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# THE EFFECTS OF DIFFERENT REMATING INTERVALS AND DIET NUTRIENT DENSITY ON THE REPRODUCTIVE PERFORMANCE AND BODY COMPOSITION CHANGES OF THE LACTATING RABBIT

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## Introduction

The reproductive behaviour, physiology and performance of the rabbit during lactation have been well documented (e.g. 1, 2, 3, 4), and the effect of gestation on milk production has been examined (5). The effect of nutrition on the outcome of concurrent pregnancy and lactation (CPL) has, however, received little attention. Evidence that nutrition can affect CPL has been provided by Adams (6), who showed that by increasing food intake, does suckling large litters (8 pups) were also able to maintain a pregnancy.

The nutrition a doe receives during reproduction impinges on two areas: A) her reproductive performance, i.e. the ability to remate, produce and rear young and B) her bodyweight and condition. The objective of the present experiment was to examine the effects of nutrition on these two variables in the concurrently pregnant and lactating doe and also to examine the effect of delaying remating until later in lactation. Does were offered a diet with either a "low" or "high" nutrient density and remated 1 or 21 days after parturition (AP), 21 days being selected as it is the most commonly adopted remating interval in commercial practice in the UK (Commercial Rabbit Association - personal communication).

## Material and Methods

Diets Two diets were formulated, each with a ratio of 14 g Digestible Crude Protein (DCP) per megajoule (MJ) of Digestible Energy (DE), but differing in nutrient density. Diets L and H contained 10.6 and 15.4 MJ DE and 151.7 and 221.6 g DCP/kg dry matter (DM) respectively (determined in a separate trial). Concentrations of essential amino-acids in both diets were above those suggested by Lang (7) for breeding does. Both diets were offered as pellets, 4.7 mm in diameter.

Animals Nulliparous crossbred does were used (NZW sire x (Californian x NZW) dam).

Housing Does were housed individually in flat deck wire mesh cages (760 x 610 x 380 mm dia.). House temperature was set at 65°F, with a daily cycle of 14 h light and 10 h dark. Water was available ad libitum.

Procedures Forty-four does were selected when 4 weeks old and reared to a mean weight of 4125±16 g at a median age of 155 days (range 150-176 d), at which they were first mated. After 30-32 d of gestation during which they were given 150 g/d of a stock diet (Diet H; see Partridge & Allan (8) for composition), does were allocated to one of 5 treatments (Table

1) at first parturition.

TABLE 1

Experimental Treatments

| Treatment | Control | 1L | 21L | 1H | 21H |
|---|---|---|---|---|---|
| Diet | - | L | L | H | H |
| Day of Remating after parturition | - | 1 | 21 | 1 | 21 |
| Number of does initially allocated to treatment | 5 | 13 | 13 | 7 | 6 |

The experiment continued until the end of the second lactation. Does allocated to the Control Treatment were slaughtered on the day of their first parturition. Does receiving Diet L were remated either 1 or 21 d AP, 7 animals on each treatment being allocated for slaughter at weaning after their first lactation (28 d AP) (1L1 and 21L1 respectively). The remainder were allowed to give birth and proceed through a second lactation. They were slaughtered at the subsequent weaning (1L2 and 21L2 respectively). Does receiving Diet H were remated either 1 or 21 d AP and all slaughtered at weaning after their second lactation (1H2 and 21H2 respectively).

Following first parturition does were phased onto their allocated diets over a 3-day period. Food was offered to appetite throughout the experiment. Voluntary food intake was measured until the second parturition and thereafter to slaughter. Mating Response was determined by the procedure described by Foxcroft & Hasnain (1). All does mating successfully were assumed to be pregnant. This was later confirmed at parturition, or at slaughter by the presence of foetuses in a gravid uterus (1 d remated animals), or of corpora lutea on the ovaries (21 d remated animals). The Conception Rate was then calculated from this information. Any doe found non-pregnant using the above criteria was discarded from the experiment.

Litter size was standardized to 7 pups, 3 days AP. Pup weight and number for each doe was recorded at birth and 28 days (weaning) AP. Data on any doe losing more than 2 pups over the course of a lactation were omitted from the analysis. The pups were not given supplementary food before weaning. All does were weighed at birth, mating, 21 and 28 days AP. The carcasses of the does were minced and analysed for DM, Nitrogen, Ash and Fat Content using standard procedures (9). The Energy value of the carcasses was calculated using the values of 23.6 kJ/g and 39.5 kJ/g for Protein and Fat DM respectively determined by Franke & Weniger (10) from rabbit muscle and perirenal adipose tissue.

## Results and Discussion

Twenty-seven of the 44 does (61%) completed the experiment (5, 9, 9, 2 and 2 on Control, 1L, 21L, 1H and 21H treatments respectively). Where possible, data sets for completed lactation periods by does failing to finish the experiment were included in the statistical analysis. Thus the numbers appearing in some treatments may be greater than stated above.

