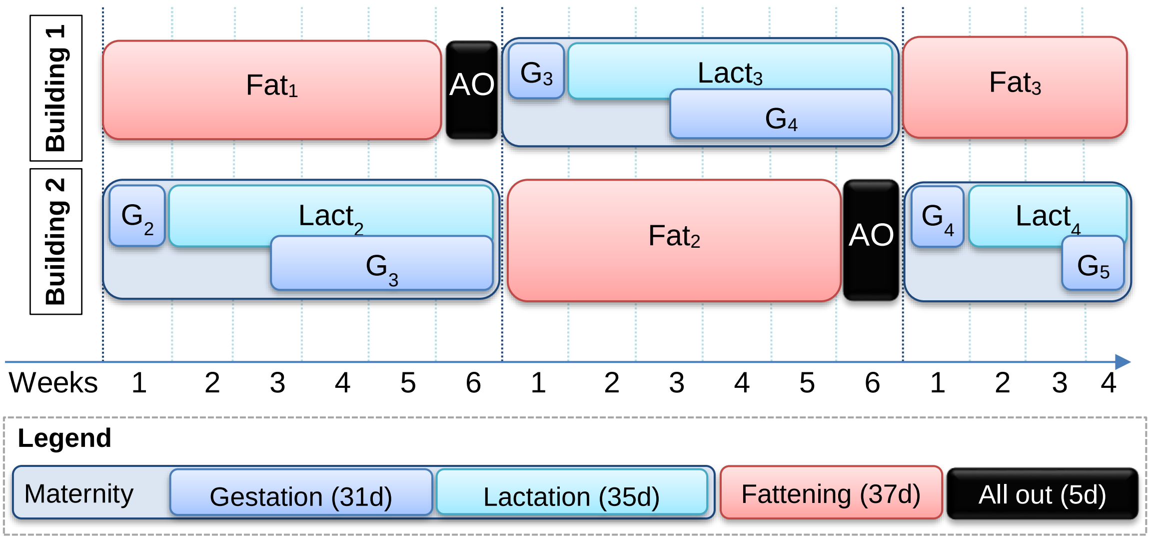

Figure 2 : Work organization of a single batch in 42 days (Le point vétérinaire, 2017).

For organic rabbit production in France, there was no relevant and reliable technical information about feed strategies, grazing methods and zootechnical performances available (INRA, 2017 ; Martin *et al.*, 2016 ; Roinsard *et al.*, 2016). This lack created a brake to the improvement of French organic rabbit farms and settlement of new farmers. The INRA center (*National Research Center of Agronomy)* of Toulouse was running a program called CUNIPAT to get insights into the organic rabbit production in France.

1.2 CUNIPAT project

CUNIPAT was a project initiated by the AgriBio4 (INRA, 2017)**.** The AgriBio4 program aimed to characterize the performances of organic production in France in order to better support them. CUNIPAT has been funded for 3 years from October 2015 until October 2018 (INRA, 2017). This thesis research was part of this project.

CUNIPAT aimed to compensate the lack of data and indicators concerning organic rabbit farming (CLIPP, 2017a). A better understanding of the organic rabbit production offered possibilities for systems improvements and enhancement of settlement of new farmers. The project was divided into 3 steps (INRA, 2017):

1. Build a computer based tool to create a technical baseline. The researchers aimed to provide relevant and reliable technical indicators.
2. Build simple tools for pests and diseases diagnosis and for the calculation of associated risks.
3. Produce a dynamic simulation model considering the results of the previous steps.

To achieve the different objectives of **CUNIPAT**, partnership had been set with the University of Perpignan, ITAB (*Technical institute of organic agriculture),* AELBF (*Organic rabbit French farmers' association) and the* CAB (*Organic association of Pays de la Loire).*

As part of the first step of the project, the research carried out in this study aimed to:

Identify the factors influencing the technical parameters in organic rabbit farms in France

The sub-research questions were:

What are the existing organic rabbit production systems in France?

What are their current technical performances?

What factors could influence the production parameters?

2 Materials and Methods

After a literature research, the organic rabbit farmers were individually visited or called. Data about the overall functioning of each farm were collected and farmers were asked to identify the underlying factors influencing their performances (Figure 3). Their daily records were also collected and gathered in a database using Excel. Farmers were met a second time in pairs to discuss their technical performances and collect additional information about the influencing factors mentioned in the first questionnaire. Finally, all the data collected were analyzed and the report was written.

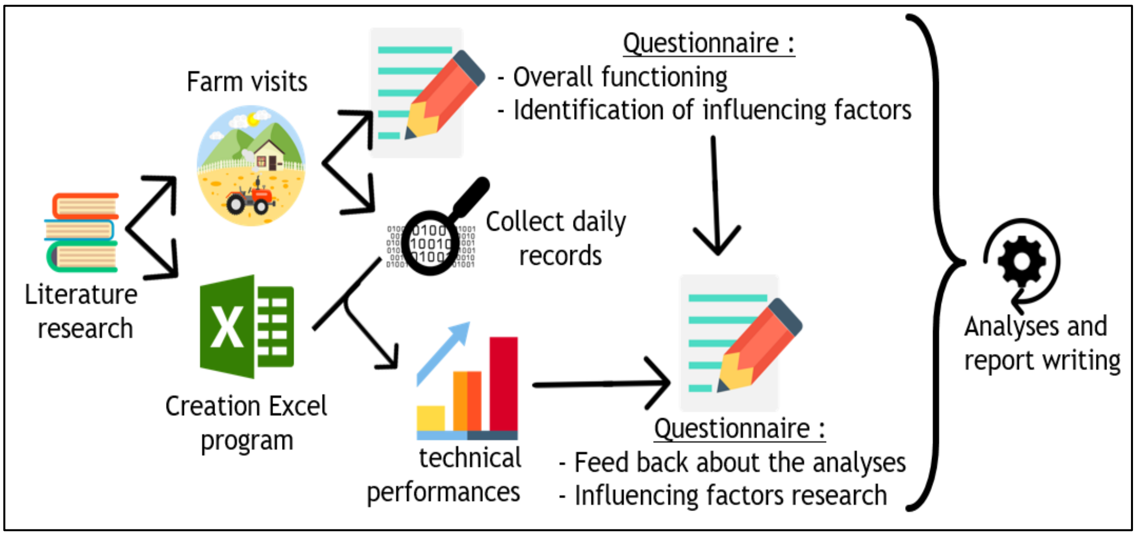

Figure 3 : Methodology to identify the factors influencing the technical parameters of French organic rabbit farms

2.1 Literature research

This research started with a literature research to get insights and gather knowledge available on organic and conventional rabbit productions in France. Some articles provided by the CUNIPAT project were the starting point and then **Google Scholar** and **Web of sciences** were used as additional information with the following key words: RABBIT, ORGANIC, FARM, SUSTAINABILITY, BREEDING, MANAGEMENT, DATA, BASELINE, ECONOMICS, SOCIAL, TECHNICAL, DATABASE.

2.2 Selection of farmers

CUNIPAT project approached farmers and selected the farms on the following criteria:

1. <u>Be certified organic.</u>
2. <u>Be in mainland France.</u> In overseas regions, production systems might be very different due to different social, economic and environmental conditions.
3. <u>Have farm records for at least 3 years.</u> The aim of this study was to calculate annual technical parameters, so records were necessary.
4. <u>Have a continuous professional production</u>.

5. Currently produce. One of the aims was to discuss the results of this study with the farmers and reflect on useful changes on farm that can be followed on the coming years.
6. Be willing to participate.

Only 4 farmers in the contacts of CUNIPAT, met the 6 criteria. Farmers meeting 4 out of 6 criteria had been kept and were used for different purposes depending on the data they got (Table 1).

Table 1 : Selected farms for the study

Criteria / Farm	A	B	C	D	E	F	G	H	I
Certified organic	✓	✓	✓	✓	✓	✓	✓	✓	✓
Location	✓	✓	✓	✓	✓	✓	✓	✓	✓
Availability of records*	✓	✓			✓	✓			✓
Continuous production	✓	✓	✓	✓	✓	✓	✓		✓
Currently producing	✓	✓		✓	✓	✓	✓	✓	✓
Willingness to participate	✓	✓	✓	✓	✓	✓	✓	✓	

** The data available depending on the period are available in appendix 1.*

Eight farmers had been met in pairs. Farmer C was not available for interviews, he however sent his farm records. Farmer I did not want to fully collaborate but she invited us for a farm visit where some information was collected. Farmers were met twice (except farmer I).

In May 2017, visits took place in:

- Farm I: with farmers I and A,
- Farm D: with farmers D and G,
- Farm E: with farmers E and H.

Farmers B and F had been contacted by phone.

In October, the second visits were in:

- Farm H: with farmers H and E,
- Farm B: with farmers B, D and G,
- Farm F: with farmers F and A.

2.3 Data description

Data collected originated from the farmers' daily records, two questionnaires (first and second visit) and few additional elements from informal discussions.

2.3.1 Daily records

Each farmer developed their own way of recording daily events (Appendix 1): agendas ordered by day, farm books ordered per event (service, birth, weaning, slaughtering) and/or doe sheets with the list of events for each female.

Daily records were collected for 6 farms (A, B, C, D, E and F). The variables most commonly recorded were used for this research and ordered within 3 categories (Table 2). Appendix 2 points out the quality and quantity of data available for each farm and per period of time.

Table 2 : Variables selected for the research from the on-farm records of 6 organic rabbit farms (A, B, C, D, E and F).

Adults	Maternity	Fattening
ID animal Gender Breed Origin[*1]	ID farm ID doe and ID buck Dates of service, birth, weaning Number of: Kits born (KBT) including alive kits (KBA) Kits eliminated or/and adopted Kits starting lactation period (KSL) Kits weaned (KW)	Date of arrival Date of slaughter ID park ID group Number of: Rabbits entering Rabbits dead Rabbits slaughtered

*[*1] It can be from the farm (auto-renewal) or bought outside.*

These data were gathered and checked with an Excel program, called the database in this report and organized in three parts. For the maternity, each record was an event which started by a date of mating of an identified doe and buck. It contained the details about mating, parturition and weaning when available. About 4 000 events were recorded, all periods and farms considered. For the reproductive animals, one record corresponds to one doe or buck, therefore it starts with its ID animal and then all its characteristics. There were 719 does and 133 bucks included in the database. Finally, for the fattening part, only data for farm A were available and it was therefore impossible to compare farms.

2.3.2 Questionnaires

Both questionnaires had been filled individually by 7 farmers (A, B, D, E, F, G, and H).

2.3.2.1 First questionnaire: Overall functioning of farms and influencing factors of the technical parrameters

The aim of the first questionnaire was to gather data about the overall functioning of the farms regarding their structure, economy, animal management and work organization.

Firstly, the variables selected to assess the farm structure were:

- The date of settlement of the farmer and of the rabbit activity
- The other productions on-farm
- The Utilized Agricultural Area (UAA) (ha), also called land use, including the areas grazed by rabbits, used to make hay and used to grow cereals for rabbit feed
- Average number of does and bucks on-farm on a daily basis
- Description of the housing systems used for maternity and for fattening

For the economy, few variables had been selected due to the difficulties of the farmers to dissociate the rabbit activity from his other production:

- Selling price of organic rabbit meat (€/kg carcass)
- The overall turnover (€/y) and the turnover of the rabbit activity (€/y)

For the animal management, farmers estimated their practices concerning:

- Age of first service for a new doe (days)
- Age of culling of does (days)
- If the farmer eliminates weak kits or/and homogenizes litters
- The ideal number of kits to start the lactation

- Interval between kindle and the next service (days)
- Age of weaning and slaughtering (days)
- Alive and carcass weights of rabbits at slaughter (kg/rabbit)

For the work organization, the questions were based on the method of Courmut and Jordan (2008) and its application by Dedieu *et al.* (2015). Each farmer was asked:

- If he gets support for the rabbit activity (h/y)
- If he goes to formations, meetings, etc. (h/y)
- If he gets help (family, trainees, employee) and how much (h/week)
- The time spent on the following tasks (h/ week): feeding animals, lactation controls, parturitions, heavy cleaning, daily checking, light cleaning, installation of the nest boxes, casual tasks, weaning, natural mating, other usual tasks, recording data, weighing animals, palpating, selling and culling, health care to sick animals, females' rotations, disinfection.

In addition with these data, each farmer was asked to identify what were the main factors influencing the technical performances.

2.3.2.2 Second questionnaire: In depth analysis of the influencing factors

At the end of the research, results were presented to the same 7 farmers and their feedbacks were collected. Based on the influencing factors mentioned in the first interview, a second questionnaire was created to further investigate:

- The feed: type of feed, feed price (€/ton), quantity bought (tons/y), the quantity daily distributed to reproductive animals and to fattening rabbits (gr/day/animal).
- Top 5 of their current criteria of selection of the does and bucks;
- Disease management:
    - Frequency of the outbreaks of the current diseases of rabbits
    - Vaccinations against VHD and myxomatosis
    - Deworming

To conclude, the farmers were asked to identify the strengths, weaknesses, opportunities and the threats of the organic rabbit productions.

2.4 Statistical analyses of the production indicators

2.4.1 Production indicators definition

Based on the type of daily data collected (Table 2), on a previous research done on the same topic (Morvan, 2016) and on the baselines of conventional rabbit farming (Jentzer, 2008; Coutelet, 2015), the following indicators had been selected:

- **Production time** for does (PD) and bucks (PB): time between the first service recorded and the last service or kindle or weaning date recorded for the animal.
- **Interval between kindle and next service** (IKS)**:** main indicator to assess the intensity of use of the does.
- **Interval between two kindles** (IKK)**:** indicator of female's performances including productivity and farmer management.
- **Total number of kits born** (KBT), kits **born alive** (KBA)**,** kits **starting the lactation** period (KSL) and **weaned kits** (KS) per parturition.

- The **age at weaning** (AW)**:** time the kits spent with their mother. Then, they enter the fattening facilities.

Three ratios were calculated based on the averages kits per litter for each farm:

- *Stillborn rate (%) = [total kits born – kits born alive] / [total kits born]*
- *Re-arrangement rate (%) = [kits born alive – kits starting lactation] / [kits born alive]*
- *Lactation mortality rate (%) = [kits starting lactation – kits weaned] / [kits starting lactation]*

To assess the accuracy of farm management, sayings of farmers about their production were compared to the indicators calculated. Therefore, farmers were asked to estimate these indicators in the questionnaires.

2.4.2 Characterization of the distributions

The normal distribution is an ideal artificial distribution of continuous variables (Labreuche, 2010). The production times (PD and PB), intervals (IKK and IKS), number of kits (KBT, KBA, KST, and KW) and age of weaning (AW) were discrete variables. None of the classic tests (Shapiro, Wilk, Anderson-Darling, Lilliefors, Jarque-Bera) to assess the normal distribution came out significant. To visually determine if the distribution could be assumed normal, the Quantile-Quantile (Q-Q) plot method was used (University of Virginia Library, 2015). The Q-Q plot is the ratio between the distribution of the data and the normal distribution. Example of Q-Q plot were given in appendix 4. More the coefficient of determination (R^2) was close to 1, the more the data were normally distributed. The number of data (n), availability of records for each indicator and the indicators assumed to be normally distributed were detailed in Table 3. Some data were missing for farms D and F.

Table 3 : Total number of data (n) and their distribution for the 9 indicators related to maternity in organic rabbit farms.

