

**ABSTRACTS OF THE 18<sup>TH</sup> FRENCH RABBIT DAYS**  
**NANTES, FRANCE, 27<sup>TH</sup>-28<sup>TH</sup> MAY, 2019.**

The 18<sup>th</sup> edition of the French Rabbit Days (Journées de la Recherche Cunicole) was organised by the association CUNICULTURE, in association with the INRA (*Institut National de la Recherche Agronomique*) and the ASFC (French Branch of the WRSA), in Nantes, over one and a half days on 27-28 May 2019. A total of 32 peer-reviewed communications, including three syntheses, were orally presented to about 90 attendants. The two most relevant subjects were: 1) studies on and possibilities for control of the viral haemorrhagic disease caused by the new RHDV2, and 2) control of digestive disorders, particularly coccidiosis, with nonchemical feed additives or diet formulation. One part of the communications was also devoted to the efforts made for the promotion of rabbit meat in France and research into consumer behaviour in relation to rabbit meat. The full texts of the communications, in French, are available on the WRSA website at the URL: <http://world-rabbit-science.com/Other-Proceedings/2019-18th%20Rabbit%20Days/000-E-Book-JRC2019.pdf>.

**PATHOLOGY & HYGIENE****GASTROINTESTINAL PARASITISM OF ORGANIC PASTURE-RAISED GROWING RABBITS ACCORDING TO AGE, SEASON AND TYPE OF PASTURE. PART 1/ NEMATODES**

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Our trial aimed to study the gastrointestinal parasitism in pasture-raised rabbits, during three seasons: winter 2014/2015, summer 2015 and spring 2016. For every season, at weaning 30 rabbits were housed in movable cages on two pastures: sainfoin and tall fescue. Nematode eggs in faeces were counted on a weekly basis. At slaughter (100 d old), the digestive tract was sampled to count the number of nematodes. The type of pasture (fescue vs. sainfoin) had no effect on egg excretion or on nematode prevalence and intensity. Spring 2016 was characterised by a high prevalence of *Trichostrongylus* sp. (93% of rabbits). A negative correlation between the intensity of infection by *Trichostrongylus* sp. and daily gain was observed, but without ruling out other factors, such

as season. These first results recommend increasing the pasture rotation time over the 2 mo required by current organic rabbit farming regulation in France.

**GASTROINTESTINAL PARASITISM OF ORGANIC PASTURE-RAISED GROWING RABBITS ACCORDING TO AGE, SEASON AND TYPE OF PASTURE. PART 2/ COCCIDIA**

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Our trial aimed to study gastrointestinal parasitism in pasture-raised rabbits; this second part is dedicated to coccidia. Coccidia oocysts were counted weekly in faeces and identified by species at weaning, 55, 69, 83 and 97 d of age. At slaughter (100 d old) the liver was examined. The type of pasture (fescue vs. sainfoin) did not affect oocyst excretion (all species). Compared to other seasons, in spring 2016 there was a 50% increase in the total excretion of oocysts, particularly in sainfoin pasture (6.5 M.OoPG), where the rotation times were shorter. *E. intestinalis* was not identified, contrary to *E. flavescens* during summer and spring 2016. During spring 2016, the

number of oocysts of *E. flavescens* excreted on the tall fescue pasture was 72% higher compared to the sainfoin pasture (11 682 and 6796 OoPG;  $P < 0.05$ ). No diarrhoea was observed during the trial, nor intestinal macrolesions in the slaughtered rabbits. However, 64% of the livers presented white nodules due to *E. stiedai*, without a significant effect of the pasture type, or of the season. The mean excretion of *E. flavescens* may explain a part of the lower daily weight gain ( $-5$  g/d) observed, whatever the pasture type, at spring 2016 compared to the two other seasons.

### PREVALENCE OF COCCIDIA INFECTION OF RABBITS IN THREE REGIONS OF ALGERIA

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A total of 40 rabbit farms located in three regions of Algeria, namely Médéa, Tizi-Ouzou and Djelfa allowed us to evaluate the prevalence and intensity of rabbit coccidiosis. The species of coccidia were been identified. We collected 273 faecal samples from weaned rabbits aged between 40 and 50 d. The search for coccidia was carried out by a quantitative and qualitative method. For all the farms surveyed, we recorded a prevalence of 90% (80.7-99.3%). The classification of the farms according to their parasite load allowed us to show that more than one third of the prospected farms had an oocysts excretion between 10 000 and 50 000 oocysts per gram (OPG) and almost a quarter excrete more than 50 000 OPG. The rest of the farms (32.5%) had an excretion of fewer than 5000 OPG. Excretion levels by region show that the region of Tizi-Ouzou ranks first with 79% of farms with a parasitic load greater than 10 000 OPG compared to the region of Médéa and Djelfa. Eight species of *Eimeria* were identified; *E. magna* is the dominant species before *E. media* and *E. irresidua* ( $P < 0.001$ ). The species weakly encountered are *E. perforans*, *E. stiedai*, *E. coecicola*, *E. piriformis* and *E. intestinalis*. The results obtained show that hygiene measures and the use of anticoccidial drugs in farms are insufficient.

