

## **ABSTRACTS OF THE MAIN PAPERS PRESENTED DURING THE “8<sup>th</sup> WORLD RABBIT CONGRESS”**

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### **GENETICS AND BIOTECHNOLOGY**

#### **GENETIC IMPROVEMENT OF MEAT RABBITS. PROGRAMMES AND DIFFUSION**

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The essential elements of a programme of genetic improvement of meat rabbits, required to satisfy the needs of animals demanded by the producers of rabbit meat in a region or country, are analysed. The three way crossbreeding scheme is adopted to discuss the programmes. In this context, the development of maternal and paternal lines is one of the central points and a historical enumeration of research or development centres involved in this activity is presented. The principal criteria

in founding new lines are discussed and the interest is noted in finding two or three populations, no matter their genetic origin (pure breed, synthetics or crossbred), that are clearly outstanding for the traits important to the desired specialisation of the line. The alternative of applying very high intensities of selection for the traits of interest in very large populations is also commented upon (for example, commercial populations made up by a large number of farms) and examples of founding a line following criteria of hyperprolificacy and another of hyperlongevity are given. Paternal lines are commonly selected for post-weaning daily gain or weight at time of marketing by individual selection. The most common criterion used to select maternal lines is litter size at birth or at weaning, but there are proposals to include traits related with the ability of the doe to nourish the lactating progeny, traits such as weight at weaning, litter weight at weaning or total milk production. Currently, mixed model methodology (BLUP) is the habitual procedure used to evaluate the animals genetically, using repeatability animal models for litter size and selecting the progeny from the best evaluated matings.

The responses reported in paternal lines range between 18 and 35 g/generation for weight at market time and between 0.45-1.23 g/d. generation for daily gain, with correlated responses increasing adult weight, intestinal content and feed intake but decreasing feed conversion, dressing percentage and maturity at a fixed weight. The responses estimated in maternal lines range between 0.05-0.13 rabbits born alive or weaned per litter and generation, figures 0.08- 0.09 being common. Depending on the lines, ovulation rate or foetal survival were the modified components that explain the responses in litter size. Comparing the responses in crossbreeds with the responses in pure lines, slightly higher responses were obtained for the crossbred does; however, the response was lower than expected for the young issued from the terminal mating, probably due to an interaction between the feed currently used to control enterocolitis and the genetic level for growth traits. Finally, two approaches to diffuse the genetic improvement to the producer are presented which modify the standard pyramid of selection, multiplication and production, aiming to increase the selection effort and minimise the genetic lag between selection and production.

**Key words:** selection, lines, response, programs, diffusion

#### SELECTION OF MATERNAL LINES: LAST RESULTS AND PROSPECTS

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The aim of this review is to discuss selection of maternal lines, to present last results and to draw research prospects. Firstly, we discuss the genetic variability of the maternal quality traits. A divergent selection experiment on uterine capacity was performed in Spain during eight generations; results put forward the hypothesis that there was a major gene affecting uterine capacity. Reproductive performance could be improved by including female fertility in a selection program but response to selection would be probably very low. Even if genetic correlation between prolificacy traits and growth traits are, in general, positive, the litter size effect, introduced in the statistical models of growth traits, is always highly significant and negative, showing the well known phenotypic relationship between litter size and weights. One spreading method for analysing female longevity data is survival analysis which allows inclusion of both censored and uncensored records of animals. Development of computer programs has made it possible to estimate the genetic potential of does for a longer

productive life and to the genetic parameters for longevity. Studies have been conducted to settle adequate models of analysis and this criterion could be included in the selection objective. Later we draw up an inventory of the 19 on going selection experiments in six different countries. Significant differences in direct genetic effects for litter size or litter weight were found. An alternative to the selection of maternal lines for crossbreeding could be the development of a multi-purpose line, through simultaneous selection for litter size and growth traits. Finally we propose some conclusions. Selection objectives of maternal lines were directed towards a new direction: productivity is always a main point but breeding has to be sustainable. Therefore, we have to reduce young rabbits mortality, to increase doe longevity and to maintain genetic variability in selected lines.

