World Rabbit Sci. 2016, 24: 267-273
doi:10.4995/wrs.2016.5155

# ADAPTIVE CAPACITY OF FEMALE RABBITS SUBMITTED TO A CHANGE IN BREEDING PRACTICES

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**Abstract:** The aim of this study was to test the consequences of a change in breeding practices on 219 multiparous rabbit does over 2 reproductive cycles (5th and 6th insemination). Three rabbit breeding systems were defined (I: intensive, S: semi-intensive and E: extensive), which varied for the females in terms of reproductive rhythm (RR: 35, 42 and 49 d, respectively) and age at first insemination (20.6, 19.6 and 16.6 wk, respectively), and for kits in terms of age at weaning (32, 35 and 30 d, respectively) and age at slaughter (63, 70 and 70 d, respectively). Females were submitted to one of the 3 systems from the 1st to the 4th artificial insemination (AI), and to another system from the 5th to the 6th AI, before returning to the initial system at the 7th AI. Consequently, they were allocated to 4 groups: I-S-I, S-I-S, S-E-S and E-S-E. Because of poor reproductive performance in the I system and despite a high growth of kits before weaning due to a more energetic diet for does, a sudden change from an I system to an S system significantly increased productivity at 28 d, from 3.37 to 5.04 kg/AI. Conversely, in the S and E systems, the females were not very sensitive to an intensification (groups S-I-S and E-S-E) or an extensification (S-E-S) of the breeding system, leading to similar productivity at 63 d (14.4 and 14.3 kg/AI, 14.4 and 13.5 kg/AI, 16.5 and 16.2 kg/AI, respectively, for groups S-I-S, E-S-E and S-E-S). The consequences of a return to the initial system deserve to be tested over a longer period.

**Key Words:** rabbit, breeding system, flexibility, reproductive performance, growth.

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## INTRODUCTION

Farm animals may face some environmental constraints throughout their lives (poor nutrition, disease, drastic thermal conditions, etc.) which they can adapt to through physiological, behavioural and/or metabolic changes. Sauvant and Martin (2010) described the ways in which systems adapt to changes in their environment, be they rigid, elastic, flexible or plastic. Animal coping processes have been well studied in extensive ruminant production systems because they are weakly controlled by farmers and are subject to fluctuating nutritional resources that challenge the adaptive ability of the animals (Blanc *et al.,* 2010). Another way is to adapt herd management as a source of flexibility for farming systems (Nozières *et al.,* 2011). Monogastric animals are generally less subject to seasonal variations in climate and food resource fluctuations than ruminants because they are usually reared indoors and the breeder controls their environment and food intake. However, in monogastric animals, it might also be interesting to take advantage of the animals' abilities to cope with environmental or economic constraints or to adapt herd management to these constraints.

As an example, in French rabbit farms, females are usually inseminated for the first time at the age of 19.6 wk and then every 42 d thereafter (42-d reproduction rhythm) in a single batch management system (Coutelet, 2015). This management technique allows for highly efficient organisation of the work on the farm until removal of animals for slaughter, while improving sanitary management. However, the market demand for rabbit meat varies throughout

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doi:10.4995/wrs.2016.5155

the year, with a drop during the summer. Additionally, the physiological capacities of females are not constant but develop over time. Firstly, primiparous rabbit does exhibit lower performance than multiparous ones due to incomplete body development and reduced feed intake capacity. Secondly, the females' feed intake decreases with increasing temperature (Cervera and Carmona, 2010). It is therefore necessary to consider the possibility of a change in breeding systems, initially to adapt meat production to consumer demand and then to adapt the practices to the animal's potential.

The aim of this study was to investigate the consequences of a change in breeding systems over 2 successive reproductive cycles on multiparous rabbit doe productivity. Both a transient extensification and intensification of breeding systems were applied before returning to the original system.

## MATERIALS AND METHODS

The experiment was performed at the ITAVI experimental farm (Rambouillet, France). All procedures were conducted in accordance with the guidelines for the Care and Use of Animals in Agricultural Research and Teaching (French Agricultural Agency and Scientific Research Agency).