Doe Reproductive Performance Mean values are given in Table 2 for

Lactations 1 and 2 and the intervening period between weaning and parturition.

Lactation 1 Does offered Diet L consumed a significantly (P 0.001) greater (29.7%) weight of dry matter than those offered Diet H. This resulted in similar Total DE and DCP intakes on all treatments. The treatments had no other statistically significant effects on the other measures taken in the first lactation.

Lactation 2 There was no difference between treatments in the total number of pups born. Fewer were born alive to does given the H diet compared with those given the L diet ($P < 0.001$). The lowered overall mean value for does on Diet H appears to have its origin in the very low number of pups surviving on Treatment 1H, which appears to be due to an extended gestation period (33.8 d). Mean pup birth weight was significantly ($P < 0.01$) greater for does remated 1 day AP and this was related to the smaller litter sizes of does on these treatments. Total DM Intake was significantly ($P < 0.05$) greater (21.8%) for does receiving Diet L, but does offered Diet H had significantly greater ($P < 0.05$) intakes of DE and DCP. The significantly ($P < 0.05$) lower number of pups at 28 days for Treatment 1H must be interpreted with caution and requires a greater number of does to clarify a true treatment effect. No significant treatment effect was found on total litter gain.

For those does completing two lactations, the differences between Lactations 1 and 2 are summarized in Table 2. No significant treatment effect was found within or between lactations in mating response or conception rate. A similar increase in DM intake from Lactation 1 to Lactation 2 has been reported by Reyne et al. (11). This probably explains the improved reproductive performance achieved by all does in the second lactation.

Doe Bodyweight and Composition The only significant treatment effect on doe weight was a greater mating weight in Lactation 1 for does remated 21 rather than 1 day AP (P 0.01). As no difference in empty bodyweight occurred between the control and 21L1 treatments this weight gain is probably attributable to differences in gut fill and body tissue hydration. The weight gain of does between birth and weaning was greater overall (P 0.01) in Lactation 2 than in Lactation 1 and again probably reflects the greater DM consumption of does in the second lactation. Overall weight gain was not significantly different between treatments (735, 911, 1237 and 1024 g for does on treatments 1L, 21L, 1H and 21H respectively).

The doe empty body composition is given in Table 3. No statistical differences in empty body weight were observed. At the end of the experiment does on Treatments 1L, 21L, 1H and 21H had gained -4, +271, +29 and 608 g of empty body weight respectively. The only significant difference in body composition was between the Control and 1L2 treatments, the latter having a lower DM and fat content and an increased protein content ($P < 0.05$).

TABLE 2

Doe Reproductive Performance (Mean ± sem)

| Measurement | Treatment 1L | 21L | 1H | 21H | Average sem | Significance level |
|---|---|---|---|---|---|---|
| **Lactation 1** | | | | | | |
| No. of does | 11 | 9 | 5 | 4 | – | – |
| Total DM Intake (g) | 8764$^{a}$ | 8332$^{a}$ | 6522$^{b}$ | 6602$^{b}$ | 493.9 | ab *** |
| Total Estimated DE Intake (MJ) | 93.1 | 88.4 | 100.8 | 102.0 | 5.9 | NS |
| Total Estimated DCP Intake (g) | 1330 | 1265 | 1445 | 1463 | 87.0 | NS |
| No. pups/litter at 28 days | 6.4 | 6.6 | 6.6 | 6.2 | 0.27 | NS |
| Total Gain of Litter (g) | 2031 | 1809 | 1886 | 2263 | 169.2 | NS |
| **Weaning - Parturition Interval** | | | | | | |
| No. of does | 6 | 4 | 5 | 4 | – | – |
| Interval Length (days) | 3.8$^{a}$ | 25.5$^{b}$ | 5.8$^{a}$ | 24.5$^{b}$ | 0.33 | ab *** |
| Total DM Intake (g) | 784$^{ac}$ | 6355$^{ad}$ | 486$^{bc}$ | 4572$^{bd}$ | 315.8 | ( ab * ( cd *** |
| Total Estimated DE Intake (MJ) | 8.3$^{a}$ | 67.4$^{b}$ | 7.5$^{a}$ | 70.6$^{b}$ | 4.1 | ab *** |
| Total Estimated DCP Intake (g) | 119.0$^{a}$ | 964.1$^{b}$ | 107.7$^{a}$ | 1013.1$^{b}$ | 58.4 | ab *** |
| **Lactation 2** | | | | | | |
| Total No. Born/Litter | 9.6 | 11.9 | 9.2 | 11.4 | 0.93 | NS |
| Total No. Born Alive | 9.6$^{a}$ | 11.6$^{a}$ | 3.6$^{b}$ | 8.7$^{b}$ | 1.97 | ab * |
| Mean Pup Birth Weight (g) | 61.7$^{a}$ | 52.4$^{b}$ | 57.5$^{a}$ | 41.9$^{b}$ | 3.81 | ab ** |
| No. of does | 4 | 4 | 2 | 2 | – | – |
| Total DM Intake (g) | 10936$^{a}$ | 11243$^{a}$ | 9751$^{a}$ | 8455$^{b}$ | 755.3 | ab * |
| Total Estimated DE Intake (MJ) | 116.1$^{a}$ | 119.3$^{a}$ | 150.6$^{b}$ | 130.5$^{b}$ | 8.88 | ab * |
| Total Estimated DCP Intake (g) | 1660$^{a}$ | 1706$^{a}$ | 2161$^{b}$ | 1874$^{b}$ | 127.3 | ab * |
| No. pups/litter at 28 days | 7.0$^{a}$ | 6.7$^{a}$ | 6.0$^{b}$ | 7.0$^{a}$ | 0.18 | ab * |
| Total Gain of Litter (g) | 2423 | 3054 | 3186 | 3298 | 377.8 | NS |
| **Overall for Experiment** | | | | | | |
| Mating Response (%) | 100 | 92.8 | 88.8 | 100 | – | NS |
| Conception Rate (%) | 93.7 | 100 | 87.5 | 80.0 | – | NS |