### EFFECT OF A POLYHERBAL MIXTURE OF SUGAR CANE AND ACACIA CONCINNA ON OOCYST EXCRETION AND ZOOTECHNICAL PERFORMANCE OF THE GROWING-FATTENING RABBIT IN POOR SANITARY CONDITIONS

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At weaning (34 d), 299 rabbits were split between two dietary treatments; one diet contained 1 kg/ton of Peptasan, a polyherbal mixture of sugar cane and *Acacia concinna*, and the control diet was without chemical or natural substances aiming to control *Eimeria* development. Droppings were collected twice during the growth period, at 50 and 70 d of age, and the mortality and weight were measured. The test took place in a deteriorated sanitary context with mortality higher than that generally observed in this rabbitry. The total oocyst excretion and particularly of the pathogenic *Eimerias* (*E. magna* and *E. media*) decreased at 50 d of age, particularly for *E. media*. The differences were lower at 70 d of age. The oocyst excretion of *E. perforans* was barely affected by Peptasan. With respect to the totality of oocyst excretion, the percentage of *E. media* decreased greatly with the Peptasan treatment, while that of *E. magna* was modified slightly and that of *E. perforans* increased. Peptasan decreased the mortality in growing – fattening rabbits highly significantly, particularly between 34 and 55 d. The growth performance was not significantly modified. Peptasan appears as a natural product affording a decrease in oocyst excretion and mortality in a sanitary deteriorated context.

### EPIDEMIOLOGICAL STUDIES OF RHD OUTBREAKS IN FRENCH RABBIT FARMS FROM 2013 TO 2017

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Rabbit viral haemorrhagic disease (RHD) is a critical health threat to the French rabbit industry, which adopted a voluntary control plan against this disease in 2018. In this context, Anses and SNGTV carried out two epidemiological studies on RHD cases that occurred between 2013 and 2018 in France. The objectives were to describe the spread of the RHDV2 and identify breeding factors influencing the occurrence of the disease, in order to guide the prevention measures recommended in the control plan. Analysis of cases in 295 farms between 2013 and 2017 showed that 32% of the farms were infected at least once; the prevalence of the disease increased significantly in 2016-2017 compared to 2013-2015. Farms already affected in 2013-2015 had a higher risk of infection in 2016-2017 than those that remained uninfected until 2015 (Relative Risk 1.7 CI95% [1.1-2.7]). A case-control study carried out on 37 outbreaks between 2016 and 2018 and 32 control farms revealed significant variability

in biosecurity and decontamination practices between farms. The risk of disease tends to be linked to these practices, but certain structural factors (e.g. manure disposal system, transfer of kits at weaning) could also influence the risk of virus introduction into farms. These results will be further developed using information from the RDV outbreak monitoring system set up in 2018.

### **CLINICAL, MACRO AND MICROSCOPIC LESION ASPECTS FOLLOWING EXPERIMENTAL RHD REPRODUCTION USING A RHDV2 HYPERVIRULENT VIRAL STRAIN**

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The emergence of a hypervirulent strain of RHDV (GI.2-OLM.2017) with a particularly deadly epizootic event was observed in the Pays de Loire region in 2017. We used that strain for a viral challenge on SPF rabbits 4 and 10 wk old. The authors observed the clinical and lesional aspects of this form of RHD. The clinical impact was similar to that previously described with other strains of RHDV2, but mortality was higher (100% in 4-wk-old rabbits and 88.9% in 10-wk-old rabbits). Maximum time of incubation of the disease was 3 d. A large increase in temperature (up to 41.5°C) was noted half a day before death, but it was followed by hypothermia 7 h before death. Jaundice was the most frequently observed lesion, followed by signs of ocular haemorrhage and non-constant epistaxis. Disseminated intravascular coagulation, jaundice and congestions of various organs were observed in histological sections.

### **RABBIT HAEMORRHAGIC DISEASE: EFFICACY OF A COMMERCIAL BIVALENT VACCINE AGAINST A RECENT HIGHLY PATHOGENIC RHDV2 STRAIN AND STUDY OF THE VIRUS EXCRETION**

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An increase in the pathogenicity of the circulating strains was recently reported. The objective of this experimental study was to assess the efficacy of a commercial bivalent vaccine against the recent highly pathogenic GI.2 isolate (2017), and to study the virus spreading in the organs and its excretion by the infected rabbits. Four-week and 10-wk-old specific pathogen-free rabbits were vaccinated.

After 7 d, controls and vaccinated rabbits were challenged and clinically monitored for 14 d. In the control groups, the challenge strain induced a mortality rate of 100% in 4-wk-old rabbits and 89% in 10-wk-old rabbits. Vaccination significantly prevented all mortality (all vaccinated rabbits were healthy at the end of the challenge), clinical signs, detection of viral RNA in serum and gross lesions in young and older rabbits. In vaccinated groups, two weeks after challenge, no RNA copies were detected by polymerase chain reaction in the lungs, kidneys and urine. In 10-wk-old vaccinated rabbits, no RNA copies were detected in the liver, spleen and faeces, unlike some 4-wk-old vaccinated animals. In older rabbits, we also demonstrated that the vaccine tested significantly protected from detectable RNA shedding via naso-conjunctival and rectal routes. In young rabbits, shedding via naso-conjunctival route was also strongly prevented; transient shedding via the rectal route was detectable eight days post challenge, and reduced thereafter. We concluded that, despite the quick evolution of GI.2 strains, the protection induced by the vaccine remains adequate.

### **DOSAGE OF RHDV-2 ANTIBODIES ON DOES AND THEIR KITS IN RELATION TO THE VACCINATION**

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Serological monitoring of 30 primiparous does and two of their kits after vaccination against rabbit haemorrhagic viral disease due to RHDV-2 was performed by c-ELISA method and by IgM2 titration on kits. The does were vaccinated with ERAVAC® when they were 10 wk old, and young rabbits were vaccinated with the same vaccine during this study when they were 45 d old. Three does out of 30 have no antibodies 4 mo after the first vaccination with ERAVAC®. The increase in geometric average antibody titres of the does 11 d after vaccination is totally similar to that of their kits 14 d after vaccination. The young rabbits with the best IgM2 titres 2 wk after vaccination were from does without or with very low antibody titres 25 d after parturition; on the contrary, kits without IgM2 were from does with the best geometric average antibodies 25 d after parturition.

