EFFECTS OF RESTRICTED FEEDING DURING REARING, COMBINED WITH A DELAYED FIRST INSEMINATION, ON REPRODUCTIVE ACTIVITY OF RABBIT DOES

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ABSTRACT

The experiment was performed to verify the effects of restricted feeding during rearing, combined with a 3-week delay in first artificial insemination (AI), on body development and reproductive traits of young rabbit does, with the aim of improving their productivity and life-span. At 11 weeks of age, 82 New Zealand White(NZW) females were divided into two groups and assigned to different treatments: *ad libitum* feeding and first AI at 16.5 weeks of age (AL-16.5); feed restriction to 75% until 10 days before first AI, performed at 19.5 weeks of age (R-19.5). Five days after AI, 10 females *per* treatment were slaughtered to determine body composition and count of corpora lutea (CL) and embryos. The career of the 62 does was checked for 160 days, during which a 42-day reproduction rhythm was followed. From 11 weeks to first AI, the R-19.5 had lower growth rate than AL-16.5 (23.1 vs 35.4 g/d; P<0.0001) but showed higher body weight at AI (3571 vs 3427 g; P=0.002). All of the slaughtered females had CL, but the embryo recovery was higher in the R-19.5 than in AL-16.5 (75.6 vs 57.6%; P=0.34). The empty body of R-19.5 was higher in both water (+104 g; P=0.005) and protein (+39 g; P=0.13), and lower in fat (-31 g; P=0.30). At the first AI, the treatment did not affect the kindling rate, but the litter size at birth was higher by 0.7 kits in the R-19.5. After 160 days, although the culled rate of R-19.5 was lower by only 6.4% than the AL-16.5 (48.4 vs 54.8%), the final value was attained more slowly, so that the average duration of activity of R-19.5 tended to be higher (121 vs 105; P=0.14). During the 160-day period, the R-19.5 showed a tendency towards higher productivity in terms of number (+2.7; P=0.16) and weight (+1.8 kg; P=0.14) of weaned rabbits. When lactating, an improvement in kindling rate was observed in R-19.5 (83.0 vs 69.5%; P=0.15). The body weight of lactating R-19.5 was constantly greater from AI to litter weaning (day 31). The restricted feeding, applied from the age of 11 weeks, meant obtaining young rabbit does that, inseminated 3 weeks later, weighed more, without any increase in body fat deposition. The better body development of females favoured an improvement in reproductive efficiency at first AI, productivity during the subsequent activity, and a tendency towards a longer life-span.

Key words: rabbit does, rearing, restricted feeding, reproduction, productivity.

INTRODUCTION

In intensive production systems, the young rabbit does show low reproductive performance and a brief life-span, as a consequence of an energy deficit which they experience in order to sustain the high nutritional requirements for their concurrent lactation and pregnancy, their feed intake capacity being limited (XICCATO, 1996). Among the approaches to resolve the problem of energy deficit, an adapted rearing program seems to be suitable (ROMMERS *et al*., 1999). During rearing, *ad libitum* feeding determines an excessive formation of fat deposits in growing females, which interferes negatively with the subsequent reproductive activity; on the contrary the restricted feeding reduces growth rate but prevents body fat deposition. In this way, according to recent evidence (EIBEN *et al*., 2001; ROMMERS *et al*., 2001), feed restriction during rearing, followed by a short flushing, and a delay of first insemination to an older age, seem to represent a promising strategy for optimising body development of young does and improving their productivity and longevity. Therefore, the object of this investigation was to verify the effects of restriction during rearing, combined with a 3-week delay in first insemination, on body growth, body development and reproductive traits of young rabbit does, and on their productivity and longevity. With this aim, females restricted from 11 weeks of age and inseminated at 19.5 weeks after a 10-day flushing, were compared with females fed *ad libitum* and inseminated early at 16.5 weeks.