### *Animals, experimental design and management of reproduction*

Three rabbit breeding systems were defined (I: intensive, S: semi-intensive and E: extensive) varying for the rabbit does in terms of reproductive rhythm (RR: 35, 42 and 49 d, respectively) and for kits, in terms of age at weaning (32, 35 and 30 d, respectively) and age at slaughter (63, 70 and 70 d, respectively), as described in Table 1. A total of 219 Hyplus rabbits (Hypharm, Roussay, France) were submitted to one of the 3 systems during the 4 first cycles (from the 1st to the 4th artificial insemination [AI]), to another system during the 5th and the 6th reproductive cycle, before returning to the initial one during the 7th reproductive cycle. Finally, the females were thus distributed according to their weight at 13 wk into 4 experimental groups differing in terms of the breeding system used over the 7 successive reproductive cycles: I-S-I group (n=65), S-I-S group (n=43), S-E-S group (n=44), E-S-E group (n=63), as described in Table 2. As we have only 3 rooms, corresponding to the 3 breeding systems used during the 4 first cycles, in order to have a "sufficient" number of does in each group before limiting the intensity in the change of the breeding system, we tested only the consequences of slight extensification (I system to S system and S system to E system) or intensification (S system to I system or E system to S system) of breeding system. Abrupt changes in breeding system (I system to E system or E system to I system) were not tested.

Females were housed in 3 independent pairs of rooms (reproduction/fattening). Groups I-S-I and E-S-E were in different rooms, and groups S-I-S and S-E-S were both in a third room. In fact, females of these 2 latter groups, all submitted to the S system from the 1st to the 4th AI, were divided into 2 subgroups, taking their weight and parity into account, and were submitted to the I system (S-I-S group) or the E system (S-E-S group) for the 5th and 6th AI before being submitted once again to the S system at the 7th AI.

As of the time they were introduced into the rooms, the does were placed under a constant 8 h light/d (between 8 a.m. and 4 p.m.). Seven days before each insemination, a light stimulation was applied (sudden change from 8 hL:16 hD to 16 hL:8 hD; light extinction at 24 h). The day of artificial insemination, the return to the initial illumination (8 h) occurred gradually over 4 d (between day 0 and day 3: –2 h/d) after AI in all groups except for the 5th AI of groups S-I-S and S-E-S for which no light simulation was provided because 2 breeding systems were applied in the same room (groups S-I-S and S-E-S). No hormonal treatment was used to induce sexual receptivity. Females were only eliminated for sanitary reasons.

Table 1: Husbandry practices in the 3 breeding systems.

| | Females | | Kits | |
|---|---|---|---|---|
| Breeding system | Reproduction rhythm (d) | Age at 1st AI (wk) | Age at weaning (d) | Slaughter age (d) |
| Intensive | 35 | 20.6 | 32 | 63 |
| Semi-intensive | 42 | 19.6 | 35 | 70 |
| Extensive | 49 | 16.6 | 30 | 70 |

Table 2: Management of females during the reproductive cycle in the 4 experimental groups.

| | Reproductive cycles | | |
|---|---|---|---|
| Group | From $AI_1$ to $AI_4$ | $AI_5$ and $AI_6$ | $AI_7$ |
| I-S-I | I system[1] | S system | I system |
| S-I-S | S system | I system | S system |
| S-E-S | S system | E system | S system |
| E-S-E | E system | S system | E system |

I: intensive, S: semi-intensive and E: extensive. $AI_n$: Artificial insemination at n reproductive cycle.

[1] Husbandry practices in the I, S and E systems are described in Table 1.

Inseminations were performed using heterospermic pools of bucks from a commercial breed (PS40, Hyplus, Hypharm, Roussay, France). The litters were homogenised to 8 for nulliparous, 9 for primiparous and 10 for multiparous, after removing non-viable (low weight) or surplus kits. Adoptions were performed within the room and free suckling was applied.

### *Feeding strategy*

Four commercial diets (INZO, Chateau-Thierry, France, except the diet for finishing rabbits: Sanders Nutrition Animale, Pontivy, France) were used during the experiment. Their composition is detailed in Table 3. After insemination, does submitted to the S and E systems were fed the P diet that meets the nutritional requirements of pregnant does (digestible energy [DE]: 2580 kcal/kg; crude protein [CP]: 17.3%). During pregnancy and from day 0 to 25, does submitted to system I were fed the L diet formulated to meet the nutritional needs of lactating does (DE: 2650 kcal/kg; CP: 17.5%).