Indicators	**Farms participating**						**n**	**Norm[*1]**
Production time of does (days)	A	B	C	D	E	F	718	No
Production time of bucks (days)	A	B	C	D	E	F	71	No
Interval kindle-service (days)	A[*2]	B	C	D	E	F	2 694	No
Interval between kindles (days)	A[*2]	B	C	D	E	F	1 619	No
Total number of kits born	A	B	C		E		1 400	Yes
Number of kits born alive	A	B	C		E		1 404	Yes
Number of kits starting lactation	A	B	C		E		1 391	Yes
Number of kits weaned	A	B	C		E	F	1 469	Yes
Age at weaning (days)	A	B	C		E	F	1 425	Yes

*Records for farms G, H and I were not available. [*1] Indicates if the distributions of indicators were normal.*
*[*2] Data older than 2 years were eliminated.*

To represent within one diagram several parameters, boxplots were chosen (Labreuche, 2010). For the data not normally distributed (R^2<0,9), the box plots were presented in the results. Medians were used instead of means. For data normally distributed (R^2>0,9), the means ($\bar{\mathbf{x}}$), standard deviations (**s**) and number of data (**n**) were presented in tables. The boxplots were in the appendices.

2.4.3 The indicators influenced by farmer decisions

The age of weaning (AW) and the intervals (IKK and IKS) were indicators highly depending on the farmer management. Therefore, testing these data was not relevant (Savietto, Pers. Comm.). For each of these three indicators, histograms were made with classes made by converting days into weeks and then truncating. To assess the accuracy of farmer management, the week corresponding to the farmer estimation was added on the histograms. Farmer D was left apart due to the little information concerning the intervals (IKK and IKS).

To a lesser extent, the production time of does was relying on farmer decisions. The reason why the doe left the system and the exact date were not available. The doe could have died, been culled or the data collection was over. Therefore, the Kaplan-Meier (Goel *et al.*, 2010) method was used to point out the differences in the production time of does between the farms. This method could not be used for bucks due to the small size of the samples.

2.4.4 The number of kits

Four analysis of variances (ANOVA) were performed an alpha of 5%. The only factor studied was the farm and the Y were the number of kits in maternity: born in total (KBT), born alive (KBA), starting lactation (KSL) and weaned (KW). For KBT, KBA and KSL, farms A, B, C and E were considered and for KW farm F was added. To perform an ANOVA according to the explanations of Ramousse *et al.* (1996), the null hypothesis H_0 for the ANOVA was stated: the means of each farm were equal for a given indicator. Then, the Fisher LSD (Least significant difference) method was used to further research this difference by comparing means in pairs with an alpha of 5% (Ramousse *et al.*,1996).

2.4.5 The fertility

The calculation made was: *Fertility (%) = Number of successful services / Total services*

Farm A did not register the unsuccessful services from 17/03/2016 to 08/06/2016 (Table 4). Therefore this period was eliminated for this analysis.

Table 4 : Periods selected for the calculation of the fertility rate of 6 organic rabbit farms.

Farm	Period kept	Duration (y)	n
All	All mentioned below	3.8	3 136
A	15/09/2015 – 16/03/2016 ; 08/06/2016 – 28/04/2017	0.9 + 0.5 = 1.4	615
B	13/01/2015 – 15/06/2017	2.4	565
C	04/11/2013 – 02/01/2016	2.2	908
D	20/12/2014 – 05/05/2016	1.4	66
E	12/09/2013 – 12/05/2017	3.7	309
F	18/04/2014 – 22/07/2017	3.3	673

Records for farms G, H and I were not available. "n" is the number of total services recorded.

To study the seasonal effect on fertility, dates of service were transformed into seasons: Spring (starting on March 20th), Summer (June 21st - September 21st), Autumn (September

22nd – December 20th) and Winter (December 21st – March 19th). Then, the fertility rate was calculated for each farm and each season.

To test the seasonal effect, the chi-square test for independence was used as explained by Diener-West M. and Hopkins J. (2008). Per farm, the four seasonal fertility rates were compared to the year fertility rate (3 degrees of freedom). The same was done taking all organic farms together. In other words, seven contingency tables were made (A, B, C, D, E, F, All farms).

2.5 Questionnaire calculations

The answers from farmers to each question were shown in tables clustered by themes. When the farmer could not give an answer, "-" appeared. Based on the answers, several calculations were made:

FTE = Working time of the farmer and other people / 35

Work productivity (Does/FTE) = Average number of does / FTE[*1]

The FTE (Full Time Equivalent) was calculated based on a 35h/week. The time spent on each task was recorded in hours/week. It had been transformed into percentage of the total amount of work on farm (farmer + outsiders).

2.6 Analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT analysis)

As described by Johnson *et al.* (2015), the SWOT analyis provides a framework to examine internal strenghts and weaknesses of the organic rabbit sector. This analysis allowed also to point out the external opportunities ans threats. The first step was to synthetize the specific issues mentionned in the individual SWOT filled in by farmers. The elements were organized by themes within the framework. Finally, a confrontation matrix was done to analyse the SWOT synthesis according to the method of Johnson *et al.* (2015). The presumption was that nobody can influence the external situation. Hence, the effects of the external elements on the internal situation were described and valued for each strenght and weakness. The underlying questions to build the confrontation matrix were:

- How can I utilise the strengh to benefit from the opportunity? (To attack)
- How can I utilise the strenght to ward off the threat? (To defend)
- How can I strenghten the weakness in order to benefit from the opportunity? (To strengthen)
- How can I strenghten the weakness in order to ward off the threat? (To be careful)

2.7 Stakeholder analysis

The stakeholders are the persons, groups or organizations that can affect or be affected by the decisions regarding the issue at stake: the development of the organic rabbit sector in France. Based on the method explained by Johnson *et al.* (2015), informal discussions with farmers and Gidenne (responsible of CUNIPAT), the potential stakeholders were listed. In a second time, the stakeholder mapping was used to provide a summary of how different stakeholders affected/were affected by the development of the organic rabbit sector. Two criteria were used: the interests and the power. Interests are how likely does the stakeholder show an interest to support or oppose the strategy. The power is the ability of individuals or groups to persuade, induce, or coerce others into following certain actions.

2.8 Conventional data

In order to compare the technical performances of the organic rabbit farms studied, conventional studies of ITAVI (2015a, 2015b) were selected. However, some of the numbers needed to be transformed to be compared with the indicators calculated for organic farms. The following calculations were made:

$Production\ time_{does}$ *(days) = 100 (%) / [renewal rate (%)] * 42 (batch period - days)*

$Time_{rabbit}$ *(h/week) = [Working time/doe/y] * [Number of does] / [52 (weeks/y)]*

$Time_{total}$ *(h/week) =* $FTE_{total} * Time_{rabbit} / FTE_{rabbit}$

3 Results

3.1 System description

3.1.1 Organic rabbit production in France

3.1.1.1 A niche market located in North-West of France

From the literature research, few reliable information was found about organic production. European rules about organic rabbit farming were very general (les agriculteurs Bio de Bretagne, 2014) and no European baseline was available (Roinsard *et al.*, 2016). The regulations related to organic rabbit productions were edited by each country; the French regulation was summarized by ECOCERT (2015) in Appendix 3.

In France, the main production areas were Pays de la Loires (52%), Bretagne (11%) and Poitou-Charentes (16%). These three regions constitute the North-West of France and produce 80% of the rabbit meat produced in France (CLIPP, 2017a). Seven out of the nine farms studied were located in this area (Figure 4).

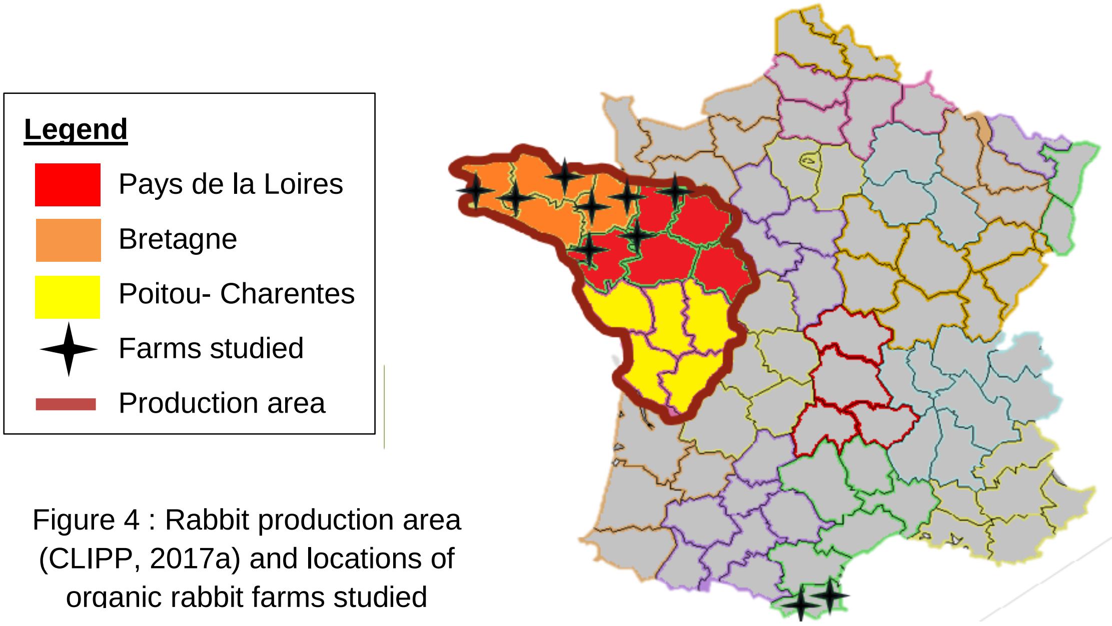

Figure 4 : Rabbit production area (CLIPP, 2017a) and locations of organic rabbit farms studied

3.1.1.2 Overall organization of organic farms : maternity and fattening parts

There was no batch in organic farms such as in conventional. In general, each doe was managed individually, in her own cage or park. Once she reached maturity at around 120 days old (Dalle Zotte, 2014), farmer selected a male for mating and left them together for a few minutes up to 10 days, usually in the cage of the buck. Then, she went back into her housing for gestation (31d). Farmers could palpate, but few of them did it, and when done, some mistakes were still noticed. They usually waited for the date of birth to rebreed the empty does. After the end of the lactation (30d), kits stayed with the doe until being weaned. Kits were moved to the fattening area: in cages or parks. Meat rabbits grew until the farmer decided to transport them to the closest slaughterhouse at a minimum of 100 days old, according to the organic specification.

According to interviews, visits and data collected, the system can be divided into two sub-systems: the maternity and the fattening. Within the organic farms and for both sub-systems, the observations confirmed the existence of many different management as explained in literature (Les agriculteurs biologiques de Bretagne, 2014).

3.1.1.3 Organic rabbits activities were part of new, small and diversified farms

Among the nine farms, farm E was the oldest (1978) (Table 5). It was an experimental farm and its purpose was more to educate and perform researches than producing meat rabbits. Farms A, B and C were the leaders of the organic rabbit production and were taken as references for the other farmers. Finally, farms D, F, G, H and I were considered as new farms and were still experimenting.

Among the 9 farms, only 2 were specialized and only produced organic rabbit meat (Table 5). In other words, it was often a secondary production (Appendix 5 – Table 23) such as 2/3 of the conventional rabbit farms in France (CLIPP, 2017a). The other productions were mainly sheep (A, B, F), cattle (A, F, conv), goats (D), plant productions (E, conv) (ITAVI, 2015b).

The grassland was often used both for rabbits and the other livestock. The number of reproductive animals varied from 20 up to 90 does but reached neither the specification limit of 200 does (Ecocert, 2015) neither the 528 does in average of conventional farms in 2014 (ITAVI, 2015b).

Table 5 : Creation date and size of the 8 organic farms studied (data 2017)

	A	B	D	E	F	G	H	I	Conv*2
Creation rabbit activity	2000	2013	2015	1984	2014	2015	2016	2015	1996
Land for rabbits (ha)	7,5	2,4	4,0	3,0	5*1	13	-	-	26
Number of									
Females	65	30	30	20	35	50	30	80	528
Males	11	6	4	4	4	5	4	-	0
Adults/ha	10,1	15,0	8,5	8,0	7,8	4,2	-	-	20,3

*"-" indicates missing data. Farmer C did not answer the questionnaire. *1The farmer produces all the feed necessary for his animals but could not identify the share of rabbit feed so no cereals area was taken into account. *2 Average data for conventional rabbit farms (ITAVI, 2015b).*

3.1.2 Housing systems

3.1.2.1 Maternity housing system

Among the nine farms studied, three maternity systems were observed with a majority of individual movable cages (67% farms) (Table 6). The housing system remained the same all the year around. Usually, a doe spent her life in the same place to avoid diseases and bacteria risks as well as stress of a new environment.

Table 6 : 3 maternity systems among the 9 farms studied (systems in 2017)

Systems/ Farms	A	B	C	D	E	F	G	H	I
Individual movable cage	✓	✓	✓				✓	✓	✓
Small park				✓		✓			
Boxes and common practice area					✓				

3.1.2.1.1 Movable cages

The movables cages were built by the farmers or bought to other outside rabbit farmers. They were divided into two parts (Figure 5). The **outside area** represented more than 25% of the cage and was all around covered with nets in order to keep rabbits inside. The **inside area** (Figure 7) was elevated for isolation reasons and divided into two parts again. The nest box was composed of hay or pellets and doe's hairs. The mother's place had a feed distributor, hay for feed, and it was the place where she defecated. Farmers moved the cages one or two times a day to offer fresh grass to the rabbits (Figure 6).

Figure 5 : Example of a movable cage

Figure 6 : Grazed pasture after the cage passage

Figure 7 : Inside area of a movable cage

3.1.2.1.2 Small parks

In 22% of the farms (farms D and F), does were living in small parks (Figure 8). They had their elevated housing for isolation reasons and accessibility for the farmer. The outside run was divided into two small paddocks and the farmer decided to open the access (yellow gate) for one of them or both depending on the quality of the grass and the needs of the doe and her litter. The inside area was organized the same way as the movable cages.

Figure 8 : Example of small maternity park

3.1.2.1.3 Sheltered boxes and outside common practice area

This last maternity system was exclusive to farm E. Does were kept in boxes in a covered place (Figure 10). Again, the box was composed of an inside and outside part (Figure 9). The gestating does were moved to a common outside run every morning and taken back inside for the night. When they have their kits, they were staying inside.

Figure 10 : Covered area for maternity boxes

Figure 9 : Outside part of the boxes

3.1.2.2 Fattening housing systems

Meat rabbits were distributed among the fattening parks (or cages) depending on farmers' preferences (e.g. by gender, date of birth/weaning). Rabbits were slaughtered when they were older than 100 days according to the French organic regulations. Among the nine farms studied, three fattening systems were observed and 100% had parks (Table 7).

Table 7 : Three housing systems for the fattening systems among the 9 farms studied

Systems / Farms	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Movable cages	✔	✔	✔		✔				
Parks	✔	✔	✔	✔	✔	✔	✔	✔	✔
Movable cages and then parks					✔				

Some farmers used the movable cages described in the maternity part. At weaning, kits were moved to another movable cage. A strategy to reduce the mortality rate, was to first move kits into a movable cage and later on in a park when they were bigger (farmer E). All the farmers owned mobile cages, usually reserved for maternity purposes, raising separately the young future reproductive does, or for keeping apart rabbits which looked sick.