**Key words:** selection, litter size, uterine capacity, growth, longevity, sustainable breeding

## REPRODUCTION

### UNDERLYING PHYSIOLOGICAL MECHANISMS CONTROLLING THE REPRODUCTIVE AXIS OF RABBIT DOES

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An increasing body of evidence unequivocally points to a strict inter-link between nutrition and reproduction. The paradigmatic case of leptin is examined to uncover nutritional-related physiological,

cellular and molecular mechanisms. The presence of leptin receptors (Ob-R) in the ovary, oviduct, hypothalamus and anterior pituitary suggests that leptin is involved in a large array of regulatory actions at different levels of the hypothalamus-pituitary-ovary (HPO) axis of the rabbit. In luteal tissue, leptin increases prostaglandin (PG) F<sub>2</sub> $\alpha$  synthesis but inhibits progesterone release using, respectively, the JAK/STAT and MAPK pathways. In the oviducts, leptin inhibits PGF<sub>2</sub> $\alpha$ , but stimulates PGE<sub>2</sub> synthesis. A nutritional challenge, evoked by 48-h fasting before AI, depresses all the reproductive parameters, reduces estradiol-17 $\beta$  pulse frequency and amplitude, lowers LH peak surge following GnRH injection, down-regulates the expression of oestrogen receptors (ER) in anterior pituitary, and causes a fall in plasma leptin concentrations. Although leptin secretion seems to be regulated by caloric intake rather than by adipose mass, taken together these findings support that leptin may act as a metabolic signal to switch on or off reproductive activity. Stress-related mechanisms are briefly discussed from the perspective of the potential benefit derived by modulating the neuroendocrine as well as the immune system during early development. Regarding the luteal function, several different luteolytic and luteotrophic forces at work as well as many levels at which these opposing and balancing influences may exert, via paracrine and/or autocrine mechanisms, their action in the corpus luteum (CL). The emerging role of the nitric oxide (NO)/NO synthase (NOS) system in the regulation of rabbit CL function is presented. Both endothelial and inducible isoforms of NOS are expressed at gene and protein levels in the CL, eNOS being regulated during pseudopregnancy. PGE<sub>2</sub> exerts its luteotrophic effect through NOS down-regulation, while the PGF<sub>2</sub> $\alpha$  luteolytic effect is mediated by NOS up-regulation both *in vitro* and *in vivo*. During luteolysis, luteal cytokines may be involved in the up-

regulation of NOS activity, while downstream NO may inhibit steroidogenesis and induce, after removal of the protective action of progesterone, the expression of p53 gene, a transcriptional regulator of apoptotic genes. First evidence for the action of endothelin-1 (ET-1), a potent vasoconstrictor synthesized by vascular endothelium, in promoting the luteolytic cascade mechanism in rabbits is enlightened.

**Key words:** reproductive axis, leptin, luteolysis, stress, rabbit.

## BREEDING OF YOUNG FEMALES DOES

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This paper describes strategies for rearing of young rabbit does with the objective to improve reproductive performance and prolong lifespan. Body development during rearing was considered the main factor to influence subsequent reproduction. Body development was manipulated by feeding level during rearing (*ad libitum* or restrictive) and age of first insemination (14.5 and 17.4 weeks) and was determined at the end of rearing by body weight and body composition. Does fed restrictively and inseminated at 14.5 weeks of age were too immature for reproduction. In these does, body weight was low (3.2 kg), protein development was not completed, and puberty characteristics were poor. An optimum body weight at first insemination was found (around 4 kg) to optimize litter size. At 14.5 weeks of age and *ad libitum* feeding during rearing, over 70% of the does did not reach optimum body weight of 4 kg.

Litter size of these does was reduced by 1.4 kit. At 17.5 week of age and *ad libitum* feeding during rearing, more than 75% of the does weighed at least 4 kg. However, heavy does were fatter, had a lower feed intake in the first gestation period, and the number of does with stillborn kits was increased. In restrictive fed does inseminated at 17.5 week of age, 60 to 80% of the does weighed around 4 kg, and the number of kits born alive was increased compared to does fed *ad libitum* during rearing and inseminated at 14.5 or 17.5 weeks of age. Milk production was influenced by the feeding strategy during rearing. Restrictive fed does inseminated at 17.5 week of age produced more milk than *ad libitum* fed does inseminated at the same age. This could be explained by the fact that restrictive fed does had not formed excessive fat depots at 17.5 week of age and had a higher feed intake as *ad libitum* fed does at the same age. *Ad libitum* fed does inseminated at 14.5 week of age, gained weight in the first gestation and first lactation period. Competition for nutrients between body growth and production must have occurred, and resulted in smaller litters and lower milk production than restrictive fed does inseminated at 17.5 week of age. It was concluded that young does should have a body weight around 4 kg at first insemination to optimize litter size. Feed restriction during rearing increased uniformity in body weight among does and stimulated feed intake in the first gestation period. The best reproductive performance in the first parity was obtained in does restrictively fed and inseminated at 17.5 week of age. Rearing strategies only affected body weight development, feed intake in the first parity. Long-term effects over three parities were absent and culling rate of does was not affected.