Table 3: Ingredients and chemical composition of experimental diets.

| | Diets | | | |
|---|---|---|---|---|
| Item | P | L | Y | F |
| Ingredients (g/kg) | | | | |
| Wheat | 33 | 101 | 0 | 15 |
| Barley | 150 | 90 | 42 | 95 |
| Bran and straw | 250 | 245 | 271 | 242 |
| Oilseed meal and whole grains | 319 | 336 | 240 | 188 |
| Molasses | 25 | 30 | 25 | 40 |
| Grape pulp | 22 | 0 | 39 | 17 |
| Beet pulp | 95 | 87 | 200 | 105 |
| Alfalfa | 80 | 80 | 158 | 280 |
| Rapeseed oil | 0 | 5 | 0 | 5 |
| Minerals | 16 | 17 | 5 | 6 |
| Amino acids | 4 | 4 | 0 | 2 |
| Additives | 6 | 6 | 20 | 5 |
| Chemical composition[1] | | | | |
| Crude protein (g/kg) | 173 | 175 | 152 | 155 |
| Ash (g/kg) | 74 | 75 | 82 | 77 |
| Starch (g/kg) | 164 | 173 | 92 | 124 |
| Fat (g/kg) | 30 | 33 | 27 | 32 |
| Acid detergent fibre (g/kg) | 186 | 179 | 234 | 209 |
| Neutral detergent fibre (g/kg) | 327 | 312 | 386 | 345 |
| Acid detergent lignin (g/kg) | 51 | 46 | 60 | 5.3 |
| Lysine (g/kg) | 8.7 | 8.1 | 6.3 | 6.8 |
| Methionine+Cysteine (g/kg) | 6.8 | 6.9 | 5.3 | 5.5 |
| Digestible energy (kcal/kg)[2] | 2580 | 2650 | 2300 | 2445 |

[1] Calculated according to the tables of ingredients (Sauvant *et al.,* 2004), unless digestible energy.

[2] Calculated according to Maertens *et al.* (2002).

Regardless of the breeding system, all the does from day 25 of lactation to weaning (day 32, 35 or 30 in systems I, S and E, respectively; Table 1) and the kits from day 25 to 49 of age were fed the Y diet formulated to meet the nutritional needs of young rabbits (DE: 2300 kcal/kg; CP: 15.2%). All the growing rabbits were fed the F diet formulated to meet the nutritional needs of finishing rabbits (DE: 2445 kcal/kg; CP: 15.5%) from day 49 to slaughter age.

Females were fed *ad libitum* but unfertilised ones received a restricted feeding (150-160 g/d) except the 6 d before insemination. Kits were fed *ad libitum* except if digestive problems occurred in a cage (2 dead rabbits in the cage). In this case, they were restricted to 80% of *ad libitum* feed intake. No antibiotics were used during the experiment.

### *Registered parameters and statistical analysis*

To avoid possible interactions with parity, the analysis of reproductive performance only concerned multiparous does (AI>2). The weight of does at the time of insemination, fertility (kindling rate, considered as a Bernoulli variable: range 0-1), litter size at birth (born alive), at 28 d, at weaning, the average weight of kits at these times and productivity (weight of kits/AI, kg) at 28 d and at weaning were analysed using an analysis of variance. The model includes the fixed effect of the breeding system within groups (12 levels: as presented in Table 4). The weight at 28 d and the individual weights at 63 d were not recorded at the 7th AI. As kits were not identified at weaning, it was not possible to select individual weights from multiparous does alone. Consequently, this calculation concerns all females (nulliparous, primiparous and multiparous). Table 4 gives the results of the analysis of variance (least square means).

## RESULTS AND DISCUSSION

The analysis concerned 1005 inseminations and revealed a significant influence of the management system for all traits (Table 4). The performances of females and kits during the first 4 reproductive cycles are detailed in Theau-Clément *et al.* (2016).