100% of the farmers had fattening parks (25m² to 2 500m²). The difference between farms was the park's protection:

- Electric fences: they kept both rabbits inside and foxes or other predators outside;
- Wire mesh: the mesh should be small enough to stop rabbits from escaping;

- Top nets: they avoided birds of prey to come and other predators (Figure 12);
- Underground mesh: The fence could be buried up to one meter deep to stop rabbit from digging under the fences.

Figure 12 : Very protected fattening park

Figure 11 : Fattening rabbit in a park

3.1.3 Health management

There were two main diseases (Myxomatosis and VHD) that affected the organic rabbits once or twice the previous two years (Table 8). The problem with these diseases was their high contagiousness, which caused the death of many animals if not the entire herd. Vaccination and deworming the whole herd were not usual in organic systems but they were for conventional farms. Then, concerning the parasites, coryza was observed by only 43% of the organic farmers. However, coccidiosis was a bigger problem to them, appearing in the 100% farms studied on a monthly or at least a yearly basis. The sanitary fallow for organic buildings was at least of 14 days and it was 2 months for parks (ECOCERT, 2015).

Table 8 : Frequency of the current diseases outbreaks in rabbit production and vaccinations according to 7 farmers (Estimation in 2017)

Tasks/ Farms	A	B	D	E	F	G	H	Conv[*1]
Myxomatosis								
Frequency	1	0	0	2	1	2	2	-
Vaccination	1	3	0	2	2	1	1	3
VHD								
Frequency	2	1	2	2	1	2	2	-
Vaccination	1	0	0	2	2	1	1	3
Other current diseases								
Coccidiosis	2	3	3	3	3	2	2	-
Coryza	2	0	0	1	1	0	0	-
Not identified	2	-	1	-	2	-	0	-
Deworming	3	0	0	0	3	0	0	3

*"-" indicated missing data. Farmer C and I did not answer the questionnaire.[*1] The frequencies indicated were observed in respectively 92, 83 and 100% of the conventional farms (ITAVI, 2015b).*

VACCINATION:
0: None of the animals
1: some of the does and bucks
2: all does and bucks
3: All the animals (does, bucks and kits)

FREQUENCY OF OUTBREAK:
0: Never the last 2 years
1: Once in 2 years
2: Once a year
3: Once a month

Sanitary issues were very different in the 72 conventional farms in the study ITAVI (2015b). For these conventional farms, 96% had sanitary airlock to enter the building, 87% systematic hand wash with disinfectant and 65% boot bath. The sanitary fallow was about 2,4 days (±0,9) every 7.4 week (±2.4) in maternity and 2.5 days (±1.0) every 11.9 weeks (±7.0) in fattening. There were 3 main diseases faced by conventional farmers in 2014:

- Pasteurellosis noticed by 52% farmers (Constant increase, 28% noticed in 2000)
- Enterocolitis noticed by 38% farmers (Constant decrease, 68% in 2004)
- Respiratory troubles noticed by 35% farmers (Constant increase, 11% in 2000)

VDH, myxomatosis, coccidiosis and coryza were absent in 94% of the farms.

3.1.4 Feed management

In organic systems, all animals had access to fresh grass. In addition, concentrates were given to both the animals in maternity and fattening (Appendix 5 - Table 27). Quantities distributed went from *ad libitum* concentrates down to no supplementation or very low (restriction). 86% of organic farmers bought feed, especially complete feed (4 farmers) and alfalfa (3 farms). Farmers E and H, located in the South of France were paying concentrates more than the others. None of them had an automated feeding system.

In the 72 conventional farms studied by ITAVI (2015b), 80% had the feeding system automated for maternity and 84% for fattening. Feed access was restricted for gestating does (45% of the farms), non-gestating does (42%), early fattening (weaning – 55d) (38%) and late fattening (55 days – slaughter) (36%). More than 98% were feeding does and kits *ad libitum* during maternity (-5 days – weaning).

3.1.5 Work

Conventional farmers spent a third of their working time on the rabbit production whereas it was from 28% to 100% for organic farmers (Table 9). All organic farmers said they spent time on the rabbit production only when they had spare time. Also, 3 farmers were helped by family or trainees. The work productivity was fluctuating from 21 (farm E) up to 80 does/FTE (farm G). which was lower than the 513 does/FTE of conventional farms (ITAVI, 2015b).

Table 9 : Working time on farm and within the rabbit production for 7 organic rabbit farmers (Based on their estimation in 2017)

Working time / Farm	A	B	D	E	F	G	H	I*1	Conv
Farmer (h/week)									
On farm	-	36	54	42	54	20	18	70	61*3
On the rabbit activity	30	21	15	21	20	20	15	70	43*3
Other workers									
Type of worker	No	Family	No	Trainees	No	Family	No	No	Employees*4
Time worked (h/week)		0,5		12		2			1*4
Work productivity (does/FTE*2)	76	49	70	21	61	80	70	45	513*5

*"-" indicated missing data. Farmer C did not answer the questionnaire.*1 Data from the farm visit. *2 FTE: Full Time Equivalent. *3 Calculations (ITAVI, 2015b) *4 For 32 farms/72. *5 (ITAVI, 2015).*

In conventional farms, the most time-consuming tasks were lactation (14%), kindles (13%), feeding (11%) and daily checking (10%). Organic farmers faced difficulties to split clearly their different tasks. They combined multiple tasks while doing their daily round. However, they agreed that feeding was the most time-consuming task (14 to 64% of the working time), followed by the heavy cleaning (Table 10). Farmer B was spending 28% of his time on managing the natural mating and 14% for palpating the females. He was the only one spending more time on reproduction issues than on feeding.

Table 10 : Share (%) of each task in the work related to rabbit according to 7 organic rabbit farmers (Based on their estimations 2017)

Tasks (%)	A	B	D	E	F	G	H	Conv[*1]
Feed animals	33	14	33	44	65	31	37	12
Control lactations	1	7	8				10	15
Control kindles	2	2	7	8		5		13
Light cleaning	2	5						5
Heavy cleaning	18		6	7	5	16	19	8
Daily checking	2	5	21	5		5		10
Install the nest boxes	3	5						5
Wean	4	2	7	7	5	9		5
Natural mating / AI	7	28	7	7	5	5	5	3
Record data	3	8	1	4	5	8	5	3
Weigh animals		3		4				2
Palpate	3	14			5			2
Cull and sell	12	5			5	6	24	2
Health care	7	1	7	7		5		2
Females' rotations	3					5		2
Disinfection of housings				7				1
Other usual tasks					5			3
Casual tasks						5		4

*Farmer C and I did not answer the questionnaire. *[1] Based on 70 farms in 2014 (ITAVI, 2015b).*

3.1.6 Farmer's experience and support supplied

There was a lack in support (Table 11) from the French and European institutions and the specialized organizations. To face this lack of support, all farmers tried to get information through farmers' meetings and formations at least 14 h/y. Mainly through their organic farmers association (AELBF), they shared their experience with the other organic farmers in order to improve their overall performance. Among 72 conventional farms in 2014, 66% subscribed to a rabbit production review, 94% were part of a group, 82% participated to farmer meetings, 30% were members of a service company and 14% did formations and trainings (ITAVI, 2015b).

Table 11 : Technical support supplied and access to information for 7 organic rabbit farms (Estimations 2017)

Tasks/ Farm	A	B	D	E	F	G	H
Technical support (h/y)	15	0	0	0	0	0	3
Meeting, formations (h/y)	15	21	30	30	40	14	30

Farmer C and I did not answer the questionnaire.

3.2 Parameters and factors related to the technical performances

3.2.1 Reproductive animal performances and management

3.2.1.1 Breeds

Organic farms kept three or more different breeds (Appendix 5 - Table 29). The fauve de Bourgogne and the Géant papillon were used respectively in 87 and 75% of organic farms. Conventional farmers were using crossbreeding using 3 breeds: the Hycole, the Californien and the Néo-zélandais Blanc (Gidenne, Pers. Comm.).

3.2.1.2 Production time of does and bucks

The production times for the reproductive animals fluctuated a lot within the farm and among the farms (Figure 13 and Figure 14). Overall, the median was 6 months for does and 14 months for bucks. Conventional does produced on average 10 months (ITAVI, 2015b).

Taking into account the confidence interval (95%) in the individual Kaplan-Meier diagrams, none of the farm could be significantly differentiated from the others. At some point, significant differences could be noticed such as the only 20% of does staying more than a year in farm D compared to the remaining 72% does of farmer C. In all the farms, less than 20% of the animals were kept more than 800 days. It can also be noticed than less than 25% of the does of farms A, D and E went over a year of production. Farmers C and B seemed to keep a higher proportion of the herd after 2 years of production.

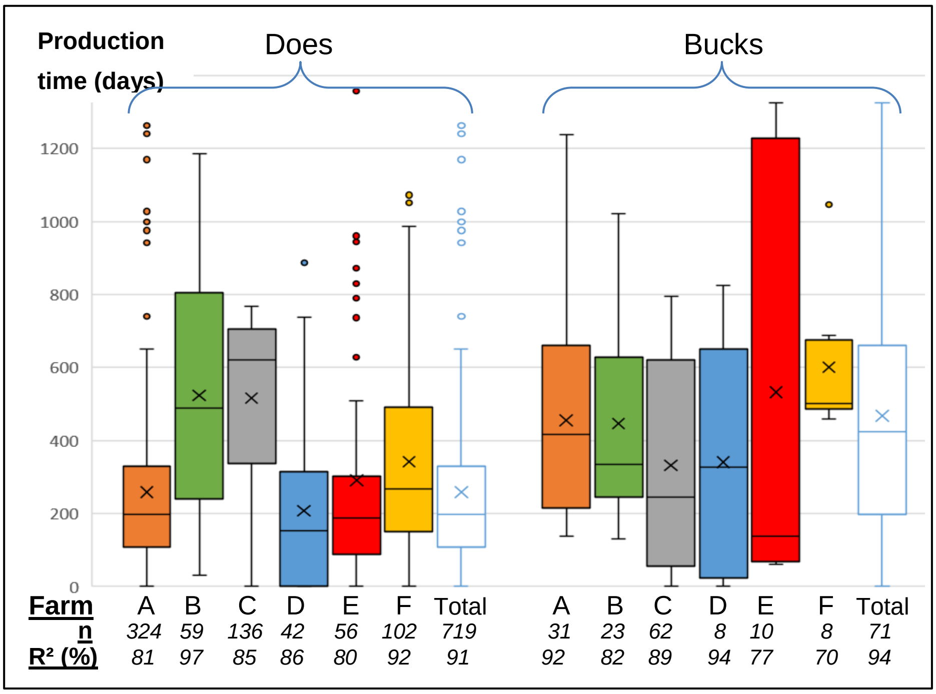

Figure 13 : Production time of does and bucks in 6 organic rabbit farms (data 2012 - 2017).

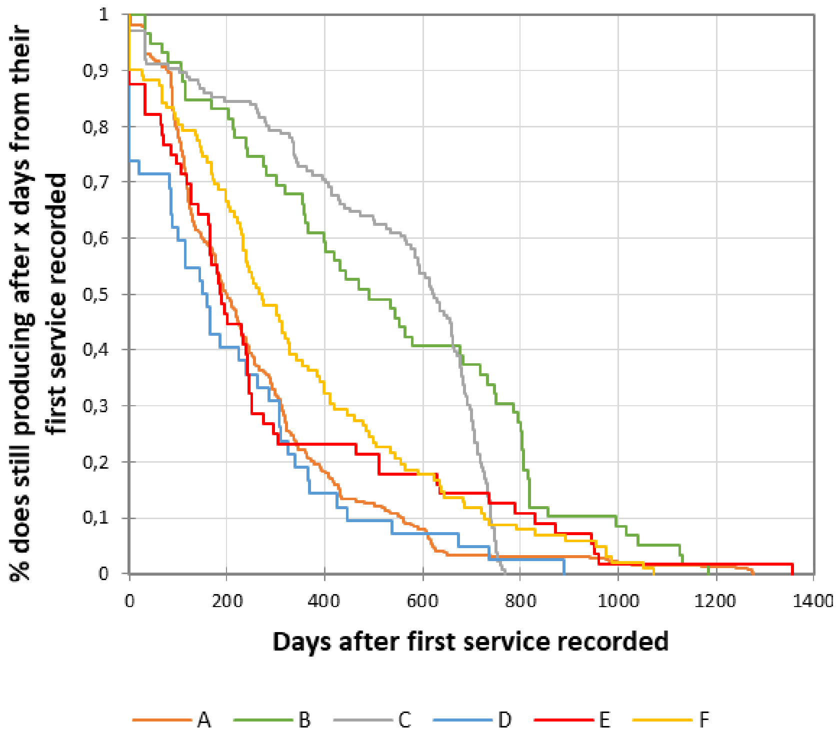

Figure 14: Kaplan-Meier diagram showing the % of does producing after x days from their first service recorded for 6 organic rabbit farms.

3.2.1.3 Fertility

The overall fertility was 57% (Table 12), going from 29% (farm D) up to 69% (farm C). It was a low rate compared to the 83% in conventional rabbit farms. The doe's age at their first service varied a lot from one farm to another. Farmer E had the earliest (130d) and farmer D the latest (210d). The culling age of does could be from 2 years (farm A) up to 4 years (farm B). Also, 4 farmers said they did not cull but they waited until the natural death of the animals.

Table 12 : Reproduction indicators for organic does in 8 organic farms

Practices/ Farm	**All**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Conv**[*1]
Fertility rate (%)	57	56	38	69	29	66	57	-	-	83
n	3136	615	565	908	66	309	673	-	-	
Farmer's estimation (days):										
Kindle - next service	-	45	45	-	50	30	35	60	30	12
Doe's age at first service	-	150	140	-	210	130	185	180	150	-
Doe's age at culling	-	730	1460	-	D[*2]	D[*2]	D[*2]	1095	D[*2]	-

"-" indicates missing data. Farmer C and I did not answer the questionnaire. Records of farms G, H and I were not available to calculate fertility rate. "n" is the number of data (services) used to calculate the fertility rate.
*[*1] Data 2014 (ITAVI, 2015a). [*2]Death – The farmer does not cull his animals, he keeps them until they die.*

Rabbits were fertile and bred all the year around. Out of the seven chi-square tests for independence, only farms A, B and E showed significant differences between the seasons (p-value < 0.05) (Table 13). The fertility of does in autumn was significantly lower in farm B (20%) and D (17%). Farm A showed lower fertility rate in summer (39%). A higher rate was noticed in spring for farmer A (86%), summer for farmer D (50%) and winter for farmer B (57%). In farm C, E anf F, seasons did not affect significantly the fertility rate.

Table 13 : Fertility (%) along the year in 6 organic rabbit farms.

	A	B	C	D	E	F	All
Spring	**86**	42	78	32	53	59	62
Summer	**39**	30	63	**50**	78	51	49
Autumn	53	**20**	58	**17**	65	52	49
Winter	60	**57**	75	22	71	66	65
Year	56	38	69	29	66	57	57

Records of farms G, H and I were not available. In ***bold****, the significant different fertility rate compared to the year average (Pearson test, p-value < 0.05).*

3.2.1.4 Intervals between kindles (IKK) and between kindle and the next service (IKS)

Organic farmers were using the natural mating unlike conventional producers who mainly used artificial insemination (Dalle Zotte, 2014 ; ITAVI, 2015b). The IKK and IKS followed a Poisson distribution for all farms, except for farm D due to too little data available (Figure 15). Overall, the median for the IKS was 61 days and 92 days for IKK. For conventional farms, the interval between kindle and the next service was 12 days and the one between kindles was 42 days (ITAVI, 2015b).