Values with different superscripts within each row are significantly different at the level quoted. (* P 0.05, ** P 0.01, *** P 0.001).

**Overall Lactation Effects**

| | | | | | |
|---|---|---|---|---|---|
| Total DM Intake | : Lactation 2 | Lactation 1 *** | Diet L | Diet H * |
| Total Estimated DE and DCP Intake | : Lactation 2 | Lactation 1 *** | Diet H | Diet L * |
| No. pups/Litter 28 days | : Lactation 2 vs | Lactation 1 NS | | |
| Total Gain of Litter | : Lactation 2 | Lactation 1 *** | | |

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TABLEAU 2 : Performances de reproduction pour les portées 1 et 2 en fonction des apports de calcium et de phosphore.

| | Première portée | | | | Deuxième portée | | | | Coefficient de variation (1) (%) | Signification des effets | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N° aliment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | | Ca (A) | Ca/P (B) | (A)x(B) | Portée |
| Calcium | + | + | ++ | ++ | + | + | ++ | ++ | | | | | |
| Phosphore | - | + | + | ++ | - | + | + | ++ | | | | | |
| Nombre de mises bas | 17 | 16 | 17 | 17 | 14 | 12 | 12 | 10 | - | - | - | - | - |
| Nés totaux/mises bas | 9,00 | 9,00 | 9,17 | 9,30 | 7,93 | 10,00 | 10,00 | 8,50 | 23,5 | NS | NS | * | NS |
| Nés vivants/mises bas | 8,88 | 8,94 | 8,89 | 9,06 | 7,71 | 9,75 | 9,08 | 7,90 | 26,3 | NS | NS | NS | NS |
| Nombre mis à élever | 9,18 | 9,13 | 9,06 | 9,13 | - | - | - | - | - | - | - | - | - |
| Morts nés | 0,12 | 0,06 | 0,28 | 0,24 | 0,21 | 0,25 | 0,92 | 0,60 | 287 | ** | NS | NS | * |
| Poids moyen naissance (g) | 55,7 | 55,3 | 54,0 | 54,5 | 64,1 | 54,2 | 54,1 | 58,6 | 14,0 | NS | NS | ** | ** |
| Nbre lapereaux à 21 j. | 8,82 | 8,81 | 8,67 | 8,31 | 6,93 | 8,93 | 8,33 | 6,30 | 24,2 | NS | NS | ** | *** |
| Poids moyen à 21 j. (g) | 289 | 312 | 294 | 303 | 388 | 330 | 309 | 349 | 19,8 | NS | NS | NS | *** |
| Nbre de sevrés/mises bas | 8,71 | 8,75 | 8,63 | 8,13 | 6,71 | 8,75 | 7,92 | 6,20 | 23,7 | NS | NS | ** | *** |
| Mortalité 0-28 j. (%) | 5,1 | 4,1 | 4,8 | 11,0 | 13,0 | 10,3 | 12,8 | 21,5 | - | NS | NS | ** | ** |
| Poids moyen au sevrage (g) | 554 | 586 | 559 | 556 | 622 | 563 | 523 | 562 | 17,4 | NS | NS | NS | NS |
| Poids total portée 28 j. (kg) | 4,78 | 5,08 | 4,74 | 4,56 | 3,91 | 4,74 | 4,10 | 3,53 | 22,4 | * | NS | ** | *** |