### **HYSTEROTOMIES FOR THE TRANSFER OF YOUNG RABBITS FROM ONE BREEDING HOUSE TO ANOTHER WITHOUT INTRODUCTION OF MICROBISM**

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In order to be able to bring in a new herd without the risk of introducing new pathogens in the midst of an existing herd, we decided to perform hysterotomies one day before the supposed date of kindling, and to place in adoption kits which had never been in contact with their biological mother with synchronised adoptive mothers that had kindled in the adoption room. The anaesthesia protocol was provided for premedication with glycopyrronium bromide at a dose of 0.01 mg/kg body weight (BW), diazepam 1 mg/kg BW, and morphine hydrochloride 2 mg/kg BW. Then, fixed anaesthesia was obtained with alfaxalone at 4 mg/kg BW provided intravenously very slowly and then maintained at a rate of 0.1 mg/kg/min. The hysterotomy was performed using disposable instruments on 84 rabbits with a rabbit survival rate of 82% after the operation. The technique has made it possible to avoid introducing new pathogens into the breeding rooms despite the entry of a new herd.

## CARCASSES & MEAT VALORISATION

### EFFECT OF WATER INTAKE BEFORE SLAUGHTERING ON RABBIT CARCASS YIELD

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Two successive sets of measures were conducted to investigate the effect of water availability before slaughtering on rabbit carcass yields. In each of the two series, 200 rabbits were divided into two different groups: water withdrawal 14 h before slaughter (R) or full access to water up to 1 h before slaughtering (E). A solid feed withdrawal was applied to all rabbits 15 h before slaughter. The slaughter was carried out on the raising site (no transport). Warm and cold carcass weights as well as carcass yields (reference liveweight measured 14 h before slaughtering) were significantly lower for R group: slaughter yield of 53.8 vs. 54.1% for group E. Water loss during carcass refrigeration varied from one series of measures to another, with an average of 2.4%, but water availability effect was not significant. On av., carcass seizure rate was not significantly modified by water restriction: 2.2%. This study shows that under the experimental conditions of slaughter, especially with the absence of transport, the possibility for rabbits to drink until 1 h before slaughter seems to have a positive effect on the weight and the carcass yield in comparison to a water restriction set up from 14 h before slaughter.

### THE MEAT OF RABBITS FED DHA FORTIFIED FEEDS MAY BE AN INTERESTING SOLUTION TO HELP MEET THE HUMAN NEEDS OF THIS ESSENTIAL FATTY ACID - A REVIEW

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The specific effects of docoheanoic acid (DHA) (C22:6 ω3 fatty acid) on human health are well-known and documented, particularly the reduction of cardiovascular risks, insulin resistance, diabetes, obesity, metabolic syndrome and age-related macular degeneration (AMD). Considering these functional properties, health authorities have recommended a DHA intake of 250 mg/d for adults. However, the Omega-3 intake, particularly that of DHA, remains insufficient in the majority of Western countries. Currently, the main DHA source in European food is still fatty fish, but it is practically impossible to increase their consumption due to the ocean overexploitation and the frequent contamination of fish by heavy metals and the persistent organic pollutants (POP). Our previous publications have proved that it is possible to increase the DHA level greatly in rabbit meat by incorporation of microalgae as *Shizochytrium* sp. in their feed. This work demonstrates that the consumption of such rabbit meat with a high DHA level helps meet the recommendations in term of human DHA intake set out by the health authorities, both for the healthy population and for certain populations with clinical risks. This study emphasises the interest in consuming rabbit meat enriched with vegetable DHA to cover the human requirement without increasing the overexploitation of fishery resources.

### RABBIT RECIPES SEARCHED ON INTERNET

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A study was conducted to determine the types of rabbit recipes available and searched for by web surfers. An analysis was made of the consultation frequency in 2018 of the 122 recipe sheets available on the website [www.cuniculture.info](http://www.cuniculture.info). These results were then compared to the types of rabbit recipes available online on the top 10 culinary sites written in French. To this end, we selected the first 30 recipes proposed by each site. On the [cuniculture.info](http://cuniculture.info) website, rabbit recipe sheets were consulted 36371 times in 2018, or in 10.9% of all visits for the year. By far the most popular recipe was the quick recipe (12 min) for rabbit livers fried in a pan with shallots (37.9% of

consultations), followed by the barbecue rabbit recipe (10.6%). Of the 10 other Web sites, 85% of recipes are for simmered dishes or more generally slow-cooking dishes prepared with rabbit meat. Rapid recipes (<30 min total) represent only 3% of total recipes but, more importantly, were absent from the top 30 rabbit recipes for 7 sites out of 10. Given the importance of simple and fast recipes viewed in Internet, particularly those with rabbit liver, an effort to promote this type of recipe could help support the consumption of rabbit meat in France.

### KNIGHTS' BROTHERHOOD OF THE "RABOILLÈRE"

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Created in 1997, along historical lines, by rabbit advocates, the Brotherhood of the Order of Knights of the *Rabouillère* brings together those present in 8 countries who support the rabbit in all its forms. Through promotional, convivial or festive activities, the organisation shares the knowledge and beliefs of this species and related products with the general public and specialists. During the past 13 yr (2006-2018) the Brotherhood has participated in or organised 124 public events to promote the rabbit in France or abroad.