As shown in Table 14, IKS intervals' ranges were large. The IKK results showed the same trends (Appendix 5 - Table 28). The IKS performances were the closest to farmer's estimation for farmer B and E, respectively 27 and 17% of mating actually happening the week farmers aimed (Table 14).Farmer B used doe sheet which allowed him to easily see the schedule for a particular doe. Farmer E used his computer program.

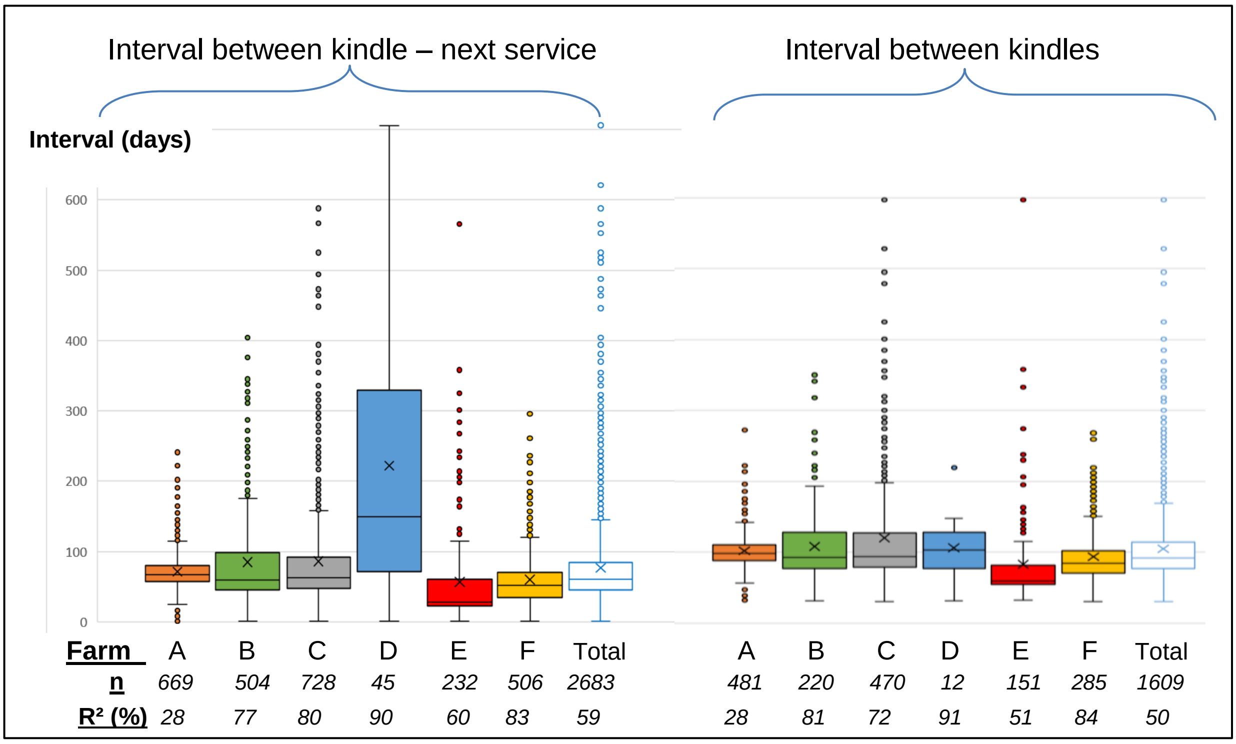

Figure 15 : Intervals between kindles and between kindle and next service in 6 organic rabbit farms (data 2012 - 2017).

Table 14 : Frequencies (%) of mating happening after x weeks from kindle in 5 organic rabbit farms.

Week	A	B	C	E	F
1	0,7	1,4	2,5	4,0	1,9
2	0,7	1,0	1,5	7,1	1,5
3	0,7	1,2	1,0	35,8	1,9
4	0,6	2,6	2,1	**16,8**	14,1
5	1,3	4,2	3,2	2,7	**8,2**
6	**3,3**	**27,0**	14,8	3,1	11,1
7	12,1	4,4	14,8	1	13,7
8	15,7	9,5	8,8	4,0	12,2
9	17,8	2,4	10,2	3,1	8,8
10	16,2	5,8	6,1	1,3	5,9
11	6,9	5,4	5,9	1,3	3,4
12	5,7	5,0	3,2	0,9	2,1
13	5,5	4,2	3,1	1,3	1,9
14	3,0	2,2	2,8	2,7	1,9
15+	9,8	23,7	20,0	14,6	11,4

Farmer C and I did not give an estimate. Records of farms G, H and I were not available. ***Bold*** *indicates the week farmer said they wean kits.*

3.2.1.5 Criteria of selection

Unlike most conventional farms (ITAVI, 2015a ; ITAVI, 2015b), all organic farmers interviewed said they selected does among their fattening rabbits and bought the males from other farmers or people breeding rabbits. The main reason for buying an animal was to avoid inbreeding. That was why they sometimes bought some does as well. The selection of the young reproductive does was based on different criteria including the four most important presented in the Table 15. Most of the criteria were subjective. The meat conformation was always mentioned and then the number of kits and the maternal qualities of the mother were important.

Table 15 : Top 4 selection criteria currently used by the interviewed farmers

	A	**D**	**E**	**F**	**H**
1	MC	Robustness	Kits/litter	MC	Kits/litter
2	MQ	Doe fertility	MQ	Calm behaviors	MQ
3	GHL	MC	Growth rate	Good looking	Growth rate
4	Kits/litter		MC		MC

Farmers B and C did not answer. Maternal qualities (MQ), meat conformation (MC), good legs and hears (GLH).

3.2.2 Litter performances and management

When a large litter of kits were born alive, some of the kits could be very weak or showed serious health problems. The identification of the weak kits was subjective, not based on precise parameters. The doe could not afford a lactation for a such large litter. Therefore, farmers could eliminate the weakest kits and homogenized the number of kits per litter among the does. However, the elimination of weak kits was not usual in organic rabbit farming: only 1 farmer out of the 8 interviewed did it on a regular basis (Appendix 5 - Table 31). Only the oldest farmers in time of activity (A, B and E) used adoptions to balance the litters. In conventional rabbit farming, elimination and adoptions were usual practices.

Overall, farmers counted 8.8 (± 3.2) kits born per parturition among which only 8.0 (± 3.1) were alive and 6.2 (± 2.6) kits weaned (Table 16). However, the ANOVA rejected H_0 and proved the means were significantly different between farms (p-value < 0.05). To a lesser extent, the ANOVA stated that 1 to 3% of the variability of the number of kits is explained by the factor farm. The boxplots for the total born, born alive and weaned kits for farms A, B, C, E and F is in Appendix 5 (Figure 19).

Taking farms in pairs, the ANOVA highlighted the differences between farms (Appendix 6 - Table 30) which could be as high as 2.3 additional kits per litter in average between two farms. Farmers A and C had higher numbers of kits born and born alive compared to farmers B and E. After litter re-arrangement, farmer C had still the highest number but farmer A was significantly lower followed by farmer E and then farmer B. The re-arrangement rate was negative for farm C and E. In fact, some litters were very small (2-3 kits) and therefore farmers gave these kits to another doe and rebred the doe. Except farmer H, all farmers agreed the ideal number of kits to start lactation was 8 kits which corresponded to the calculated average number.

At the end of maternity, farmer A weaned the most kits per litter (6.6 kits), followed by farmers C, E and F. Farmer B had a high mortality rate and weaned the lowest number of kits (4.6 kits).

Table 16 : Indicators related to kits for 8 organic rabbit farmers (Data 2012-2017)

Number of / Farm		All	A	B	C	D	E	F	G	H	Conv[*1]
Total kits born	$\bar{x}$	8.8	9.0$_A$	8.4$_B$	9.1$_A$	-	8.2$_B$	-	-	-	10.7
per parturition	s	*3.2*	*2.7*	*2.9*	*3.9*	-	*3.0*	-	-	-	-
	n	1408	585	264	350	-	201	-	-	-	-
Stillborn rate (%)		*9.1*	*8.9*	*10.7*	*8.8*	-	*7.3*	-	-	-	5.6
Born alive kits	$\bar{x}$	8.0	8.2$_A$	7.5$_B$	8.3$_A$	-	7.6$_B$	-	-	-	10.1
per parturition	s	*3.2*	*2.6*	*3.1*	*3.5*	-	*3.3*	-	-	-	-
	n	1415	585	268	350	-	201	-	-	-	-
Re-arrangement litter (%)		*0*	*1.2*	*2.7*	*-3.6*		*-5.3*	-	-	-	7.5
Starting lactation	$\bar{x}$	8.0	8.1$_{AB}$	7.3$_C$	8.6$_A$	-	8.0$_B$	-	-	-	9.3
per parturition	s	*2.6*	*2.3*	*1.9*	*3.3*	-	*2.7*	-	-	-	-
	n	1391	292	258	350	-	192	-	-	-	-
Farmer's ideal number		-	8	8	-	8	8	7	8	5.5	
Lactation mortality (%)		*22.5*	*18.5*	*37*	*25.6*	-	*21.3*	-	-	-	7.7
Total kits weaned	$\bar{x}$	6.2	6.6$_A$	4.6$_C$	6.4$_B$	-	6.3$_B$	6.2$_B$	-	-	8.6
per parturition	s	*2.6*	*2.3*	*2.3*	*2.2*	-	*2.6*	*3.1*	-	-	-
	n	1480	768	255	127	-	181	138	-	-	-

*"-" indicated missing data. Records of farms G, H and I were not available. Farmers C and I did not answer the questionnaire. *[1] Data 2014 on 6 263 batches (ITAVI, 2015a). $_{ABC}$ Indicates the significant ranking of the organic farm according to their performances (Fisher test, p-value<0.05). $_A$ indicate the best values and $_c$ the worst.*

The average weaning age was 71 days (± 14) for farms A, B and C (Table 17). Farmers E and F weaned earlier with averages respectively of 40 (± 6) and 53 (± 11) days. More details are available through Table 18 and the boxplots (Appendix 5 - Figure 20). According to Table 18, farmers did not respect strictly their respective weaning aims. Farmer E was the most accurate with nearly 50% of the weaning happening the fifth week after kindle. He was also the only one to have a computer based tool which created a time schedule for each operation on farm. In conventional farming, the batch in 42 days imposed to wean kits when 35 days old (le point vétérinaire, 2017).

Table 17 : Weaning age estimated and calculated for 8 organic rabbit farms (data 2012-2017)

Weaning age/ Farm	**All**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Conv[*1]**
Farmer's estimation	-	50	60	-	45	40	45	60	60	35
Calculated										
$\bar{x}$	64	71	71	68	-	40	53	-	-	35
s	17	14	16	13	-	6	11	-	-	-
n	1425	666	231	136	-	168	224	-	-	-

*"-" indicates missing data. Records of farms D, G, H and I were not available. Farmers C and I did not answer the questionnaire. [*1] (Le point vétérinaire, 2017).*

Table 18 : Frequencies (%) of weaning happening after x weeks from kindle in 5 organic rabbit farms.

Week	A	B	C	E	F
3			0,7	0,6	0,4
4	0,1	0,4	0,0	20,8	2,2
5	0,3	1,7	7,4	**44,7**	8,9
6	1,5	5,2	0,7	24,4	**24,2**
7	**11,9**	2,2	8,1	8,9	27,7
8	20,9	**27,7**	10,3	0,6	17,9
9	17,4	18,6	20,6		12,1
10	18,0	18,6	19,1		4,9
11	9,8	5,6	25,0		0,0
12	9,5	4,8	3,7		1,3
13	5,7	4,8	4,4		0,4
14	2,7	3,9			
15	1,8	3,5			
16	0,3	1,3			
17	0,1	0,4			
18		1,3			

Farmer C did not answer the questionnaire. Records for farms D, G, H and I were not available. ***Bold*** *indicates the week farmer said they wean kits.*

3.2.3 Fattening part

The fattening part could not be as researched as the maternity part due to a lack of on-farm records. However, few elements were noticed (Table 19). The highest growth rates were observed in farm A and E, respectively 13.8 and 13.6 $g_{carcass}$/day. Farmers slaughtered their animal between 110 and 150 days when they weighed between 2.4 and 2.9 kg alive or 1.4 to 1.8 kg carcass. In 2014, conventional rabbits were slaughtered at 74 days old. They weighed 2.47 kg alive and sold to slaughterhouses for 1.86 €/kg alive (ITAVI, 2015a). Prices evolution were presented in Appendix 5 - Figure 21. Consumers paid 14.00 to 16.50€/kg carcass for organic rabbit, which was twice the price for conventional rabbit meat (8.09€/kg) (Coutelet, 2015).

Table 19 : Available indicators for the fattening rabbits for 7 organic rabbit farmers (Estimations for 2016 - 2017) and for conventional farms (Hurand and Lebas, 2016)

Practices/ Farms	A	B	D	E	F	G	H	Conv
Age of slaughter (days)	120	140	150	110	150	110	150	74*1
Live weight (kg/rabbit)	-	2.60	-	2.50	2.90	-	2.40	2.47*1
Carcass weight (kg/rabbit)	1.65	1.60	1.80	1.50	1.65	1.40	1.50	-
Carcass yield (%)	-	61.5	-	60.0	57.0	-	62.5	-
ADG ($g_{carcass}$ /day)	13.8	11.4	12.0	13.6	11.0	12.7	10.0	
Selling price (€/kg)	14.25	15.00	14.00	-	15.50	16.50	15.00	3.26*2

*"-" indicates missing data. Farmers C and I did not answer the questionnaire. Average daily gain (ADG): Carcass weight / Age of slaughter. *1 Data 2014 (ITAVI, 2015a). *2 Estimation of Coutelet (2015) based on the data 2014 (ITAVI, 2015a).*

3.3 Stakeholders of the organic rabbit sector

Within the organic rabbit sector, customers were key because they created the very good market opportunities with an increasing demand for organic rabbit meat (Table 20). The good market opportunities attracted the organic farmers which needed support to produce in the best conditions. Support and information were given by the research centers such as INRA and professional organizations including ITAVI. Finally, the AELBF was the central stakeholder managing the sector.

Table 20 : List of the stakeholders in the rabbit sector

Stakeholders	**Involvement in the issue**
Banks	They help farmers in their investments.
Activist groups	They act against conventional rabbit production and unmask the conditions of breeding to customers. Organic farmers appear to be more respectful of animal welfare in comparison.
Customers	They create the market and buy the meat at a certain price.
Organic farmers	They produce organic rabbit meat.
Slaughter houses	Not all the slaughterhouses are allowed to slaughter rabbits.
Organic shops	They buy rabbits to farmers and sell to customers.
AMAP	They are farmers' associations which deliver local products to customers.
Classic distributors	They buy from slaughterhouses but are not currently involved.
Conventional farmers	They produce large amount of conventional rabbit meat.
French government	They edit laws and regulations to control organic and conventional productions at French level.
European government	They edit laws and regulations to control organic and conventional productions at European level.
Feed suppliers	They produce organic rabbit feed
AELBF	They gather organic farmers and pass information when available.
ITAVI	They offer support to farmers
Research center (INRA)	They research specific elements in order to help improving the production.
Certification organisms	They control the practices on farm.
Insurances	They insure the production.