Table 4: Influence of a change in breeding system on reproductive performance and young growth.

| | No. | AI weight (g) | Fertility (%) | Born alive | Litter size at day 28 | Litter size at weaning | Weight at day 28 (g) | Weaning weight (g) | Productivity at day 28 (kg/AI) | Productivity at weaning (kg/AI) |
|---|---|---|---|---|---|---|---|---|---|---|
| Average | 1005 | 4785 | 80.8 | 10.75 | 9.70 | 9.58 | 659 | 867 | 3.88 | 6.59 |
| RMSD | | 426 | 37.7 | 3.56 | 0.83 | 1.05 | 60 | 86 | 2.32 | 3.42 |
| Breeding system | | | | | | | | | | |
| *P*-value | | <0.001 | <0.001 | 0.023 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Group I-S-I | 112 | $4461^{a}$ | $48.2^{a}$ | $10.41^{b}$ | $9.65^{bcd}$ | $9.62^{cd}$ | $724^{c}$ | $911^{d}$ | $3.37^{a}$ | $4.23^{a}$ |
| AI$_3$ - AI$_4$ : I$^1$ | 136 | $4818^{bcd}$ | $85.3^{bc}$ | $10.61^{b}$ | $9.40^{b}$ | $9.28^{ab}$ | $647^{a}$ | $892^{d}$ | $5.04^{b}$ | $6.92^{c}$ |
| AI$_5$ - AI$_6$ : S$^2$ | 67 | $4725^{bc}$ | $82.1^{bc}$ | $10.42^{b}$ | $9.85^{d}$ | $9.59^{bcd}$ | - | $826^{bc}$ | - | $6.38^{bc}$ |
| AI$_7$: I$^3$ | | | | | | | | | | |
| Group S-I-S | | | | | | | | | | |
| AI$_3$ - AI$_4$ : S$^1$ | 119 | $4698^{b}$ | $78.2^{b}$ | $11.24^{b}$ | $9.88^{d}$ | $9.85^{d}$ | $661^{ab}$ | $882^{d}$ | $5.10^{b}$ | $6.79^{c}$ |
| AI$_5$ - AI$_6$: I$^2$ | 85 | $4801^{bcd}$ | $87.1^{bc}$ | $10.40^{b}$ | $9.66^{cd}$ | $9.45^{bc}$ | $677^{b}$ | $850^{c}$ | $5.39^{bc}$ | $6.71^{c}$ |
| AI$_7$: S$^3$ | 40 | $4969^{e}$ | $80.0^{bc}$ | $11.75^{b}$ | $10.00^{d}$ | $9.44^{bc}$ | - | $888^{d}$ | - | $6.68^{c}$ |
| Group S-E-S | | | | | | | | | | |
| AI$_3$ - AI$_4$ : S$^1$ | 119 | $4698^{b}$ | $78.2^{b}$ | $11.24^{b}$ | $9.88^{d}$ | $9.85^{d}$ | $661^{ab}$ | $882^{d}$ | $5.10^{b}$ | $6.79^{c}$ |
| AI$_5$ - AI$_6$ : E$^2$ | 89 | $4889^{de}$ | $83.2^{bc}$ | $10.40^{b}$ | $9.49^{bc}$ | $9.45^{bc}$ | $642^{a}$ | $718^{a}$ | $4.85^{b}$ | $5.39^{b}$ |
| AI$_7$: S$^3$ | 45 | $4867^{d}$ | $82.2^{bc}$ | $8.89^{a}$ | $9.00^{a}$ | $8.89^{a}$ | - | $1064^{f}$ | - | $7.35^{cd}$ |
| Group E-S-E | | | | | | | | | | |
| AI$_3$ - AI$_4$ : E$^1$ | 91 | $4782^{bcd}$ | $90.1^{c}$ | $11.30^{b}$ | $9.85^{d}$ | $9.82^{d}$ | $669^{ab}$ | $804^{b}$ | $5.93^{c}$ | $7.10^{c}$ |
| AI$_5$ - AI$_6$: S$^2$ | 147 | $4934^{e}$ | $89.1^{c}$ | $11.19^{b}$ | $9.77^{d}$ | $9.72^{cd}$ | $632^{a}$ | $976^{e}$ | $5.41^{bc}$ | $8.32^{d}$ |
| AI$_7$: E$^3$ | 74 | $4828^{c}$ | $86.5^{bc}$ | $10.64^{b}$ | $10.00^{d}$ | $9.83^{d}$ | - | $726^{a}$ | - | $6.18^{bc}$ |