## GENETICS

### METAGENOMIC RESPONSE TO SELECTION OF INTRAMUSCULAR LIPIDS IN THE RABBIT

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A metagenomic analysis of 2 rabbit lines divergently selected for intramuscular fat (GA and GB) was performed. Caecal content samples from 40 rabbits belonging to each line were analysed. After analysing the quality of the sequences obtained, 6230 genes were identified from the metagenomic samples. The undetected genes in 25% of the samples were removed, eventually leaving 4540 genes. Considering that they are composition data, they were transformed using the log-quotient centred method. PLS-DA (Latent Projection, Discriminant Analysis) analysis was performed to identify genes related to the discrimination of high and low intramuscular fat lines. After the first PLS-DA analysis, "VIP" genes with a VIP>1 were selected, leaving 105 genes capable of discriminating individuals belonging to each line, with cross-validation Q2=0.92. These microbial genes encode proteins involved in different

metabolic pathways, the most important pathways being related to energy metabolism (18 genes). The analysis was repeated for these 18 genes, obtaining cross-validation with Q2=0.52. Two genes involved in methane metabolism, beta subunit of malate-CoA ligase (K14067) and dihydroxyacetone kinase (K00863), had the highest VIP value, showing a relevant relation with intramuscular fat. The GA line showed a greater abundance of genes involved in specific carbohydrate pathways such as mannose and fructose, L-rhamnose isomerase (K01813), P=0.99, and dihydroxyacetone kinase (K00863), P=0.82. In the low intramuscular fat line (GB), other genes such as D-sedoheptulose 7-phosphate isomerase (K03271) and O-antigen ligase (K02847), involved in lipopolysaccharide biosynthesis, were more abundant (P=0.98 and P=0.99, respectively).

### INTEREST OF MEASURING THE RESIDUAL FEED INTAKE IN RATIONED FEEDING FOR THE IMPROVEMENT OF FEED EFFICIENCY IN A HYCOLE MALE LINE

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A study was conducted on several criteria for optimising food efficiency: the residual consumption (RC) and the feed conversion ratio (FCR). The objective was to identify one or more criteria for selecting and improving the feed efficiency of animals. The study involved a sample of 393 data from X HYCOLE line males, from May 2017 to January 2019. Food consumption measurements were performed under hourly feeding to match field realities. The measurements were carried out on cages containing two full sibs in order to limit the biases. Statistical analyses were estimated under software R and genetic parameters under ASReml. Our results showed a heritability of 0.20±0.15 for RC and 0.18±0.13 for FCR, with a strong phenotypic correlation between these two criteria (0.71). RC and FCR have low or medium phenotypic correlations with growth criteria, so they have little influence on animal growth. Genetic parameters analysis does not allow us to obtain significant correlations but makes it possible to determine interesting trends for the RC criterion.

### RELAPA PROJECT (GENOMICS FOR RABBIT GENETIC RESISTANCE TO PASTEURILLOSIS): HAEMATOLOGICAL STATUS OF SUSCEPTIBLE AND RESISTANT RABBITS

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Pasteurellosis is the first cause of female mortality in rabbit farms. During the RELAPA project, 953 rabbits were inoculated at 6 wk of age with a pyogenic strain of *Pasteurella multocida* (*Pm*) and monitored for 14 d. Disease response was highly variable among animals, with 7% of resistant animals and 11% of highly susceptible rabbits. A complete blood count was performed 14 d post-inoculation on 574 inoculated and 28 control rabbits. Significant differences in white blood cell, red blood cell, and platelet counts were observed according to the disease resistance score. Susceptible rabbits had a lower red blood cell count, probably due to the haemolytic and haemorrhagic activity of *Pm*. They also had a higher percentage of monocytes, neutrophils and eosinophils involved in the innate immune and inflammatory responses and, conversely, a lower percentage of lymphocytes (involved in the adaptive immune response) as compared to highly resistant and control rabbits. They seem to be unable to mount an immune response to control the infection. Significant sire effects on several levels of white blood cell populations suggest some genetic variability underlying the haematological response to *Pm* infection.

#### RELAPA PROJECT (GENOMICS FOR RABBIT GENETIC RESISTANCE TO PASTEURERLOSIS): GENETIC PARAMETERS

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This study is a first approach to estimate genetic parameters of resistance to pasteurellosis by experimental infection of a crossbred rabbit population with *Pasteurella multocida*. Novel disease-related traits were the abscess dissemination score collected post autopsy, a score related to the presence or absence of *Pasteurella* in the organs, from which a composite resistance score was created. For disease-related traits, heritability estimates ranged from  $0.09 \pm 0.05$  to  $0.16 \pm 0.06$ . Highest heritability was estimated for the resistance trait. Results for heritability estimates suggest a contribution of a genetic component in resistance to pasteurellosis. The genetic correlations between disease resistance and growth traits were high and positive, varying from  $0.70 \pm 0.14$  to  $0.98 \pm 0.06$ . These results support the implementation of a selection against pasteurellosis in the French breeding programmes for meat rabbits using these criteria. Further investigations will be performed using additional disease-related and production traits.

#### RELATIONSHIP BETWEEN RESISTANCE TO PASTEURERLOSIS IN INOCULATED RABBITS AND GROWTH AND REPRODUCTION TRAITS IN RABBITS RAISED IN COMMERCIAL FARMS

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Pasteurellosis is the first cause of female mortality in rabbit farms. The RELAPA project studies the genetic determinism of resistance to pasteurellosis. A group of 955 rabbits produced by 28 sires from 6 commercial lines was inoculated at 6 wk of age with a pyogenic strain of *Pasteurella multocida* (*Pm*) and monitored for 14 d. These rabbits were scored for resistance to pasteurellosis from 0 to 4, by taking into account post-mortem examinations. The 28 sires also produced 5164 rabbits tested for growth and 884 females with 3568 litters tested for reproduction in commercial farm conditions. Fertility was the only significantly different trait between the offspring of the 14 resistant sires and the offspring of the 14 susceptible sires, with a difference of 7 points in favour of the resistant group. Residual correlations were all low and not significantly different from 0. Genetic correlations between resistance and growth traits were positive but not significantly different from zero ( $0.32 \pm 0.51$  for weaning weight and  $0.27 \pm 0.49$  for final weight). Genetic correlations between resistance and prolificacy traits were unfavourable but not significantly different from zero ( $-0.43 \pm 0.45$ ,  $-0.68 \pm 0.40$ ,  $0.70 \pm 0.65$  for total number born, number born alive and stillbirth, respectively). These genetic correlation values are given for information but should be interpreted with caution due to their low accuracy.