*Primary stakeholders appear in **bold.***

The primary stakeholders were the key players in the sustainable development of the organic rabbit sector (Table 21). Groups A and B could slow down the process if involved. The stakeholders of category C do not need to take part in the decisions but need to be taken into consideration.

Table 21 : Stakeholder mapping for the development of the organic rabbit meat sector

	Level of interests	
	Low	**High**
Low	*A - Minimal effort* Banks Feed suppliers Insurances	*B - Keep informed* Activist groups Organic shops & AMAP Certification organisms
Level of power **High**	*C - Keep satisfied* French government European government Slaughter houses Classic distributors Conventional farmers	*D - Key players* Research centers ITAVI Customers Organic farmers AELBF

3.4 SWOT analysis (Strengths, Weaknesses, Opportunities and Threats)

The SWOT analysis (Table 22) and confrontation matrix (Table 23) portray the issues of the organic rabbit sector.

Farmers managed the whole production chain and could therefore adapt the production to their needs. They liked their independence and did not feel isolated thanks to their developing farmer association (AELBF). Rabbits were easy to handle (small size) but weree very vulnerable to diseases, parasites and predators. Due to the production system designed as close as possible to the natural way of life, farmers must deal with the health problems and predators. Economically, these events made the production irregular. The economic profits were not stable and even not good at the moment. Limited investments were needed but the labor was very intensive. Being a niche market brought both advantages and disadvantages. The competition was limited. However, there were few farmers and slaughter house. Information, researches and support were absent. The demand was higher than the offer (INRA, 2017).

Table 22 : SWOT analysis of the organic rabbit production in France

Strengths	Weaknesses
Farmer's autonomy: he is responsible of the whole chain from the feed, to the births and the slaughter and sells Farmer organizes his work as he wants and he is able to use his creativity to face some problems. Few investments are needed for this production. The animal is appreciated for its small size and gentle behavior. The animal welfare offered to the animals satisfies the farmer because it is close to the natural way of living of this animal. The taste of the meat is appreciated and its conservation is easy. It is an herbivore so the feed costs are limited Many organic rabbit farmers are motivated to share their experience and knowledge: the association is a great element of improvement The offer is way less than the demand (good economic profitability).	This production needs a daily work which can be toil The rabbit is vulnerable to many predators and diseases The economic profitability is not good currently There is a lack of knowledge, baselines and support regarding this production It is often a secondary production which means it is not the priority of the farmer Some of the farmers have trouble to find some good reproductive animals It is a niche market: few farmers, few slaughter houses
Opportunities	**Threats**
Good market opportunities The farmers' association is developing: researches and collaborations are done with the INRA and ITAB, many farmers are thinking about producing organic rabbit which is a proof of the rising interest for this production. It has a very positive image because it is "grass fed", "free range", the meat quality is known and the animal welfare is at its best.	There is a lack of research funding mainly due to the small size of the sector. The production is not constant because of outside elements (predators, weather, diseases). Diseases are not under control and can kill all the animals in few days. The specifications are reviewed and the access to grass field as such is not compulsory for organic rabbits anymore. Current organic farmers fear the arrival of conventional farmers in conversion which can be huge farms. Organic rabbit production is very technical.

Community issues	Work issues	Missing information
Animal issues	Economic issues	

Table 23 : Confrontation matrix of the elements from the SWOT analysis about the organic rabbit sector

	Strenghts	**Weaknesses**
Opportunities	*To attack*	*To strengthen*
Positive image	The positive image of organic rabbit production is due to the production system created by farmers. The animal welfare is an objective for farmers and is highly valued by customers afterwards. The quality and taste of the meat due to the free range and grass-fed practices are also noticed and highly appreciated.	To promote the positive image of organic rabbit production, the economic aspect should be improved and the production should be less considered as secondary. The vulnerability to predators and diseases harm the positive image because it is perceived as a lack of animal welfare.
Good market opportunities	The demand is higher than the offer which means that new farmers or farmers increasing their production can reach customers easily. Due to farmers' autonomy, they do not rely on another stakeholder and can seize opportunities on their own. In addition with the few investments, a quick economic profitability is expected.	The lack of slaughterhouses and farmers to supply the customers are brakes to benefit from the good market opportunities.
Farmer association	The farmer association AELBF gives multiple opportunities. Anyone interested in organic rabbit production can participate. Current farmers are willing to share their experiences and train new farmers. The collaboration leads to better understanding and optimization of the production (work organization, technical performances).	As it is a secondary production, farmers have other priorities. With a better work organization, farmers would be able to benefit from the support and good information provided by the AELBF. In addition, the inherent consequence of a niche market is the little number of stakeholders involved and therefore the farmer association count few active and loyal members. That is why developing the sector is necessary.

Threats	*To defend*	*To be careful*
High skills	Their autonomy and the small size of rabbits and farms make the management and organization flexible and easy for trial planning in order to improve skills. Sharing knowledge and practices is also an important lever for overall improvement.	The vulnerability, economic lack of profitability and the place of secondary production do not allow farmers to reach the sufficient skills to make organic farm successful. Better work organization is needed.
Lack of information	The lack of information is currently addressed by the farmer association in partnerships with research centers on the first hand and by the farmers themselves in a second hand. Also, the increasing interests of customers and farmers in this production tend to increase the importance of the sector which is becoming interesting to further study.	The niche market is too little for the bigger companies to invest or research centers to get interests in. Therefore, the lack of current knowledge makes any research nearly starting from scratch.
Diseases outbreaks	The diseases outbreaks can be limited by vaccinations. It is an additional costs but organic rabbit farms require low investments so farmers might be able to afford vaccinations.	Due to the poor health resistance of rabbits, the diseases outbreaks leave heavy consequences which may discourage farmers to continue their production or start one. Vaccinations, deworming and disinfection are key levers.
Irregularities in the production	The irregular production is highly linked to the diseases outbreaks which can be better controlled through vaccination. It is also due to the lack of information. The farmer association in collaboration with research centers are working on this issue.	In addition with the diseases, rabbits are small animals which make them the prey of several predators. Protection with nets, fences or noisy animals can be a solution. Also, additional knowledge and better organization would stabilize the production.
Specification changes	Due to the specification changes, conventional farmers can enter the organic rabbit market. Because current organic farmers manage sells, they can anticipate these new entries by securing the loyalty of their current customers.	The lack of economic results in addition with the entry of conventional farms can lead to the end of the current organic farms which are very small and would not be competitive to those way bigger farms in conversion.

4 Discussion

4.1 Current situation

In France in 2017, about 30 organic rabbit farms are known and are mainly located in the North-West of France. The organic systems studied were new with 66% of them settled after 2013. Both organic and conventional rabbit production are secondary activities in farms. Compared to the 528 does within conventional rabbit farms, the average organic does herd was little: 20 to 90 does (ITAVI, 2015b). In addition, organic systems were extensive with less than 15 adults/ha compared to the 20 adults/ha of conventional farms.

Organic rabbit meat sector is in the development stade of its life cycle (Johnson *et al.*, 2015). The market rivalry is low. The growth of the sector is slowly increasing but is still characterized by low sales and high production costs. Currently, there are no-profit systems. Organic rabbit meat sector is a niche market where the offer does not yet satisfy the demand (INRA, 2017). The key stakeholder to further develop the sector is the farmer association (AELBF) which gather all the other important stakeholders: research centers, ITAVI and organic farmers.

This study highlighted the key levers in order to better accompany the sustainable development of the organic rabbit sector. First of all, this study showed the diversity of practices in organic rabbit farming. It was however impossible to identify which organic farms had the best performances. In fact, each farmer had performances both higher and lower than the others. However, all of these different organic systems had lower technical performances than conventional farms in France.

In the organic farms, does were kept in individual movable cage and meat rabbits in parks. Does spent their life in the same housing to avoid cross-contamination and stress; for the gestation (31d) and lactation (31d). The only time they left their housing was for natural mating in the cage of the buck for few minutes up to 10 days. Fertility rate was 57% for organic and 82% for conventional. Overall, 8.8 kits were born per kindle among them 8.0 were alive and 6.2 weaned. In conventional farms, numbers were higher: 10.7 total born, 10.1 born alive and 8.6 weaned. Mortality rates were a lot higher in organic maternities than conventional. The stillborn rate was higher than 7.3% (vs 5.6% in conv) and the mortality during lactation was higher than 18.5% (vs 7.7% in conv). Finally, the growth rate of rabbits in organic systems was twice lower than conventional: kits are 110-150 days vs 72 days old at slaughter for similar live weights.

The technical results in maternity were significantly different among the organic farms studied, up to 2.3 additional kits per litter in average between two farms. In fact, farmers A and C had significantly the highest numbers of kits born and born alive. Farmer B had the lowest performances for all indicators. The litter re-arrangement and the mortality rate during lactation made a significant difference.

Dal Bosco *et al.* (2002) proved the better results of rabbits raised into indoor wire netted pens compared to conventional bicellular cages and straw-bedded pens, partly due to the absence of contact with excreta. In most organic production practices, the contact with excreta could not be avoided. Unlike the organic rabbit production based on an outside access, the conventional rabbit farms keep rabbits in closed buildings with controlled light, air and temperatures facilities. The organic systems were less mechanized and did not have automatic feeding systems (CLIPP, 2017a). It explained the higher share of the feed task in the organic farmer work (14-64% vs 11% in conv). Indeed, they needed to move cages to supply fresh grass to the animals once or twice a day, and provided them concentrates and water.

The management and organization related to the rabbit activity can be improved. The organic farms studied showed a management of rabbit reproduction based on farmers availabilities and not according to precise reproduction schedules. Farmers B and E were the only ones recording information per doe and their performances always fitted the most their estimations given in the questionnaire. In fact, for the others, the estimations did not fit their performances calculated. From the research results, it seemed that the older was the farm, more experienced was the farmer and the better was his reproduction management. In fact, the older the farm was, the more farmers were using adoptions and eliminations of weak kits after kindles. Young farmers said they were not enough organized and settled to handle these methods properly. Not only the reproduction and the kindle management were not accurate, but also the weaning and slaughtering processes. Among organic farms, some showed early (45d) or late (70d) weaning with high standard deviation (>10 d) except for farmer E who had a scheduling program. To go beyond and improve the overall farm organization, we can imagine a system in batches such as in conventional farms. Among the organic farmers interviewed, no batches could be identified: does were managed individually and independently from the others.

4.2 Productivity in maternity

The productivity in maternity can be measured with the number of **kits weaned/doe/y** (Figure 16). Several factors of improvements were pointed out by this study.

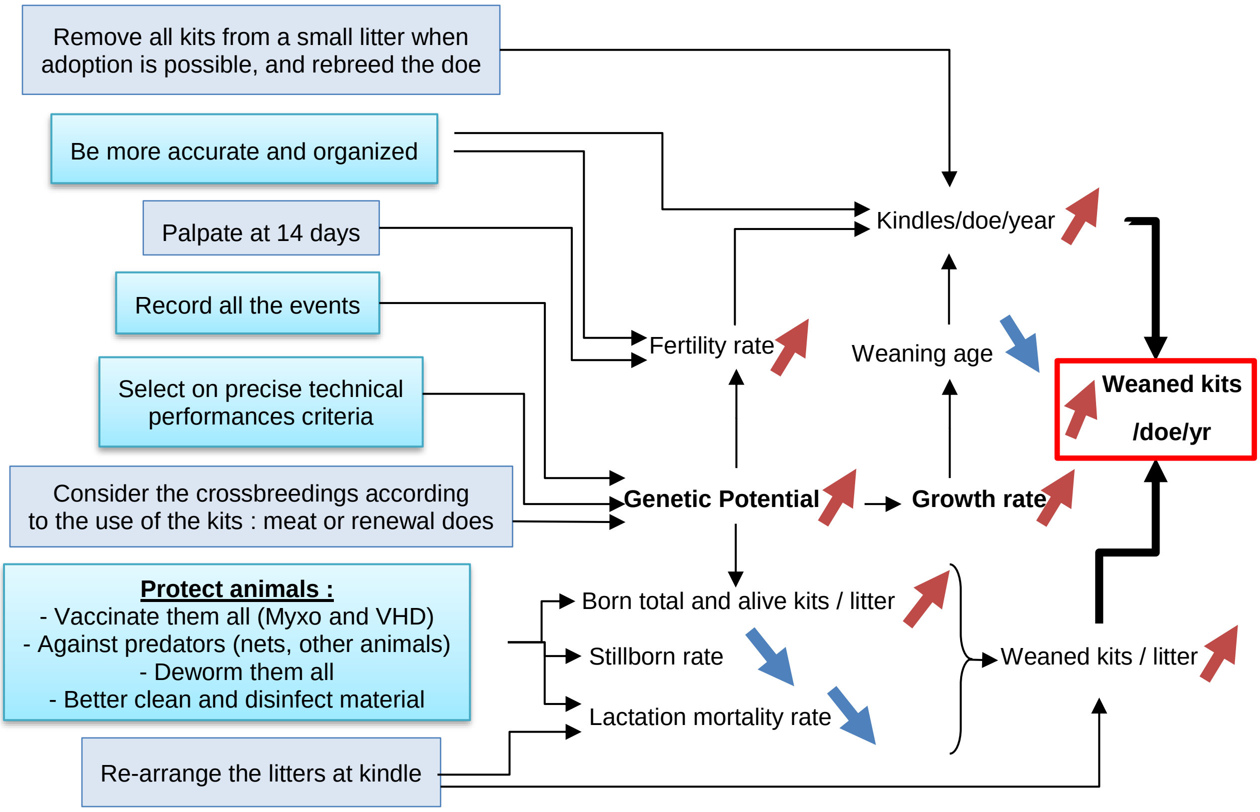

Figure 16 : Levers to increase productivity (weaned kits/doe/yr) in maternity in organic rabbit farms

The **number of kindles per year** was limited by the organic specification (6 maximum) but none of the farmers reached this performance. First cause was the low fertility rate (57%) despite the natural mating technique had better results than artificial insemination (Heba-T-Allah *et al.*, 2016). Main levers to face this lack of performance are the genetic potential of does and bucks, farmer work organization (better observations) and environment understanding (including seasonal effects). In spite of assisting the mating by holding the doe which is not recommended, farmers can better observe the vulva of does: does with red vulva are more likely to accept the males and become pregnant (Delaveau, 1979a). In some of the organic farms, the fertility of organic does dropped significantly in autumn, as noticed in conventional farms (Appendix 6), so reproduction management should be adapted to the seasons. Farmers seemed to have better results in spring and winter.

Another way to increase the number of kindles per year is to remove the kits, through adoption when litters were small (<4 kits). The doe is rebred earlier, as performed by farmers C and E and more litters being born as the parturition to remating interval decreased. Palpation at 14 days, like farmers A, B and C, would also allow farmers to rebreed empty does 14 days earlier. Last option would be to wean the kits earlier as suggested by Chen *et al.* (1978). To handle these practices (adoptions of kits, palpation and early weaning), records and strict organization are needed.