(1) Rapport entre l'écart type résiduel et la moyenne générale

* P < 0,10 ; ** P < 0,05 ; *** P < 0,01

TABLE 3

Doe Empty Body Composition (Mean ± sem)

| Treatment | Measurement: Empty body weight (g) | DM (g/kg) | Ash (g/kg DM) | Fat (g/kg DM) | Protein (g/kg DM) | Energy (kg DM) |
|---|---|---|---|---|---|---|
| CONT (5) | 3718 | $413^{a}$ | 69 | $506^{a}$ | $471^{a}$ | 31.1 |
| 1L1 (5) | 3671 | $388^{ab}$ | 71 | $450^{b}$ | $518^{ab}$ | 30.0 |
| 1L2 (4) | 3714 | $373^{b}$ | 87 | $405^{b}$ | $549^{b}$ | 29.0 |
| 21L1 (5) | 3701 | $421^{ab}$ | 67 | $477^{ab}$ | $499^{ab}$ | 30.6 |
| 21L2 (4) | 3989 | $390^{ab}$ | 82 | $397^{ab}$ | $556^{ab}$ | 28.8 |
| 1H2 (2) | 3747 | $427^{ab}$ | 67 | $511^{ab}$ | $453^{ab}$ | 30.9 |
| 21H2 (2) | 4326 | $457^{ab}$ | 57 | $546^{ab}$ | $422^{ab}$ | 31.5 |
| Average sem | 206 | 14.6 | 7.6 | 35.9 | $32.0^{ab}$ | 0.95 |
| Significance level | NS | ab* | NS | ab* | ab* | NS |

Values with different superscripts within each column are significantly different ($P < 0.05$).

Although caution must be exercised, due to the small numbers of does completing the experiment (in particular those on Treatments 1H and 21H in the second lactation), it appears that despite the imposition of different remating intervals and diets both doe reproductive performance and weight change are unaffected. No major difference in doe body composition was apparent after completion of the first lactation, but by the end of the second lactation it had become evident that does offered Diet L showed a trend towards negative energy balance, whilst those offered Diet H maintained energy equilibrium. This suggests that the observed increase in reproductive performance in Lactation 2 for does offered Diet L was supported in part by adipose tissue mobilisation indicating a deficit in energy intake, whilst for those does offered Diet H this did not occur as their energy intake seemingly fulfilled the energy requirement for pregnancy and lactation. Composition of the dry fat-free body was practically constant in all treatments (Ash % $12.59 \pm 0.74$, Protein % $87.39 \pm 0.74$). Lebas (12) showed that does fed ad libitum should complete lactation with a similar fat content to that at the previous mating. Does on Treatments 21L, 1H and 21H confirm this finding, whilst those on Treatment 1L show a downward trend in fat content over two cycles. The ability of does to maintain the reproductive performance on Treatment 1L over successive reproductive cycles is questionable in that they have a reduced fat reserve to call upon in periods of energy deficit. If the diminution in fat reserves continued it is likely that reproductive performance would suffer, as has been reported for other monogastric species (13, 14).

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## Summary

Forty-four nulliparous crossbred does were used in a comparative slaughter experiment to assess the effects of diet nutrient density on doe reproductive performance and body composition changes. Two diets were used, diet L (10.6 MJ DE/kg DM and 151.7 g DCP/kg DM) and diet H (15.4 MJ DE/kg DM and 221 g DCP/kg DM). A control group of does were slaughtered at first parturition and the rest of the does were allocated to one of four treatment groups to be remated either 1 or 21 days after parturition and to be offered diet L or diet H (treatments 1L, 21L, 1H, 21H respectively). Half of the animals allocated to treatments 1L and 21L were slaughtered at the end of their first lactation (day 28) while the remainder and the does on treatments 1H and 21H were slaughtered at the end of their second lactation.

There was no significant difference in total litter weight gain to weaning between treatments within Lactations 1 or 2, however, mean values were significantly greater in the second lactation than in the first ($P < 0.001$). This was a result of significantly greater DM, DE and DCP intakes in Lactation 2 for all does ($P < 0.001$). Pup number at weaning (28 d) was not different between treatments in Lactation 1, but was significantly ($P < 0.05$) lower for does on Treatment 1H in Lactation 2. The lack of sufficient doe numbers on this treatment precluded any firm conclusion on the existence of a real treatment effect. Doe weight gain from birth to weaning was significantly greater ($P < 0.01$) for all does in Lactation 2 than Lactation 1. Does offered Diet H maintained energy equilibrium over the course of the experiment, whilst those offered Diet L showed a trend towards negative energy balance. Does on Treatment 1L at the end of the experiment had significantly less DM and fat and a greater protein content ($P < 0.05$) than those on the control treatment. It is suggested that this downward trend in body fat if continued over subsequent lactations could affect the ability of these does to maintain their reproductive performance.