#### REPRODUCTION & MANAGEMENT

##### EFFECT OF FEEDING LEVEL AND RATE OF PROTEIN INTAKE ON LIBIDO AND RABBIT SEMEN CHARACTERISTICS

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Twenty-seven male rabbits of the synthetic strain "ITELV 2006", aged from 7.5 to 8 mo, were divided into three experimental groups to study the effect of an increase in dietary protein content (19.7 vs. 14.5%) on sexual ardour and semen characteristics. Lot A received *ad libitum* a standard pelleted feed with 14.5% crude proteins, and lot B received only 120 g/day of the same diet. The 3rd



lot (C) received 120 g/day of the same pelleted feed, the protein level of which was increased up to 19.7% by daily supplementation with 6.6 g/meat peptone. Daily measurements of intake quantities and weekly measurements of body weight and male libido were carried out. For each male, two successive ejaculates at 10-min intervals were collected once a week for 8 wk. The average daily intake was 132 g/d, 115 g/d and 112 g/d for the males of lots A, B and C respectively. Body weight gains in 8 wk were +229, -134 and +59 g for lots A, B and C. Rabbits responded well to solicitations and had a very high useful collection rate (100%). The mean volume of ejaculates was identical for the 3 lots (0.48 mL). A mean concentration of  $445 \times 10^6$  spermatozoa per mL of ejaculate (spz/mL) and mean values of 4.76 and 3.15, respectively, for mass and individual motility were recorded without significant difference between groups. In the same way, few significant variations were observed, apart from vitality and abnormalities; no difference was revealed for the ejaculate characteristics between the three groups, although vitality and percentage of abnormal spz are affected when the males are rationed and without supplementation. It can be deduced from these results that the protein supplementation partly corrected the reduction in performance associated with male feeding at 120 g/day of standard diet with 14.5% proteins.

#### REPRODUCTIVE PERFORMANCE OF RABBIT DOES OF THE STRAIN "ITELV 2006" ACCORDING TO THE ARTIFICIAL KINDLING-INSEMINATION INTERVAL - PRELIMINARY RESULTS

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Sixty primiparous rabbits does of the Itelv-2006 strain, of comparable weight and age (on av. 3870 g and 5.7 mo) were distributed after kindling in three lots of 20, corresponding to an artificial insemination (AI) performed 4, 7 or 11 d after kindling. The parameters studied were receptivity (colour of the vulva) at the time of AI, fertility and prolificacy (total kits born) following this AI. Rabbits inseminated on D4 or D11 *postpartum* were significantly more receptive than those inseminated at D7: 70 and 80% vs. 30% respectively ( $P=0.003$ ). Fertility at kindling was similar for lots D4 and D11 (70 and 75%), but significantly lower for lot D7: 60% ( $P=0.030$ ). Finally, the lowest prolificacy was observed for group D11: 7.86 total born per litter, vs. 8.78 and 9.75 for lots D4 and D11 ( $P=0.01$ ). However, a very high stillbirth proportion (on av. 47%), probably related to the very unfavourable external conditions at the time of kindling, means that this latter result must be considered with precautions.

#### EFFICIENCY OF STATE AIDS IN RELATION TO THE PRODUCTION PERFORMANCES: CASE OF RABBIT FARMS IN TIZI-OUZOU REGION, ALGERIA

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The objective of this study was to evaluate the production characteristics of rational rabbit farms and the level of adherence of farmers to the financing mechanisms for the development of rabbit farms in the Tizi-Ouzou area. Sixty-seven rabbit farms were surveyed for 5 mo in 2017. The results showed that 73% of breeders were between 31 and 55 yr old. Women represented only 22% of the surveyed breeders. Rabbit breeding was still either a secondary activity (only 6% considered it as the main activity), practised mainly by men who are agro-breeders (48%) or had an extra-agricultural profile (45%). The size of farms was on average 43 females, with a variability ranging from 8 to 250 females. The average number of kindlings/year was  $6.6 \pm 1.1$ , and the number of rabbits born alive/female was on average  $7.0 \pm 0.72$ . The pre-weaning and fattening mortality rates were  $8.9 \pm 5.9$  and  $14.3 \pm 6.2\%$ , respectively. Sales reached an average of  $36.2 \pm 9.4$  rabbits/female /year with a weight of rabbits of 2.42 kg on average. State aid for the farms at start-up only concerned 42% of respondents, and applications for technical assistance reached 63%. A typology based on the numbers of females showed that the big breeders are the major beneficiaries of State aid. These show the best production performance. In general, livestock productivity varies little according to whether or not they are assisted by the State. However, given these results, it is recommended to further facilitate access to this assistance and strengthen the training component in order to improve productivity and encourage better organisation of rabbit breeders.