The **number of kits weaned/litter** can be increased. In a first place, re-arrangement (adoptions and eliminations) of litters at kindle is a strategy to increase and stabilize the number of kits starting lactation at 8 kits. In this research, the overall average kits starting lactation was 8.0 but the standard deviation was high (± 2.6) and should be reduced. According to Matheron and Rouvier (1978), farmers should select bucks carefully because their viability genes transmitted to embryos are partly responsible of the litter size. Moreover, increasing over 8 kits per litter seems to bring several disadvantages according to farmers and should not become an aim. Rashwan and Marai (2000) proved the more total kits were born per litter, the higher was the mortality rate during lactation. In addition, Castellini *et al.* (2003) proved that compared to does with 8 kits, the does with 6 kits had higher sexual receptivity and fertility rate, higher quantity of milk suckled per kits and therefore heavier kits, and finally a lower mortality rate during lactation. For instance, the doe gets exhausted because of the large quantities of milk she has to produce. She can lose weight and be more vulnerable to health and fertility problems. The kits get reduced quantity and quality of milk due to their number and the competition within the litter. The growth rate can decrease and kits were weaned and slaughtered later. They require extra space and feed.

To further increase the number of kits weaned/litter, the number of stillborn and the mortality during lactation have to be reduced. In 2017, stillborn rate in organic farming was 9.1% and lactation mortality was 22.5%. One of the factor of high mortality rate during lactation could be the doe's age as stated by Rashwan and Marai (2000). In fact, mortality decreased during the doe production time between 4 to 12 months. Over 12 months, the mortality rate increased and stabilized to a high level.

In organic systems, most of rabbits were kept in outdoor conditions. Therefore, compared to conventional farming conditions, they were exposed to other types of risks such as predators, diseases from wild animals and pests (CLIPP, 2017a; Dalle Zotte, 2014 ; Gidenne, 2015). To prevent predator attacks, housing can be improved with nets or electric fences. Another solution was the keeping of noisy animals with the rabbits, like geese, to frighten some predators (Farmer F, pers. Comm.).

Mortality issues did not only concern the kits but also does. In fact, the mortality rate of the adults could not be calculated due to a lack of data. Nevertheless, doe mortality rate was expected to be very high because farmers said they cull does when older than 24 months but they seemed to die before reaching that age. Taking into account the first service was done when does were 4 to 7 months old, the average production time for does should always be more than 28 months. According to the results, it was about 6 months for does. The low number of bucks did not allow to draw any conclusion.

Feed quality and quantity might explain part of the mortality rates (Coudert and Lebas, 1985). In addition, this study revealed that organic and conventional producers did not face the same sanitary problems. The most frequent diseases for organic rabbits were myxomatosis and VHD due to the casual vaccination procedures. These diseases are highly contagious and the outbreaks left several dead rabbits. As vaccinations represented extra-costs and extra-working time, farmers refused this practice. The coccidiosis is due to parasites into feces and the only lever is hygiene (disinfection, regular cleaning, cage daily moved). On the other hand, conventional farmers face pasteurellosis, enterocolitis and respiratory problems; all linked with the confined living conditions. These differences in sanitary issues between systems could be explained by the higher use of preventive procedures by conventional farmers such as systematic vaccinations and precautionary practices (airlock, hand wash, boot bath, wire mesh cages and automated washing) (Dalle Zotte, 2014 ; Rashwan *et al.*, 2000). Taking into account theses preventive procedures, we can assume conventional farmers in fact got rid of myxomatosis, VHD and coccidiosis. Among the underlying factors causing health problems in organic farms, the combination of livestock density, the lack of preventive care (vaccinations and deworming) and the lack of disinfection and cleaning, seems to explain the maternity mortality rates.

The relation between these factors and pre-weaning mortality were visible from the results obtained from the 9 farms studied. Farm B had the highest livestock density (15 adults/ha), the highest disease frequencies and the worst mortality rates of all the farms studied. Regarding the importance of preventive care on rabbits, the lowest stillborn and lactation mortality rates were found in farms A and E. As a consequence, they had the highest number of kits weaned per parturition. These farmers were also the ones spending the most time cleaning the housings and taking care of the rabbits (respectivelly, 27% and 21% of their working time). An explanation might be the farmer experience as farmers A and E were among the 3 most experienced farmers in the sample.

Finally, the last lever to increase both the number of kindle/doe and kits/litter per year was selection for an increased genetic potential. Three kinds of conventional farms could be identified: for animal selection, for multiplication, and most of them for production (Fortun-Lamothe and Gidenne, 2008). This was not the case in organic farms, where farmers selected the future does among their fattening rabbits and bucks were bought from organic farmers or people breeding rabbits. The breed influenced the mortality which means the mortality rate can be decreased through efficient selection using different breeds (Rashwan and Marai, 2000). Where conventional farmers used mostly crossed breed animals based on 3 breeds, organic farmers combined at least 3 breeds among the 13 identified in the farms studied. However, organic farmers did not have precise selection schemes such as in conventional farming. It may have led to a loss of genetic potential over the generations. The selection done by farmers was done mostly on visual traits of the does. The pedigree and performances of its family were not taken into account at all.

The lack of on-farm records for the fattening part did not allow this research to conclude about the overall farm performances. To improve the overall performances of organic farms, the improvement of maternity was the first step and should be followed by the improvement of the fattening part. We can imagine a third step of improvements on farm level. As suggested by the INRA recommendations (2017), it would include feed strategies and pastures management as well as enhancement of the sanitary management.

4.3 Development of the sector

In fact, rabbit production is an easy production in the sense that it necessitated low financial, material and time investments compared to other productions. Some farmers were starting a rabbit activity, stopped few months later, then started again a year after. It was also the reason why we could not count precisely the number of organic rabbit producers in France. However, this proved the low amount of economical and time inputs needed to start the activity. It also testified the easy transfer of organic farms. In comparison, 54% of conventional farms were considered hard or impossible to transmit (ITAVI, 2015b).

Rabbit meat is one of the best meat considering the human nutritional needs (Lecerf and Clerc, 2009; CLIPP, 2017b). With low calorie, sodium and cholesterol contents, it is however rich in omega 3, vitamins (B3, B12, E) and minerals (iron, selenium, phosphorous, potassium). In addition, organic productions were valorized by consumers who paid 14 to 17€/kg which was twice the conventional price (8€/kg). Such as Delaveau (1979b), the customers of the organic farmers interviewed noticed the differences of carcass' properties of organic rabbit meat (rational system) compared to conventional (traditional system). These elements made the organic rabbit market a very good opportunity for farmers looking for diversification of their farm and extra revenue if they technically manage well this rabbit activity.

The small size of the sector seemed to limit its good development. Unlike conventional farmers, organic farmers were facing a lack of support. Farmers interviewed pointed out the lack of technical performances and as a consequence, the lack of economic results of their production. This was the main brake to the continuation and settlement of organic rabbit farms. For instance, they did not have service companies, journals concerning organic rabbit and very few scientific articles were available. They addressed this situation through the creation and development of the AELBF, their farmer association. It can be expected that more stakeholders are getting involved, fewer brakes will block the development of the sector.

Mainly three opportunities for the sector could be highlighted: the positive image of the production, the good market opportunities and the farmer association. The internal strengths of the sector should be used to seize the opportunities and further develop the sector while the weaknesses have to be strengthened. Similarly, the strengths and weaknesses of the current sector have to be smartly used to ward off the five threats: the high skills, lack of information, diseases outbreaks, irregular production and the potential changes in the organic specification.

Providing farmers with reliable information and efficient advice would allow better technical performances and better economic results. If the production is financially interesting and the demand remains higher than the offer, then more farmers will be willing to settle.

The more people are involved, the more important the sector becomes. Then, the professional institutions and organizations get interest into the production. The more interests there are, the more communication, support and researches are started. The communication would ensure the increasing demand and promote the new alternative to conventional rabbit meat.

4.4 Limits of the research

This work was a preliminary research on a new animal production system. The main limits were the availability and reliability of the data. Only nine farms were contacted and each one kept different type of data. For example, farmer A,B,C and E wrote down the number of kits born and born alive while farmer D and F did not keep these information. Due to the small sample and the diversity of data, finding common reliable indicators was difficult and may be biased. The results showed some trends but deeper analyses could not be performed due to the diversity within the small-sized sample. The uncertainty should be reduced by more observations and more precise measurements.

In addition with the lack of reliability of the daily records, some answers to the questionnaires were farmer's estimations, which can be biaised. For example, the average weaning age calculated did not fit farmer's estimations, except for farmer E. Except him, all farmers did not record and analysed their data and can therefore give eroneous replies.

The SWOT analysis had been made only with farmers. However, a rich diverse representative SWOT only can be obtained by including a heterogeneous group of stakeholders. Next time, more stakeholders should be involved such as conventional farmers and people from ITAVI and research centers.

Conclusion

What are the existing organic rabbit production systems?

- About 30 farms, mainly located in the North-West
- They are young (66% settled after 2013) and small sized (20-90 does)
- The rabbit activity is a secondary production
- Does are living in movable cages and meat rabbits are raised in larger parks
- Feed is based on daily fresh grass supply and complete feed
- Almost no vaccination against Myxomatosis and VHD and deworming
- Reproduction is by natural mating
- Males are kept longer (14 months) than females (6 months), culling is not common or late (>24 months)
- There is 100% of self-renewal of the does mainly based on visual criteria of the future doe
- Litter re-arrangement is done by few farmers. Adoption is more usual than elimination.

What are their current technical performances?

- All farms had different technical performances but none of the farm was significantly performing better than the others.
- Overall, fertility rate is 57% slightly affected by seasonal effects. 8.8 (± 3.2) kits are born per kindle, 8.0 (± 3.1) are alive and 6.2 (± 2.6) kits are weaned.
- Mortality rates are high: stillborn rate > 7.3% and lactation mortality rate > 18.5%.

What factors influence the production parameters?

- The genetic potential including fertility, prolificacy, health resistances, growth rate, meat conformation.
- The sanitary management through vaccines, deworming, disinfection, cleaning.
- The animal protection from predators with fences and nets.
- The working time spent on the rabbit production and especially on hygiene issues.
- The feed quality and sufficiency.
- The information and support available.

Recommendations

Farmers should pay attention to the details of their management to improve their production systems. The first important step is to record data, which is easy with the Excel program given. This program can be used to select properly the reproductive animals and better organize the work. Finally, farmers can check their technical performances and therefore adapt their practices to be more efficient. The other recommendations relate to livestock protection (diseases, parasites, predators) and litter's re-arrangement.

Simultaneously, the sector has to continue its development. The AELBF, the current farmer association, is the key stakeholder. It should organize formations, trainings, start more projects with research centers and launch professional institutions and organizations. Finally, it should communicate to promote organic rabbit meat and secure the market. Managing an organic rabbit farm should be easier than today to encourage new farmers to settle and current farmer to keep on producing.

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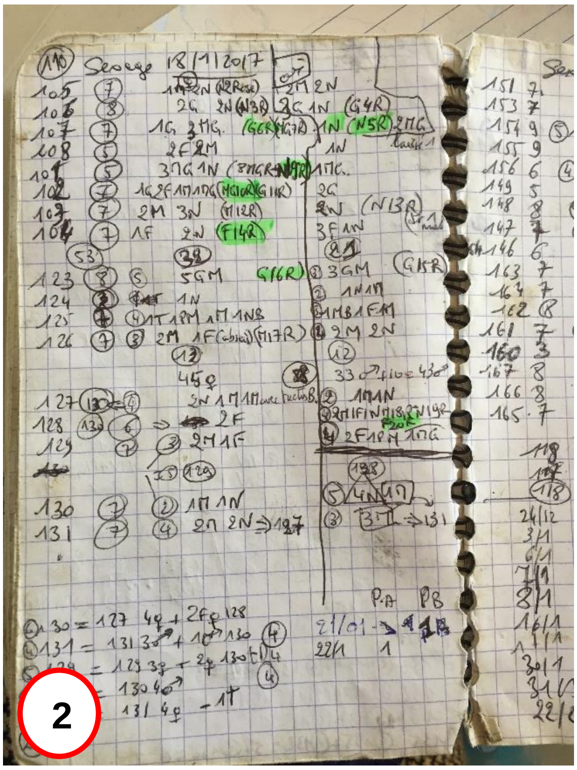
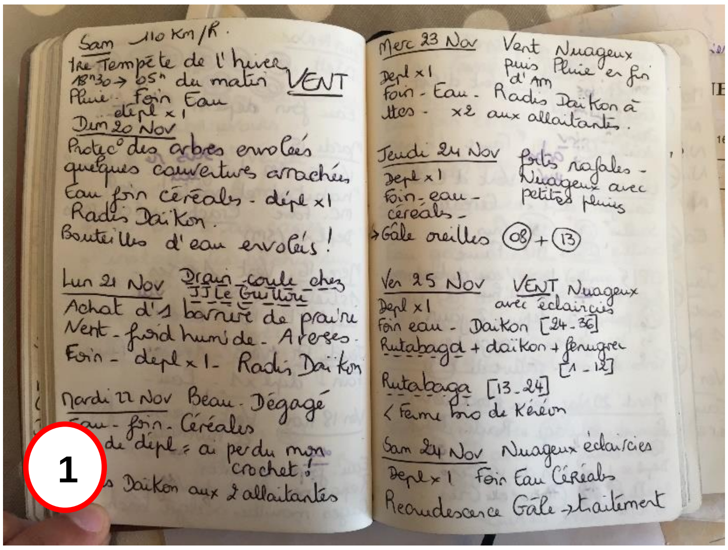
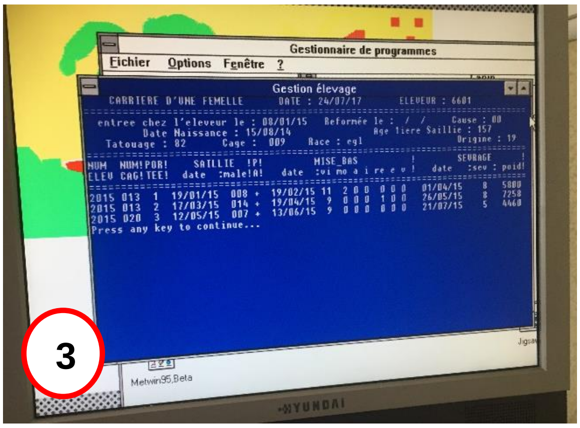
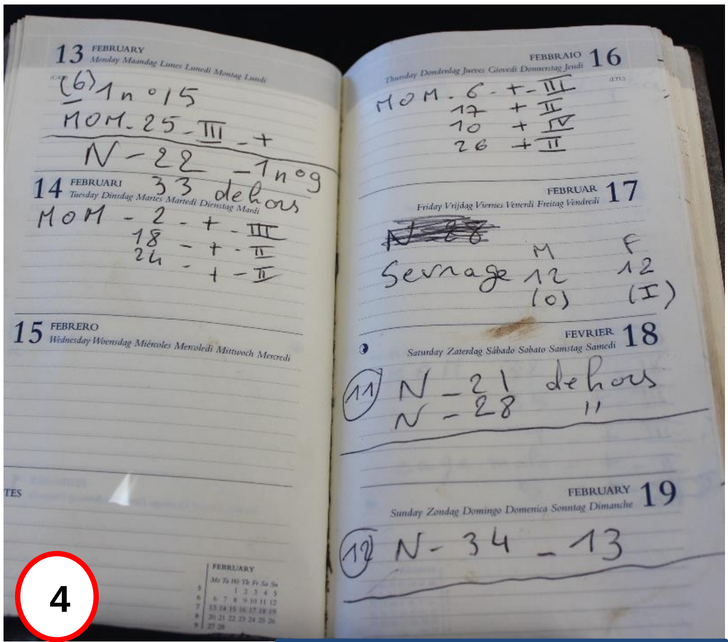
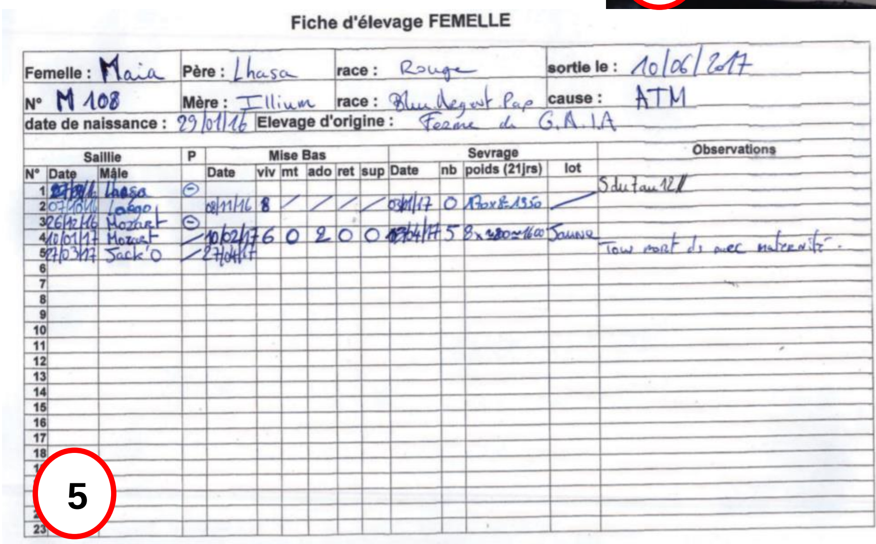
Appendix 1 : Diversity of the daily records tools