**Key words:** rearing management, reproduction, body development.

## PATHOLOGY & HYGIENE

### DOMESTIC RABBIT ENTEROPATHIES

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Digestive disorders are the main cause of morbidity and mortality, in fattening rabbit and are responsible for important economic losses in industrial rabbit farms. Among the specific causes of the intestinal pathology, parasites (coccidia) and some bacteria, mainly enteropathogenic *Escherichia coli*, are predominant. Since 1997, a new gastrointestinal syndrome called epizootic rabbit enteropathy (ERE), close to another digestive pathology, the mucoid enteropathy, has appeared in Europe with a high incidence on mortality and morbidity. The etiological agent of this emergent disease was still not identified for the moment. During the last ten years, thanks to the rise of biotechnologies and molecular biology, considerable progress were obtained with regard to the identification of the virulence factors and to the knowledge of the mechanisms of pathogenicity of the rabbit *E. coli*. In parallel, beside coccidiostats available for the treatment of coccidiosis, new prophylactic prospects based on vaccination were developed against the coccidia. In spite of difficulties, an experimental model to study ERE has been established and efforts are concentrated by some teams to identify and isolate the pathogenic agent(s) of this disease. Associated with the understanding of the physiopathology of the gut, at least in part under the influence of nutritional factors (both not developed here), the data obtained in these different areas would lead to new perspectives of control of the rabbit enteropathies.

**Key words:** rabbit, enteropathy, enteritis, diarrhea, coccidia, *Escherichia coli*, *Clostridium* spp.

## FEEDING & NUTRITION

### REFLECTIONS ON RABBIT NUTRITION WITH A SPECIAL EMPHASIS ON FEED INGREDIENTS UTILIZATION

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In this invited communication the author proposes a list of nutritional recommendations for rabbits of different categories: growing from 18 to 42 days, from 42 to 80 days, for breeding does according to productivity (40-50 kits weaned per doe/year or more than 50) and for a single diet suitable for all rabbits. Recommendations taking account the last published data, are divided in 2 groups. The first corresponds to nutrients which contribute mainly to feed efficiency: digestible energy, crude and digestible protein, amino acids, minerals, and fat-soluble vitamins. The second group corresponds to nutrients which contribute mainly to nutritive security and digestive health: different fibre components (lignins, cellulose, hemicelluloses) and their equilibrium, starch and water soluble vitamins. In a second part, 387 papers published during the last 30 years on raw material utilisation in rabbit feeding were analysed. In a total of 14 tables, the 542 corresponding experiments were summarised each by the identification of the raw material, by the highest level of

incorporation used in the experiment, by the highest acceptable level, by the main ingredient(s) replaced by the raw material studied, and finally by the authors reference. Raw materials studied were those used in temperate as well as in tropical countries. The raw material were grouped according to the following categories : raw material used as single food (24 experiments), cereals and byproducts (43 exp.), other carbohydrates source of energy (62 exp.), fats (27 exp.), full-fat oleaginous grains (10 exp.), oil cakes and meals (43 exp.), proteic seeds such peas or beans (42 exp.), miscellaneous sources of protein such yeast or leaf protein (18 exp.), animal products (21 exp.), non-protein nitrogen source such urea (9 exp.), forages (157 exp.), cereal straws, alkali treated or not (33 exp.), cover or parts of dried grains source of fibre such stalks, hulls or cobs (19 exp.) and industrial byproducts usable as fibre source (51 exp.).

**Key words:** nutritional recommendations, raw materials, data basis

## DIGESTIVE PHYSIOLOGY

### INTERACTIONS BETWEEN GUT MICROFLORA AND DIGESTIVE MUCOSAL IMMUNITY, AND STRATEGIES TO IMPROVE DIGESTIVE HEALTH IN YOUNG RABBITS