#### SOCIO-ECONOMIC IMPACTS OF FEED INTAKE RESTRICTION STRATEGIES FOR THE GROWING RABBIT AFTER WEANING - A 10-YEAR RETROSPECTIVE ANALYSIS

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The young rabbit, like all young mammals, has to deal with digestive disorders around the weaning period. In breeding, it is desirable to reduce the risk of digestive disorders (diarrhoea) without using drugs, including preventive antibiotic practices. INRA has conducted an

ambitious research programme in collaboration with ITAVI and the main animal feed companies (federated in a group: "GEC"). These works have shown that good control of the post-weaning feed intake reduces the risk of digestive diseases while improving feed efficiency. In terms of impacts, this leads to both a reduction in the losses of growing rabbits (720 000 rabbits saved/year or 30M€ over 2005-2015), a reduction in the use of drugs (-50% antibiotics used against digestive disorders) and a lowering of food costs (+5% of feed efficiency, or 40M€ in savings between 2005-2015). This temporary restriction of intake after weaning also favourably affected the environment (-9% of global warming potential, -11% of eutrophication potentials and -12% of acidification, and -10% occupation of agricultural areas). This practice therefore combines economic, environmental and social benefits.

### A TECHNICAL REFERENCING DATABASE FOR ORGANIC RABBIT FARMING IN FRANCE: FIRST RESULTS

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A first simplified technical referencing system (RTS) was created based on 6 organic rabbit farms with data collected over 3 yr of production (2015 to 2017) for the maternity unit (movable cages on pasture or individual pens, average herd = 33 females). The productive lifespan of a female was on average over one year, and can reach 2 yr (variability 75%). Female mortality averaged 21% over the period. With 5 matings, 3 litters per female/year (60% fertility rate) were obtained, for a total of 25 live kits and 19 weanlings (26% mortality before weaning). Thus, from the technical data calculated in our study, the income of a full-time organic rabbit farmer could potentially be around 26.3k€. This first RTS will be extended to a larger number of breeders, with the deployment of a smartphone application (GAELA) managing the rabbit farm and synchronised to a database.

## NUTRITION & FEEDING

### IODINE REQUIREMENTS OF RABBITS: DEFICIENCY, EXCESS AND RECOMMENDATIONS – A REVIEW

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Until the 2010s, the authors of nutrition reviews considered that there was no published scientific paper able to quantify the rabbit's needs for iodine. Recent publications with progressive iodine additions make it possible to set the minimum requirement for growing rabbits at 0.7-0.9 mg of iodine per kg of finished feed. For lactating does, the value of 0.9 mg L/kg is proposed and 0.4 mg L/kg covers the iodine requirements of adult rabbits at rest or of pregnant does. The upper safety limit beyond which performance begins to be degraded is 2.0 to 2.5 mg L/kg of feed, well below the legal maximum of 10 mg/kg applicable in Europe to rabbit feeds. This review provides the average iodine content of some 40 common raw materials used in rabbit feeding. Their content generally varies between 0.05 and 0.10 mg iodine/kg, values quite insufficient to cover the needs and thus requiring iodine supplementation. However, some raw materials such as molasses, calcium carbonate, fish meal or oyster shells have significantly higher levels of iodine: 1 to 10 mg/kg. Special attention should be given to the iodine content of the finished feeds when using algae among the raw materials of the feed. Indeed, their content may vary from 1 mg/kg to 10 g/kg of dry matter (1%) in the case of laminaria. Finally, it is recalled that raw sea salt (not artificially iodised) contains very small amounts of iodine (<2 or <0.7 mg/kg of salt according to the authors), which are notoriously insufficient to cover rabbit iodine requirements.

### DRY MATTER DIGESTIBILITY OF GRAZED SAINFOIN AND TALL FESCUE AND ESTIMATION OF SOIL INTAKE IN THE ORGANIC PASTURED GROWING RABBITS: FIRST RESULTS

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The development of organic rabbit production in pasture is limited by a lack of technical references, particularly about real grazed forage intake and digestibility. Moreover, to measure digestion at pasture we must know the intake of soil (minerals), as the latter could occasionally contain some pollutants. Therefore, after weaning (43 d) 30 growing rabbits were allotted to two groups and housed in movable cages on two types of pasture: one with 70% of sainfoin (*Onobrychis viciifolia*) and the other with 100% tall fescue (*Festuca arundinacea*). Each cage contained 3 animals, with a shelter of 0.4 m<sup>2</sup> and a pasture surface of 1.2 m<sup>2</sup>, and was moved every day. A pelleted commercial feed was distributed daily at a level of 60 g/rabbit, and was totally consumed. Daily grass intake was calculated by difference between offered and residual grass (cut over 3 cm). The *in situ* digestibility of the forage+pellets mixture was estimated after total collection of faeces left on the



soil for 2×4 d. Soil intake was estimated with an internal marker (acid insoluble ash) from its concentrations in soil, pasture, feed and faeces, as well as dry matter digestibility (DMd). The DMd of pelleted feed, both vegetation types and their mixtures were also determined with metabolism cages (as a control). The DMd of tall fescue varied from 37 to 43%, respectively, for a measure at pasture or indoors, whereas the DMd of sainfoin varied only by 1 unit (65.5 to 66.6, resp.). The rabbit's growth was 25% higher on the sainfoin pasture, while the total DM intake (pellets+grass) was similar to that of the fescue group (55 vs. 56 g/d and rabbit), but the protein intake was 25% higher for the sainfoin group. Soil intake was lower ( $P<0.05$ ) on tall fescue meadow (1.3% of total DM intake or 1.9 g/d) in comparison to sainfoin (3.0% of total DM intake or 4.2 g/d). The smaller soil intake on pasture of tall fescue could be due to the better soil cover by grass forming a buffer between animals and soil, in comparison to the sparser sainfoin cover.