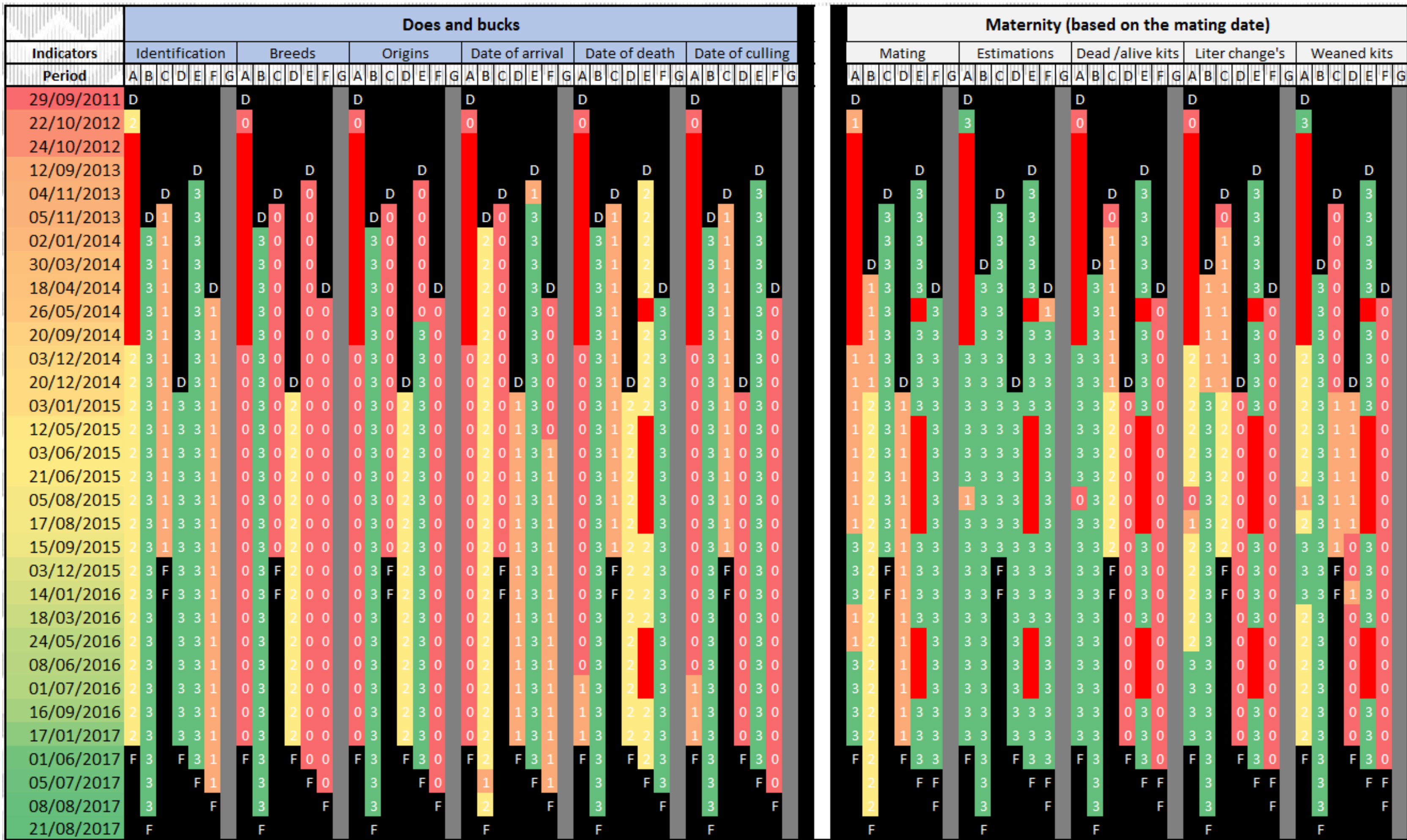






1. Agenda (per day)
2. Record (per event)
3. Doe computer sheet
4. Agenda
5. Printed doe sheet

Appendix 2 : Quality and quantity of data per farm, per period of time



Period	TOTAL	TOTAL D&B	TOTAL MATER.
29/09/2011	0	0	0
22/10/2012	9	2	7
24/10/2012	0	0	0
12/09/2013	0	0	0
04/11/2013	24	9	15
05/11/2013	35	14	21
02/01/2014	54	31	23
30/03/2014	54	31	23
18/04/2014	65	31	34
26/05/2014	56	33	23
20/09/2014	78	38	40
03/12/2014	91	40	51
20/12/2014	91	40	51
03/01/2015	112	50	62
12/05/2015	95	48	47
03/06/2015	96	49	47
21/06/2015	96	49	47
05/08/2015	88	49	39
17/08/2015	95	49	46
15/09/2015	115	51	64
03/12/2015	101	48	53
14/01/2016	102	48	54
18/03/2016	98	48	50
24/05/2016	81	46	35
08/06/2016	84	46	38
01/07/2016	86	48	38
16/09/2016	103	50	53
17/01/2017	103	50	53
01/06/2017	71	36	35
05/07/2017	35	21	14
08/08/2017	31	17	14
21/08/2017	0	0	0

Gap in the records.
D First date mentioned in the records.
F Last date mentioned in the records.
0 No information about the criteria.
1 Few information about the criteria.
2 Most of the information but doubts on the reliability.
3 Most of the information and good reliability.

Appendix 3 : French organic rabbit specification

Translation of the document of ECOCERT (2015)

- FARM LEVEL -

- The maximum number of reproductive females is 200 per site and 400 for one farm.
- It is not possible to keep a conventional and an organic rabbit production at the same place.
- Farmer should choose breeds that are adapted to local conditions, healthy and resistant to diseases. Ancient or local breeds are preferred.
- Reproductive animals must be clearly identified (tattoo, tags, etc.)
- Kits wear an identification of the litter with a technic not traumatic
- New reproductive animals must be older than 16 weeks
- Maximum litters per year is 6 per doe.
- Slaughtering is the same day the rabbits lef the farm
- Rabbits must be older than 100 days.

- CONVERSION PERIOD -

- Conversion period starts when the farming conditions meet the requirements of the regulations RCE 834/2007, 889/2008 and CC FR Bio.
- For land, one year is necessary to be certified organic from conventional practices. There are few exceptions at six months for some grassland for example.
- For reproductive animals, it is 3 months.
- For rabbits sold as organic meat, they must have been born and raised organically.

- ANIMAL PURCHASES –

- Animals not certified organic can be bought when the farmer cannot find organic rabbits with the criteria he’s looking for.
- Reproductive animals can be bought if raised under organic certification from weaning.
- Reproductive animals have to be younger than 4 months when bought
- Reproductive does have to be virgin when bought
- Only 10% of the herd can be bought every year.
- Farmers must keep bills and documentary proofs to justify the new animals
- Few exceptions to the 10% rule can be noticed: it can be 40% of the herd if:
- The herd size is increasing up to 30 % of the herd
- Breed change
- Nearly extinct breed

- FEED -

- Minimum 50% of the dry matter is coming from the products of the farm.
- Kits must get mil, preferably from its mother, during the first 3 weeks at least.
- Are strictly forbidden: Conventional products, amino acids.
- Lists of oligo-elements, technologic additives, yeasts and mineral raw materials give the authorized products
- Enzymes and micro-organisms are allowed as zootechnic additives
- Natural vitamins and synthetic A, D and E vitamins which are same as the natural one are allowed

- At least 60% of the feed must be coarse fodder.
- Exceptions are made for the products originated from a farm/land in conversion

- HOUSING -

- Three types of housings are allowed:
- Movable cages on grassland daily moved
- Parks with fences on a grassland
- Half free range with an outside run which can be concrete. It can be partially covered but need to be open on at least 3 sides.
- The sanitary fallow for buildings is at least of 14 days and 2 months for parks. The cleaning products allowed are listed.
- For buildings:
- Breeding on nets, slatted floor, without bedding or in rabbit hutches is forbidden
- The bedding must be certified organic straw or not treated woodchips
- Buildings must have nest boxes for kits
- Outside access is compulsory when the climatic conditions, rabbit physiologic state and soil conditions are good enough.
- The minimum space and maximum density elements of Table 24 must be respected.

Table 24 : Minimum space and maximum density regulations for organic rabbit productions (Source: ECOCERT, 2015)

Animals\Housing (m²/animal)	Building	Movable cage	Park	Outside run	Max density (animals/ha/y)
Doe with kits	0.40	2.4	5	2	100
Reproductive animal	0.30	2.0	4	2	100
Fattening rabbit	0.15	0.4	5	2	625

In conventional farms, the minimum is varying depending on the size of animals from 0.05 up to 0.07m²/animal.

- PROPHYLAXY -

- Diseases management is based on selection of resistant breeds, good farming practices, quality of feed, reasonable density of animals and adapted housing.
- The preventive use of chemical medicines is forbidden. Its use for a seek or injured animal is allowed.
- Plant based and homeopathic products are allowed as far as they have a real effect.
- A treatment is a curative medicine given to a rabbit for its disease. It can therefore be a commercial product with multiple active ingredients; an injection followed by some days of local applications or different medicines which need to be taken for few days. Deworming products, external disinfectants and vaccines are not considered as treatments and are therefore allowed without limits.
- Only one treatment per fattening rabbit is allowed. 3 treatments every year are allowed per reproductive animals
- None of the rabbits can be slaughtered less than 30 days after a treatment
- All the legal instructions about delay before consumption, specific to medicines must be doubled.

Appendix 4 : Example of Q-Q plot diagram

For each sample, the Q-Q plot method is used to figure out if the dataset has a standard distribution. All the graphics will not be shown. For example, Figure 17 and Figure 18 are the Q-Q plot diagrams for does and bucks production times for farm A.

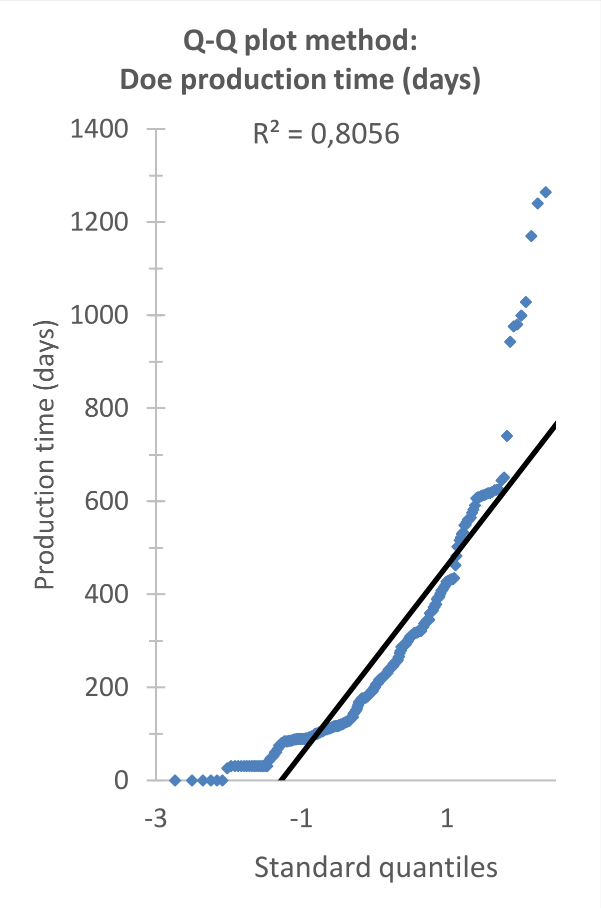


Figure 18 : Q-Q plot diagram for the dataset of the doe production time

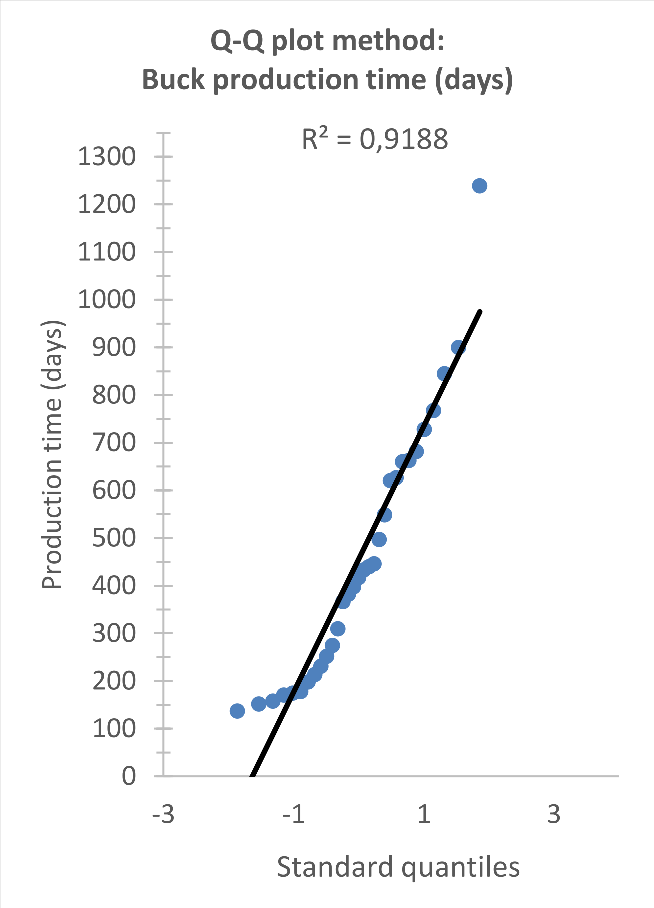


Figure 17 : Q-Q plot diagram for the dataset of the buck production time

The coefficient of determination (R^2) and number of values (n) were detailed in the report.