RMSD: root-mean square deviation. $^1$ Initial breeding system. $^2$ After changing the initial breeding system. $^3$ Return to the initial breeding system. I: intensive, S: semi-intensive and E: extensive. AI$_n$: Artificial insemination at n reproductive cycle. Within columns (12 levels), means with different letters are significantly different at $P<0.05$.

### Average weight of does at AI

Considering only the initial breeding system (from the 3rd to the 4th AI), the weight of does at the moment of insemination was significantly lower when an I system was applied. A change from an I to an S system significantly increased the weight at AI (from 4461±338 to 4818±452 g) without any effect when returning to the initial one. A sudden change from the S to the I system had no significant effect on the weight of does at insemination, whereas a return to an S system increased the weight at AI. In contrast, a change from an S to an E system increased the weight of does without any significant effect when returning to the original one. Conversely, a change from an E to an S system increased the weight of does at AI, with a decrease when returning to the original one. The weight at insemination seems to highly depend on the breeding system. Castellini *et al.* (2006) showed that the estimated energy deficit and body mobilisation increased when the reproduction rhythm was more intensive.

### Reproductive performance

Considering only the original breeding system in multiparous does (from the 3rd to 4th AI), the lowest fertility was obtained for an I system and the highest for an E system (48.2±50.2, 78.2±41.5 and 90.1±30.0%, respectively, for the I, S and E systems). This result is in agreement with the conclusions of Theau-Clément *et al.* (1990), Blocher and Franchet (1990) and Theau-Clément *et al.* (2000). A change from an I to an S system (I-S-I group) at the 5th and 6th AI significantly increased fertility without any effect when returning to the original one (I system) at the 7th AI. In contrast, in the 3 other groups, a change in breeding system, whether an intensification or an extensification, had no effect on fertility following the change or when returning to the original system. The poor reproductive performance of females submitted to the I system can be linked to their low weight at insemination and could be a consequence of an energy deficit, as revealed in a previous communication, on the same dataset (Theau-Clément *et al.,* 2016).

During the first 3 reproductive cycles, the litter size at birth, as well as at 28 d (after standardisation at 3 d after kindling) and weaning did not vary according to the breeding system. The change in breeding system had no significant impact on litter size at birth (born alive) in the I-S-I and S-I-S groups, whether subsequent to the change or when returning to the original system. In contrast, the number born alive was significantly lower after a return to the original breeding system in both the S-E-S and E-S-E groups. Such a result could be linked to a depressive summer effect, as reported by Marai *et al.* (2002).

A change in the breeding system at the 5th and 6th AI significantly reduced the litter size at 28 d in group S-E-S, whereas it had no effect in the other groups. Similarly, a return to the initial system restored the initial (before the change) litter size in all groups except group S-E-S, for which the litter size decreased again (from 9.49 to 9.00). This result occurred despite the standardisation of litter size at birth to 10 kits in all groups and could be a consequence of high temperatures. Indeed, the change in reproductive rhythms among the groups caused a break in kindling synchronisation between groups and females. Therefore, some results are difficult to interpret as the inseminations were not contemporary and the effects of practices could be confused with the effect of environment (in this case, temperature). Except for group E-S-E, the litter size at weaning (age varying according to the system) significantly decreased after the 1st system change, and except for group S-E-S, the number of weaned kits remained at the same level after returning to the original system.

For all groups except the S-E-S group, litter size at birth and at 28 d seems to be robust until the first change in breeding system. This observation is original and we found no elements to substantiate the discussion in the bibliography. However, the return to the original system was accompanied by a decrease in litter size at birth for both the S-E-S and E-S-E groups (–1.51 and –0.79 born alive, respectively).