#### INFLUENCE OF METABOLITES ISSUED FROM 2 STRAINS OF LACTOBACILLUS ON REPRODUCTION AND GROWTH PERFORMANCE IN RABBIT

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One hundred and sixty does in a first reproduction cycle and 117 in a second one were split between 2 treatments: one as control and the other with a feed containing 1.3 kg/ton of Métalac, a fermentation product of 2 lactobacillus strains, *Lactobacillus farciminis* CNCM-I-3699 and *Lactobacillus rhamnosus* CNCM-I-3698, simultaneously gathering the metabolites and microorganisms. The test consisted of studying the reproduction performance of these does and the results on growing – fattening performance of their offspring, which received a single feed between weaning and slaughter (70 d). Even with a higher prolificacy for the control group, the better homogeneity of the “2 day old rabbits” in the Métalac group enabled the breeder to achieve a lower initial elimination rate for this group than for the control animals. Consequently, the number of weaned rabbits/litter is significantly higher for the Métalac treatment (+0.15 /litter). The mortality rates before weaning were not modified. Simultaneously, the weights at weaning of the rabbits and of the litters were heavier (+30 g and +406 g, respectively) with the Métalac. Concerning the growing – fattening period, the Métalac distribution to the does before weaning failed to modify the mortality and growth of their offspring. However, the weight at 70 d remained higher (+ 9 g). Feed intake and feed conversion ratio were not modified. Slaughter yields

were improved by +0.8 points for rabbits that received the Métalac before weaning.

#### CHARACTERISATION AND EVALUATION OF THE PREBIOTIC POTENTIAL PROVIDED BY THE GALACTOMANNAN EXTRACTED FROM FENUGREEK IN GROWING RABBIT

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In the search for alternatives to antibiotics in industrial meat rabbit breeding, galactomannans (GM) extracted from fenugreek seeds (*Trigonella foenum-graecum*) has been proposed as a soluble fibre that may have prebiotic effect. To qualify a soluble fibre as prebiotic, it must satisfy three conditions: non-digestibility by stomach and intestinal enzymes, high fermentability by caecal bacteria, and selective stimulation of the microbial activity in the hindgut. In this context, the aqueous extraction of galactomannan was made from fenugreek seeds produced in Tunisia. In a pilot trial to test the non-digestibility and fermentability, the GM and two commercial rabbit feeds [supplemented with 10% soluble fibre (FS) or lignin (LIG)] were subjected to digestion by pepsin and pancreatin followed by fermentation with a caecal inoculum. In a second trial, the GM was included in a rabbit diet at three levels (0, 0.25 and 0.5%) and its effect on fibrous fractions digestibility was studied. According to our results, fenugreek GM was characterised by a purity of 69% and a galactose/mannose ratio of 1.06. Most of the ingested GM (83.6%) escapes *in vitro* digestion by pepsin and pancreatin. GM is fully fermented by caecal inoculum, contributing to a high production of volatile fatty acids (46.10 mmol/L) and a low ammonia nitrogen concentration (27.04 mg/L). GM may improve the digestibility of the fibre fraction, especially that of neutral detergent fibre. In conclusion, GM from fenugreek satisfies two properties to be considered as a prebiotic, although its effect on rabbit caecal microbiota needs to be studied to be qualified as a functional soluble fibre with a prebiotic effect in rabbits.

#### EFFECT OF FERMENTATION PRODUCTS FROM SACCHAROMYCES CEREVISIAE ON VIABILITY, GROWTH, AND MEAT COMPOSITION OF GROWING-FINISHING RABBITS

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A total of 1684 rabbits, 46 d old, were split between 2 treatments, one Control and another containing 1 kg/ton of a fermentation product of *Saccharomyces cerevisiae*, the Diamond V Original XPC. The experiment was conducted with 2 replications to evaluate the effects of Original XPC on mortality, growth, feed intake, feed conversion and the fatty acid profile of rabbit meat. Globally, Diamond V Original XPC reduced the mortality at 40-70 d (-3.7%) and improved rabbit growth (+2.8 g/d). This observed effect is particularly important in the first repetition, during which the sanitary status was lower than that normally observed on this test farm. Therefore, Diamond V Original XPC is particularly active in deteriorated sanitary conditions, in agreement with the literature to date. Finally, after slaughter at 70 d, Diamond V Original XPC significantly increased the deposits of Omega 3 (+30-50%), particularly ALA (+30-40%) and DHA (+25%) in rabbit meat, which is an important strength in a strategy of enrichment of animal products in these essential fatty acids.

#### **EFFECTS OF DIETARY OMEGA 3 FATTY ACID FORTIFICATION ON THE FATTENING PERFORMANCE AND NUTRITIONAL QUALITY OF RABBIT MEAT**

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The effects of a dietary increase of omega 3 fatty acids on growth performance and meat quality of rabbits were studied in 2 consecutive assays involving 1825 rabbits studied between weaning (35 d.) and slaughter age (69 d.). Three feeds were compared: a control diet with a low level of  $\omega$ -3 (0.07%), and 2 diets with 0.61%  $\omega$ -3, provided either by extruded linseed Tradi-lin® (3%) or by raw rapeseed seed (13%). Overall, mortality was significantly reduced by increased levels of omega-3 in the feed (-4.4 points) and this effect was higher with Tradi-lin® compared to rapeseed seeds. These results agree with the literature and previous experiments. The incorporation of Tradi-lin® is therefore an important part of programmes aimed at reduction or total elimination of the use of antibiotics in rabbit production. In the present experiment, the growth rate was slightly more reduced (-9%) than in previous results. On the other hand, the nutritional quality of rabbit meat was broadly improved by a strong increase in its  $\omega$ -3 fatty acids content (+115%) and a decrease in the  $\omega$ -6/ $\omega$ -3 (3.5 vs. 7.5) and LA/ALA (6.6 vs. 8.4) ratios, with a higher efficiency for the Tradi-lin® treatment. The analytical characteristics of the meat support its classification as a "source of omega 3" and meet the French «Bleu Blanc Coeur» specification.