MATERIAL AND METHODS

Animals, housing and feeding treatments

A total of 182 healthy females, weighing = 500 g at weaning (35 d of age), were singled out from 48 litters from NZW does, housed in group cages (4 *per* cage) and fed *ad libitum* a weaning diet (10.5 MJ/kg DE, 19.5% CP and 27.0% ADF). At 8 weeks of age, 128 females, weighing = 1300 g, were further selected and fed *ad libitum* a growing diet (11.2 MJ/kg DE, 19.2% CP and 24.0% ADF) over the following 3 weeks. A final selection was performed at 11 weeks of age, singling out 107 females weighing = 2000 g, from which 44 pairs of sisters were constituted, with weight deviating by less than 10% within each pair and 25% among all 88 subjects. The sisters were housed in adjacent individual flat-deck cages and kept under a light program of 16 h/d; each of them was assigned to a different treatment. The treatments, differing with regard to feeding level, which was *ad libitum* or restricted, related with a different age at first AI, were performed from 11 weeks of age until first AI, on a supply of the growing diet. The *ad libitum* group was inseminated at 16.5 weeks of age (AL-16.5) and the restricted one 21 days later, at 19.5 weeks (R-19.5). In the R-19.5, the restricted amount of feed was weekly adjusted to 75% of the average intake of AL-16.5 in the previous week; for 10 days before AI, the R-19.5 were fed *ad libitum* to stimulate receptivity.

Reproduction

During rearing, 3 pairs of sisters were removed from the experiment, because of the death of one of them. The first AI involved 41 females at 16.5 weeks and as many at

19.5 weeks. AI was performed with 0.6 ml of diluted fresh heterospermic semen. Ovulation was induced at the moment of AI by i.m. injection of 0.2 ml of a GnRH analogue (Receptal, Intervet, Milan, Italy). After AI, all rabbits were fed 180 g/d of a commercial reproduction diet (11.1 MJ/kg DE, 21.4% CP and 25.5% ADF). Five days after AI, 10 pairs of sisters were slaughtered in order to determine body composition and examine reproductive traits. After first AI, the careers of the 31 living pairs of sisters were monitored for 160 days. They were housed in individual flat-deck cages under a light program of 16 h/d, and fed 180 g/d of the reproduction diet, provided *ad libitum* when lactating. A 42-day reproduction rhythm was followed using 2 batches of does inseminated at 21-day intervals. AI and ovulation induction were performed as previously described. At parturition, litter size was equalised to 8 kits in the primiparous does and 8-9 kits in multiparous does. Nursing was free, and controlled only in the 2 days prior to AI, in accordance with the method proposed by BONANNO *et al*. (2004) for inducing oestrus. The litters were weaned at 31 days of age.

Measurements

During the rearing phase, animals were weighed at 5 and 8 weeks of age, and weekly from 11 weeks to first AI. Individual feed intake was determined weekly from 11th week to first AI by weighing supplied and refused feed. At first AI, the does were weighed and their vulva was observed in order to score sexual receptivity. Uterus and ovaries were removed from the females slaughtered 5 days after first AI. Both uterine horns were flushed twice with 5 ml of saline and embryos were collected and counted. Corpora lutea (CL) were counted on the ovaries. The recovery rate was calculated as the number of embryos divided by the number of CL. The contents of the digestive tract and bladder were removed and weighed in order to determine the empty body weight. Empty bodies were frozen at -18 °C until grinding and homogenization. Representative samples of the empty bodies were freeze-dried to determine the water content; in freeze dried samples, dry matter at 105 °C was determined, as well as fat extracted with petroleum-ether in Soxhlet apparatus, ash at 525°C and protein for difference. During the reproductive phase, does were scored for sexual receptivity at AI; at parturition, fertility rate, number of total born and number and weight of alive-born were recorded. Size and weight of litters were checked at day 1 (after equalisation), 11, 21 and 31 (at weaning) after birth. Lactating does were weighed at day 1, 11, 21 and 31 after parturition. Milk yield was recorded on day 11 by weighing does before and after nursing.

Statistics

The data were analysed using the GLM procedure of SAS 6.12 (1989). Proportional data were considered as variables of Bernoulli (0-1). Parameters relating to female growth, feed intake, body composition and reproductive traits at first AI, were analysed by a randomized complete block model, in which the blocks were the pairs of sisters and the effect was the treatment (AL-16.5 and R-19.5). Parameters regarding lactating does were analysed by a linear model including effects of treatment (AL-16.5 and R-19.5) and lactation order (1 and 2-3); their interaction was omitted because it was not significant. Differences between means were tested by Student's "*t*" test. For the other parameters, means of the treatments were compared by Student's "*t*" test.

RESULTS AND DISCUSSION

Performances from weaning to first AI

The groups showed an analogous growth rate from weaning to 11 weeks of age, reaching the same body weight (table 1). From 11 weeks to first AI, the R-19.5 grew more slowly, but they were able to achieve a higher body weight at AI, performed 3 weeks later, when compared to AL-16.5. While the AL-16.5 showed a higher daily feed intake, as expected, the R-19.5 females had a total feed intake higher by 1664 g on DM than the AL-16.5; this difference corresponds to 1.9 kg of fresh feed and represents the only supplementary charge for delaying the first AI of a single rabbit by 3 weeks. Taking into account a price of 0.37 €/kg, the increase in the cost of feed should be equal to only 0.70 € *per* reared female. Feed conversion during rearing showed an increasing tendency with restricted feeding, probably because their nutrient intake was destined to satisfy the maintenance requirements.