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Enteric diseases frequently occur in rabbit around weaning leading to extensive use of antibiotics in rabbit breedings. In this context, breeders as well as consumers ask for alternative strategies that improve the health of animals. But the maintenance of gut health is complex and relies on a delicate balance between the mucosa (including the absorptive epithelium and the digestive immune system), the commensal microflora and environmental factors including diet. Firstly, immune and non-immune mechanisms of protection against pathogens in the gut were presented followed by installation and composition of the gut microflora in the rabbits and its role on health. Finally, several strategies to stimulate digestive immune system or favour beneficial flora to exclude enteric pathogens were discussed. Several nutrients were implicated in the development of immune response and could be used to improve immune ability of animals. Among which, dietary fatty acids (ù3/ù6 ratio) could be of interest in the rabbit. The role of dietary fibres on digestive health have been demonstrated in weaned rabbits,



and strong relations between fibres supply and caecal microflora were evidenced. Some works also reported an influence of fibre level in the diet given to the young before weaning on health status of rabbits after weaning. Therefore, nutritional needs of suckling rabbits, more especially fibre requirements, to enhance subsequent gut health need to be deeply studied, in relation with needs of their mothers. Exogenous flora could also be added to the diet to stimulate the digestive immune system and prevent the development of enteric pathogens. Finally, vaccines permit protection of the host against specific pathogens.

**Key words:** gut, immunity, nutrition, microflora, probiotics, rabbit.

injuries due to the wire bottom are seldom observed in fatteners. Nevertheless, one of main behavioural needs of rabbits seems to be the possibility of gnawing. Based on experimental results, there seems to be an antagonism between increased group size and or size of the area assigned to growing animals, and their growth performance and sanitary risks. Moreover, in large groups aggressiveness is a problem especially near puberty age. More research is necessary to determine the minimal space required per rabbit to obtain a sufficient level of welfare and optimal production results. Finally the attention is drawn to the fact that alternative pen housing does not fit with actual management systems used in intensive breeding units.

**Key words:** fatteners, housing, performances, welfare.

## MANAGEMENT AND ECONOMICS

### COLONY REARING OF FATTENING RABBITS

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After weaning, rabbits are nearly exclusively housed in small collective cages till slaughter age. Group size ranges from 2 to over 50 fatteners and the space per animal in commercial units between 500 and 700 cm<sup>2</sup>. The different housing systems are discussed in this paper and special attention is focussed if the barren environment and restricted natural locomotion pattern causes behavioural problems. Stereotypes or

## FAO RABBIT SCIENCE AND PRODUCTION IN DEVELOPING COUNTRIES

### RABBIT PRODUCTION IN HOT CLIMATES

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In hot climates, rabbit production is faced with many problems. At environmental temperatures of 32° c and higher heat stress occurs, leading to production losses. When temperatures of 35° c and higher persist, the greatest losses from heat stress may result. In this article, the effect of heat stress on rabbits performance, all requirements of successful intensive rabbit production in hot climate are discussed.

## WELFARE AND ETHOLGY

### MATERNAL BEHAVIOR IN RABBITS: REGULATION BY HORMONAL AND SENSORY FACTORS

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Maternal behavior in rabbits involves building a nest of straw and body hair inside an underground burrow, before parturition, and the display of a single, brief (ca. 3 min.), nursing bout per day throughout lactation. The onset and decline of digging, strawcarrying, and hair-pulling is controlled by specific combinations of estradiol, progesterone, testosterone, and prolactin (PRL). These hormones also prime the maternal brain to respond effectively to the newborn pup s: antagonizing the release of PRL that occurs before parturition (by injecting bromocryptine s.c.) abolishes maternal behavior in most rabbits. This effect is counteracted by the intracerebro-ventricular administration of rabbit PRL. We have investigated the brain areas involved in regulating specific aspects of maternal behavior by: a) determining the distribution of receptors for estradiol (ER-alpha) and progesterone (PR); b) implanting estradiol in the forebrain and quantifying the display of nest-building; c) establishing the expression of an immediate early gene (*c-fos*) in association with the display of maternal behavior. These studies have revealed that specific forebrain regions (e.g., the preoptic area and septum) play a major role in the control of nest-building and maternal responsiveness: they are rich in ER-alpha and PR; implants of estradiol benzoate

stimulate digging and straw-carrying in ovariectomized rabbits treated with progesterone s.c.; an increase in the number of *c-fos* immunoreactive neurons is observed following nursing. In addition to hormonal stimulation, the adequate display of maternal behavior relies heavily on the perception of stimuli coming from the young. By preventing mother/young contact at parturition or during early lactation maternal responsiveness is altered or abolished. Suckling stimulation *per se* is not essential to maintain maternal behavior as mothers deprived of nipples (i.e., thelectomized) are responsive to the young. However, the duration of the mother/young interaction is greatly extended in thelectomized females and also in mothers whose nipples have been covered with cushions. Moreover, decreasing the amount of suckling stimulation (by providing only one pup) or providing a litter that is unable to suckle (by placing adhesive tape over the mouths) also extends the time mothers spend with the young inside the nest box. These results show a major role of suckling stimulation in timing the duration of mother/young contact. In summary, the behavior of mother rabbits is regulated by a multiplicity of hormonal and somatosensory stimuli that act in concert to determine the onset, offset and duration of specific maternal activities.