Appendix 5 : Complementary results

Table 25 : Details about land use of the 6 organic farms studied

	A	B	D	E	F	G	Conv*3
UAA*1	33	13	32	3	45	13	26
For rabbits:							
Grassland	4	0,6	1	3	4	4	-
Hay production	1	0,3	3	0	*1*	4	-
Cereals production	2,5	1,5	0	0	22*2	5	-

*"-" indicates missing data. *1UAA: Utilized Agricultural Area. *2 The farmer produces all the feed necessary for his animals but could not identify the share of rabbit feed. *3 (ITAVI, 2015b)*

Table 26 : Turnovers for the 9 organic rabbit farmers.

	A	B	D	E	F	G	H	I	Conv
Turnovers (€/y)									
Overall	75 000	-	110 000	-	-	5 000	-	-	172 000
Rabbit	32 500	7 500	15 000	-	-	5 000	-	-	137 600
Share of the rabbit activity [1](%)	50	<100	14	<100	<100	100	100	100	80

*"-" indicates missing data. *1Share of the rabbit activity in the overall turnover. "-" indicates missing information. *2 (ITAVI, 2015b)*

Table 27 : Information available about feed for 6 organic farmers on a year basis

	A		B		D	E	G	H	Conv*1
Type of feed	CF	AA	AA	RO	CF	CF	AA	CF	CF
Price (€/ton)	490	300	350	400	580	880	350	880	287
Quantity bought (tons)	6	6	2	0,15	5	3,5	1	-	-
Quantity distributed									
in maternity	0	0	90	5	75	60	50	180	-
in fattening	25	50	5	5	50	Ad libitum	50	180	-

*"-" indicates missing data. *1Data 2014 (ITAVI, 2015a). Complete feed (CF), Alfalfa (AA), Rape oil (RO). Farmer F produce 100% of the feed and do not figure in the table for this reason.*

Table 28 : Frequencies (%) of kindle happening after x weeks from previous kindle in 5 organic rabbit farms.

Week	A	B	C	E	F
4	0,6	1,4	0,9	0,7	2,1
5	1,0	2,3	2,3	4,0	1,8
6	0,4	0,9	2,8	3,3	1,8
7	0,8	0,5	0,9	21,9	1,1
8	1,0	0,9	1,1	33,1	3,2
9	1,0	1,8	1,7	8,6	14,0
10	2,5	16,4	8,7	1	7,0
11	7,1	20,9	17,7	2,6	16,8
12	16,0	3,6	8,7	2,6	10,5
13	15,4	4,1	11,3	4,0	11,2
14	19,3	4,5	6,4	0,7	8,8
15	9,6	4,5	4,7	2,0	3,2
16	5,6	6,8	4,5	1,3	1,8
17	6,0	5,9	2,1	0,0	2,1
18	3,5	5,0	2,6	1,3	1,8
19	1,0	2,3	3,0	2,0	2,1
20+	9,2	18,2	20,6	10,6	10,7

Table 29 : Breeds used among farms 8 organic rabbit farms (farmers' estimations in 2017)

Breed / Farm	A	B	D	E	F	G	H	I	Total
Argenté de Champagne	✓	✓	✓	-	-	✓	-	-	4
Bleu de Vienne	-	✓	✓	-	-	✓	-	-	3
Californien	-	✓	-	✓	-	-	✓	-	3
Chamois de Thuringe	-	✓	✓	-	-	-	-	-	2
Lapin Chèvre	-	-	✓	✓	-	-	-	-	2
Fauve de Bourgogne	✓	✓	✓	✓	✓	✓	✓	-	7
Géant des Flandres	✓	✓	✓	-	✓	-	-	-	4
Géant Papillon	✓	✓	✓	✓	✓	✓	-	-	6
Grand Russe	-	-	-	-	-	-	-	✓	1
Gris de l'Artois	-	✓	✓	-	-	✓	-	-	3
Lignée HHHycole	-	✓	-	-	✓	-	-	✓	3
Néo-zélandais Blanc	✓	-	-	✓	-	-	✓	✓	4
Normand	✓	-	-	✓	-	✓	-	-	3
Total different breeds	6	9	8	6	4	6	3	3	-

"-" indicates the breed is never used by the farmer.

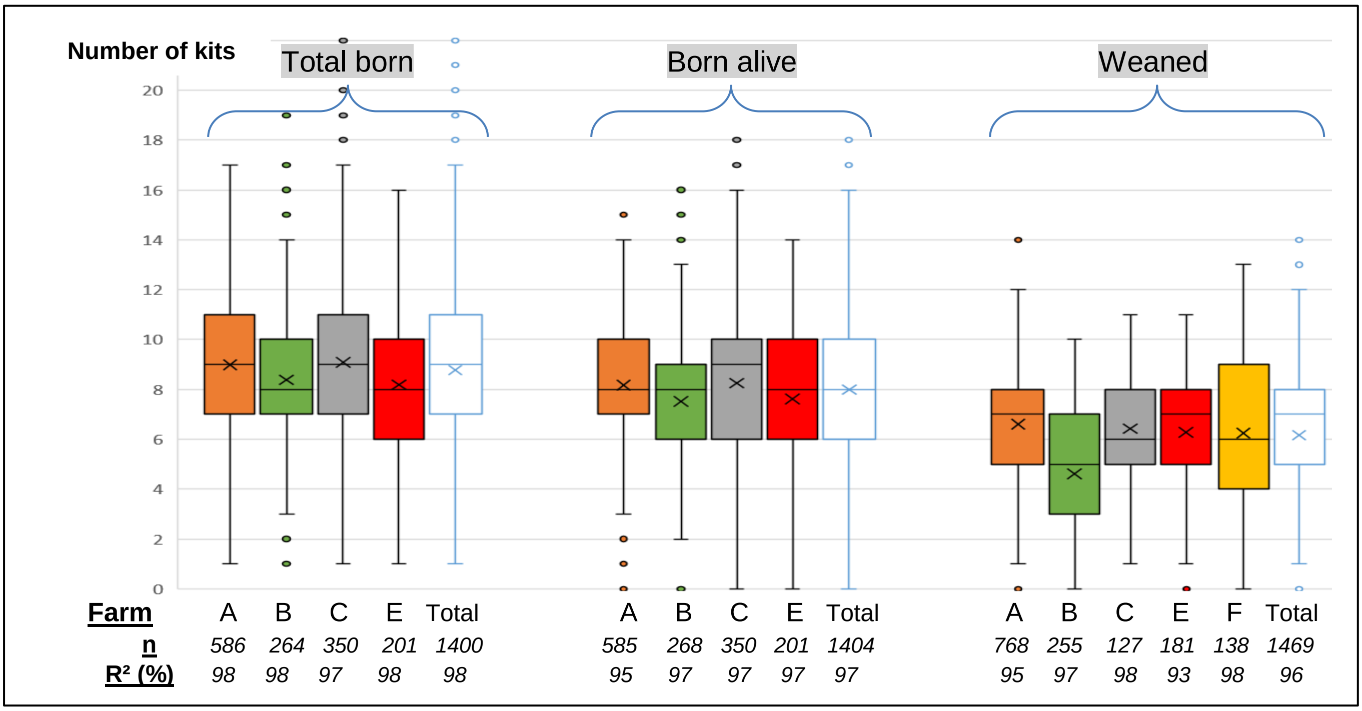


Figure 19 : Litter's sizes in 6 organic rabbit farms (data 2012-2017).

Table 30 : Results of Fisher test concerning the differences between the number of kits in maternity in 6 farms

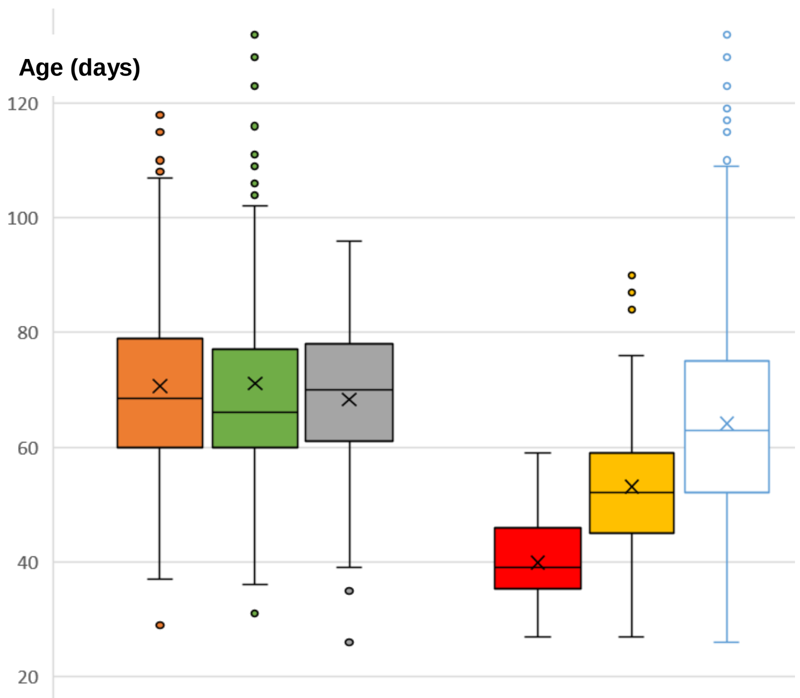
Fisher test	Total born		Born alive		Start. Lact.		Weaned	
	p-value	Diff.	p-value	Diff.	p-value	Diff.	p-value	Diff.
E vs C	**0,002**	-0,973	**0,020**	-0,685	**0,010**	-0,614	0,931	-0,022
E vs A	**0,003**	-0,911	**0,027**	-0,637	0,076	-0,416	**0,019**	-0,588
E vs B	0,283	-0,350	0,963	-0,014	**0,017**	-0,607	**< 0,0001**	+1,665
B vs C	**0,010**	-0,623	**0,004**	-0,671	**< 0,0001**	-1,221	**< 0,0001**	-1,687
B vs A	**0,016**	-0,561	**0,005**	-0,623	**< 0,0001**	-1,023	**< 0,0001**	-2,254
A vs C	0,765	-0,062	0,806	-0,048	0,218	-0,198	**0,001**	+0,566
B vs F	ND	ND	ND	ND	ND	ND	**< 0,0001**	-1,601
F vs A	ND	ND	ND	ND	ND	ND	**0,001**	-0,653
F vs C	ND	ND	ND	ND	ND	ND	0,657	-0,087
F vs E	ND	ND	ND	ND	ND	ND	0,809	-0,065

***Bold** indicates the significant difference with a risk of 5%. Farmer F only kept the number of weaned kits.*

Table 31 : Elimination and re-arrangement at kindling by 7 organic rabbit farmers

Farm	**A**	**B**	**D**	**E**	**F**	**G**	**H**	**Conv**
Elimination?	Often	Sometimes	Rarely	Never	Never	Never	Never	Often
Adoption?	Often	Often	Rarely	Often	Never	Never	Never	Often

Four choices had been proposed: Never, Rarely, Sometimes, Often.



Farm	A	B	C	D	E	F	Total
n	*666*	*231*	*136*	*0*	*168*	*224*	*1425*
R² (%)	*97*	*93*	*95*		*98*	*97*	*99*

Figure 20 : Weaning ages for 5 organic rabbit farms (data 2012 - 2017).

Figure 21 : Price of conventional rabbit meat (€/kg alive) in 2014, 2015 and 2016 (Hurand and Lebas, 2016)

Appendix 6: Seasonal effect

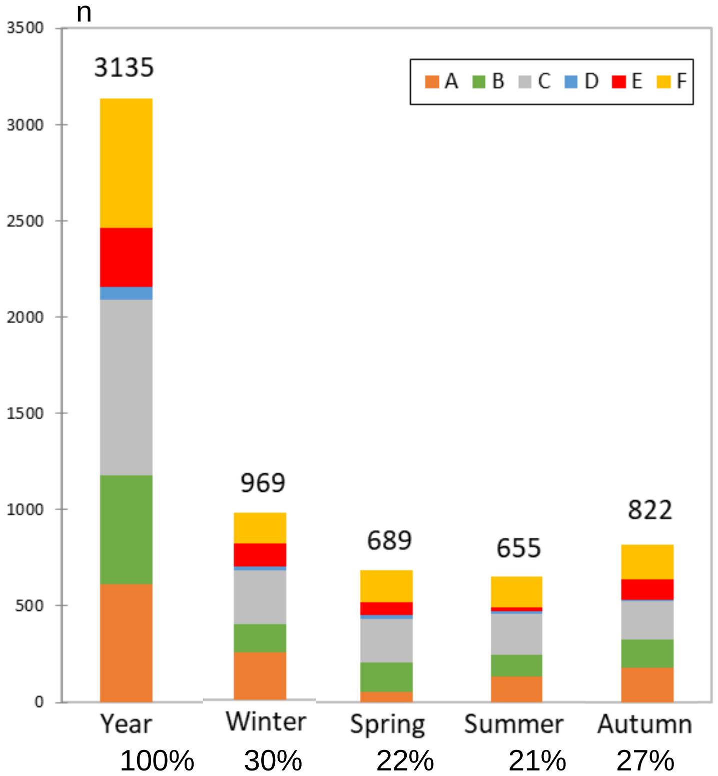


Figure 22: Distribution of the services along the year for 6 organic rabbit farmers and the contribution of each farm (data 2012-2017)

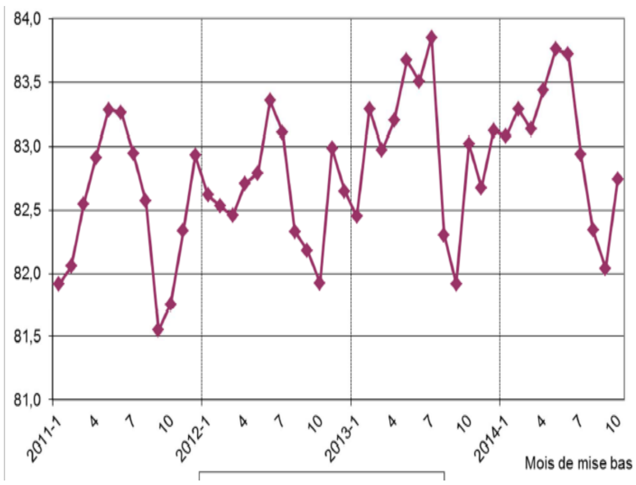


Figure 23 : Fluctuations of the fertility rate of conventional does under seasonal effect (ITAVI, 2015a)

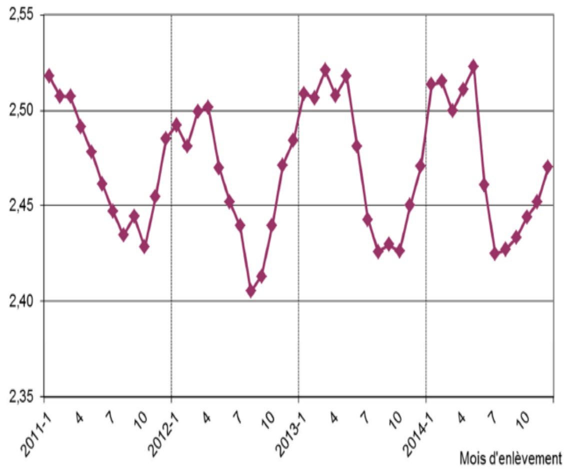


Figure 24 : Live weight of conventional rabbits at slaughter depending on the period they are slaughtered (ITAVI, 2015a).