### Kit growth

For the original system, the average weight of kits at 28 d was higher for the I system. It was probably the consequence of the more energetic diet given to the females in this group during lactation. Thus, the feeding strategy adopted here to feed females in the I system with a high energy diet to meet their higher nutritional needs due to their intensive reproduction rhythm led to higher live weights of kits at weaning and failed to preserve the weight of females at AI. The feeding strategy could also explain the lower weight of kits at weaning in the I-S-I group at the 5th and 6th AI

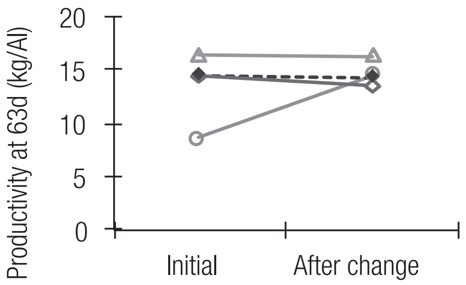

**Figure 1:** Productivity at 63 d according to the experimental groups. I-S-I: –○–, S-I-S: -◆-, S-E-S: –◇–, E-S-E: –△–.

(when changing from an I to an S system: 724±56 *vs.* 647±65 g), although they were older at weaning. However, the reverse was not observed in the S-I-S group when females changed from the S to the I system, as similar weight at weaning was observed (661±58 *vs.* 667±65 g) despite differences in age at weaning between systems. In other cases, the ages of kits, varying among breeding systems, explained the differences of weight at weaning between groups.

### *Productivity*

For the original system (from the 3rd to the 4th AI), the productivity at 28 d (kg/AI) was the highest for group E-S-E (5.93±2.04 kg/AI) and the lowest for group I-S-I (3.37±3.56 kg/IA). In the E-S-E group, these results were due to both a high fertility of females and a high growth of kits before weaning. Conversely, in group I-S-I, the low productivity was due to a low fertility of females despite the high growth performance reached by suckling rabbits, as their mothers were fed a more energetic diet. Only a change from an I system to an S one (I-S-I) made it possible to increase the productivity at 28 d (3.37±3.56 *vs.* 5.04±2.50 kg/AI, respectively). In the other groups, the change in breeding system did not affect the productivity at 28 d. At weaning, the productivity was highly related to the age of kits, which varied between systems (Table 1).

A change in breeding system influenced the productivity at 63 d (Figure 1) only for a shift from an I system to an S system (8.7 *vs.* 14.6 kg/AI). The other changes in breeding systems did not greatly modify the productivity (from an S to an I system: 14.4 and 14.3 kg/AI; from an S to an E system: 14.4 and 13.5 kg/AI; and from an E to an S system: 16.5 and 16.2 kg/AI; Fig. 1).

This study confirms that in multiparous does, the productivity per insemination increases with an extensification of the reproductive rhythm. This result agrees with Theau Clément *et al.* (2000), and Castellini *et al.* (2010) and, as suggested by Feugier and Fortun-Lamothe (2006), may be the consequence of a reduction in the duration of concurrent lactation and pregnancy and, therefore, a reduction in the energy deficit. We can hypothesise that females submitted to S or E systems at the onset of reproductive life (S-I-S, S-E-S and E-S-E groups) are close to equilibrium, which makes them more resistant to a change in practice, as shown by a constant productivity at 63 d after a change in the breeding system. In contrast, females submitted to the I system (I-S-I group) are faced with high nutritional demands that reduce their productivity at 63 d, and a change in breeding system leads to an adaptive response of the animal, i.e., increased productivity.

## CONCLUSION

This study aimed to test the consequences on performance and productivity of a change in breeding systems over 2 successive reproductive cycles, before returning to the initial system. The results showed that a sudden change from an intensive system to a semi-intensive one increases the productivity of females at 63 d by 68%. In contrast, in semi-intensive or extensive systems, the females are not very sensitive to changes in breeding practices. However, the consequences of a return to the initial system deserve to be tested over a longer period of time to rule out the possible residual effects of such changes in the reproductive cycle.

**Acknowledgements:** This work was supported by the CAS DAR (Cunipalm n° 9023) and by the French rabbit Interprofessional Association (CLIPP).

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