**Key words:** maternal behavior, nest-building, steroid hormones, prolactin, suckling.



## MEAT QUALITY AND PROCESSING

### RABBIT MEAT PROCESSING AND TRACEABILITY

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Rabbit meat is a highly digestible, tasty, low-calorie food, often recommended by nutritionists over other meats, yet it is still considered a niche product, especially because of its time consuming preparation which requires culinary skills and because of cultural differences among European consumers. For this reason, the processing industry in Europe is gradually improving the availability of rabbit meat in a large variety of processed ready-meals which make it easier to prepare thus meeting the demands of modern consumers. This shift towards further processed products in Europe will soon underscore the necessity for higher standards in rabbit meat in order to improve sensory characteristics and functional properties. Rabbit production and processing involve a series of interrelated steps and the quality of rabbit muscle as food depends upon chemical, physical, and structural changes that occur in the conversion of muscle to meat. During the production and management of rabbits, (preslaughter) factors not only exert important effects on muscle growth, composition, and development, but also determine the state of the animal at slaughter. Moreover, large rabbit industry integration is becoming more important and the development of rabbit meat production is forcing processing plants to improve

slaughter capacities by using high-speed and more automated slaughter lines. From the point of view of food safety, these changes can lead to higher microbial risks due to the possible cross-contamination during preslaughter (crating, transportation, and holding conditions) and processing (skinning and evisceration) operations. Furthermore, European rabbit production has been influenced by the introduction of more restrictive regulations and higher consumer attention to food safety aspects. All this has come about as a consequence of the many meat safety crises of previous years which have convinced the European Union to enact several regulations aimed at guaranteeing meat safety and systems to prevent or at least manage similar future crises. From January 1st 2005 (Regulation 178/2002/EC), it will be compulsory for all feed and food operators to adopt a traceability system. The major objective is to enforce the provision of clear and reliable information to consumers at sales points, based on a system of being able to track meat back to the source animal, the slaughterhouse and the cutting unit of origin. This paper is divided in two sections, the first provides an overview of the steps of rabbit processing and its influence on product quality, while the second focuses on the application of traceability to rabbit production.

**Key words:** rabbit, slaughtering, processing, product quality, traceability.

## EFFECTS OF NUTRITION AND SELECTION ON MEAT QUALITY

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Nutrition and selection are both factors which mainly affect rabbit carcass and meat quality. Effects of feeding level and of dietary fibre, dietary fat and fat quality and protein quality are summarised. Four ways of studying the effects of selection for growth rate on rabbit carcass and meat quality are also reviewed.

**Key words:** Rabbit, Nutrition, Selection, Growth, Meat quality

## ALTERNATIVE AND SUSTAINABLE PRODUCTION SYSTEMS

### SUSTAINABLE AND ALTERNATIVE SYSTEMS OF RABBIT PRODUCTION

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The ideal small-scale rabbit production model (SSRPM) represents an alternative and self-supporting system, based on renewable farm resources, that embodies the greatest potential for achieving a favourable, sustained impact (chiefly nutritional and

economic) on limited-resource farm families who are mostly from the lesser-developed countries. The objective of this paper is to address major issues and factors that influence the degree of impact from the three-tiered SSRPM as a development project planning tool. Sustainability issues of meat rabbit production profoundly depend on ecological (*e.g.*, renewable natural or on-farm resources), economical (*e.g.*, investment and operating costs and market outlets), and sociological (*e.g.*, gender sensitivity and community participation) aspects as external factors of the SSRPM. Intermediate factors that support or guide the SSRPM involve the dimensions of project development: feasibility, design, implementation, monitoring, and evaluation. Internal factors that influence SSRPM components (*i.e.*, genetics, materials for housing and equipment, diet quality, health management, and other factors) are likewise critical. In summary, as rabbit scientists, we should share a common mission of promoting appropriate - environmentally-friendly, economically sound, and socially acceptable - SSRPM's, designed to meet the forecast of increasing pressures on natural resources and greater demands for food for the rising world population. In this mission, if success is realized, we can claim that meat rabbit production, in part, indeed sustained humanity.

**Key words:** alternative agriculture, sustainable development, natural resources, rabbits.

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