#### **QUANTIFICATION OF SOLID FEED INTAKE OF SUCKLING RABBITS AND EFFECTS OF PELLET DIAMETER AND HARDNESS ON DIETARY PREFERENCES**

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Stimulation of the early feed intake of suckling rabbits represents an avenue of research to improve robustness by promoting a resilient gut microbiota. This study aimed to (i) quantify and characterise early solid intake as of 8 d with an innovative feeding system (in the nest, 8-17 d; outside of the nest in feeders, 15-35 d); (ii) to separately determine the effects of pellet diameter and hardness on their palatability. In the first experiment, four pellets of different diameters were tested in pairs: 2.0, 3.0, 4.0 and 6.0 mm. In a second experiment, pellets with the same diameter (2.5 or 4.0 mm) were pelletised with three die channel lengths: 10, 12, 14 mm or 18, 20 and 24 mm to obtain different hardness. Pellets of a given diameter were tested in pairs against each other (n=10 litters per treatment). Solid feed intake was observed at the litter level as of 8 d ( $0.02 \pm 0.02$  g of dry matter (DM)/rabbit). A total of  $1.63 \pm 0.76$  g of DM/rabbit was ingested in the nest with a high inter-litter variability. The milk intake did not have an effect on the early solid intake ( $P > 0.05$ ). The litter weight at equalisation was correlated with the feed intake at 2 wk of age ( $0.4 \leq r \leq 0.5$ ;  $P = 0.03$ ). The attractiveness of 2.0-mm-diameter pellets when they were available in the feeders was highlighted (from 61 to 86% of total consumption). The effect of pellet hardness on the suckling rabbits' dietary preferences still needs to be investigated. The onset of young rabbits' solid intake may be stimulated with easy access and palatable pellets. Better knowledge of suckling rabbits' feeding behaviour is paving the way for new studies on microbiota modulation through diet.

#### **IMPACT OF FEEDER ACCESS TIME BEFORE WEANING ON THE GROWTH PERFORMANCE OF RABBITS RAISED IN LITTERS OF 11 RABBITS PER MULTIPAROUS RABBIT DOE**

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The breeding of 11 rabbits per litter is possible on farms where the technicality and quality of young rabbits at birth is good. The first objective is to raise 11 kits per doe to study the growth of young rabbits, and the second is to study the effects of feed restriction applied 8 h a day

during the 10 d before weaning. Forty rabbits does and their 11 kits were divided into 2 groups; animals in the first were fed *ad libitum*, while the other group had access to the feeder only from 4 pm to 8 am each day. From weaning to 70 d of age, all rabbits received the same feed and had access to the feeder 12 h per day. The sanitary condition of this trial was very good in maternity as well as in fattening. There was no effect of feed restriction during the maternity period on the weight of young rabbits (935 g vs. 929 g for *ad libitum* and restricted groups,  $P>0.05$ ) or the feed consumption recorded (712 vs. 706 g/d cage;  $p>0.05$ ). At 42, 49 and 56 d of age, rabbits from the *ad libitum* group were significantly heavier than rabbits with restricted access to the feeder (between +3% and +2.5%,  $P<0.01$ ). At 63 and 70 d of age, the weights between the 2 groups were similar ( $P>0.05$ ). The ADG over the period 35-49 d of age was different depending on the type of access to the feeder (5% variation,  $P<0.0001$ ), but was not different over the other periods studied. In conclusion, the reduction in access time to the feeder had no impact on the growth performances and health status of the rabbits. Under the conditions of this trial, breeding 11 rabbits per doe allowed good zootechnical results, consistent with the standard.

is significant throughout the first part of the fattening period (32 to 50 d old): A 2.7 point reduction in DSR is observed per 0.1 points of DF/ADF. Throughout the second part of the fattening period (50 to 71 d old), this effect was not significant but tended to decrease the RSD by 1.1 points per 0.1 points of DF/ADF ( $P=0.16$ ). In terms of performance, the Average Daily Gain (ADG) ( $P=0.96$ ) and the Feed Conversion Ratio (FCR) ( $P=0.98$ ) were not influenced by this ratio. These results suggest that the beneficial effects of DF and IF on health status can be optimised when their intake respects a certain balance.

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#### EFFECT OF THE DIETARY RATIO BETWEEN DIGESTIBLE AND INDIGESTIBLE FIBRES ON THE DIGESTIVE HEALTH AND PERFORMANCE OF FATTENING RABBITS

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In animal nutrition, it is common to distinguish digestible fibres (DF) from indigestible fibres (ID), which both have benefits on rabbits' performances and health. In previous studies, dietary ID were usually represented by the ADF. By means of meta-analysis, the aim of this study is to explore further the influence of the ratio between DF and ID thanks to the DF/ADF ratio on the sanitary status and performance of fattening rabbits. The database contains 28 diets from 8 trials run in the same experimental centre (3856 rabbits from Hyplus genetic), with a DF/ADF ratio ranging from 0.73 to 1.03. Within each trial, feeds from different selected diets were distributed with the same quantity and had a similar nutritional content (except for fibre). Throughout the fattening period (32 to 71 d old), there was a significant decrease in the digestive sanitary risk (DSR) ( $P<0.01$ ), mortality and morbidity ( $P<0.05$ ) when the DF/ADF ratio increased. By breaking down the DSR into different types of pathologies, this beneficial effect is also observed on Rabbit Epizootic Enteropathy (REE) and on paresis ( $P<0.05$ ), but not on diarrhoeas ( $P=0.27$ ). The influence of the DF/ADF ratio on the DSR