Table 1. Growth performance of females from weaning to first AI (means ± sd).

	Age (weeks)	Treatment		Prob >*f*
		AL-16.5	R-19.5	
Females (n)		41	41	
Body weight (g)	5	706 ± 106	726 ± 106	0.16
	11	2193 ± 122	2206 ± 138	0.38
	first AI	3427 ± 274	3571 ± 188	0.002
Weight gain (g/d)	5-11	35.4 ± 2.6	35.2 ± 2.9	0.68
	11-first AI	32.5 ± 6.1	23.1 ± 2.9	<0.0001
Total feed intake (g DM)	11-first AI	7440 ± 620	9104 ± 398	<0.0001
Daily feed intake (g DM)		195.8 ± 16.3	154.3 ± 6.7	<0.0001
Feed conversion		6.3 ± 1.7	6.8 ± 0.7	0.10

Reproductive performance at first AI and body composition

On the whole, both sexual receptivity (70.7 vs 61.0%) and pregnancy rate (80.5 vs 70.7%) were higher in the R-19.5, but not significantly. With regard to the slaughtered females (table 2), all showed CL, but the average number of CL, the number of females producing embryos, the average number of embryos and the embryo recovery were higher in the R-19.5 than in AL-16.5. The ovary efficiency in the R-19.5 must be related to the better sexual maturity achieved. The treatment did not affect the kindling rate of living does (table 2), higher by only 3.2% in the R-19.5. The lower weight of AL-16.5 at first AI was only partly recovered by the higher growth rate during first pregnancy, so that the difference in weight between groups was also consistent at kindling. The litter size at birth was higher by 0.7 kits in the R-19.5, but the viability of young rabbits was lower, so the number of alive-born and the incidence in equalised litters were similar between groups. Treatment did not affect the weight of alive-born. The R-19.5 had higher empty body weight than AL-16.5, due to higher water and protein content (table 3). In R-19.5, the body fat was lower by 31 g compared to the AL-16.5, in accordance with the hypothesis being advanced. ROMMERS *et al.* (2001) found a higher gap in body fat, which was lower by 123 g in restricted females inseminated at 17.5 weeks than in does fed *ad libitum* and inseminated at 14.5 weeks.

Culled rate and reproductive performance during the activity period

During the 160-day reproduction period, the culled rate of AL-16.5 was higher by only 6.4% than the R-19.5 (54.8 vs 48.4%). Nevertheless, the final value was achieved more slowly by the R-19.5; in fact, at 100 days of activity, the culled does were 54.8% in AL-16.5 and only 29.0% in R-19.5. As a consequence, the average duration of activity of R-19.5 tended to be higher by 16 days (121 vs 105; P=0.14). On the whole, the sexual receptivity at AI and kindling rate were not affected by the treatment. Nevertheless, because the R-19.5 showed a tendency towards a higher number of AI (+9), fertility (+5.6%), the number of total (+0.6) and alive (+0.4) born, the incidence of equalised litters (+5.9%) and the number of weanings/doe (+0.3), each restricted doe had a higher productivity at weaning, in terms of both number (+2.7; P=0.16) and weight (+1.8 kg: P=0.14) of young rabbits. In this way, 2.5 kg being the weight of a fattened rabbit, the productivity of a restricted doe during rearing, and inseminated later, should be higher by 6.75 kg. Taking into account a unit price of 2.2 €/kg, the profit for a single doe should be equal to 14.85 €. When lactating, the sexual receptivity at AI did not differ between groups, whereas the gap in kindling rate increased in favour of R-19.5 (83.0 vs 69.5%; P=0.15). A slight improvement in R-19.5 lactating does was also observed for litter size (+0.3) and viability (+0.8) at birth, and the incidence of equalised litters (+10.8%); no difference emerged for milk yield at day 11 of lactation. The weight variations in rabbit does from AI to litter weaning (day 31) demonstrated a constant superiority of R-19.5 when compared to the other group. In fact the body weight of R-19.5 was higher at AI (3742 vs 3624 g, P= 0.05); the difference decreased during the subsequent phase, reaching its lowest value at day 21 post partum (+44 g) and increased during the last 10 days, being equal to 102 g at day 31. The size and growth of nursed litters were not influenced by the rearing strategy to which the young does were subjected. In fact, no difference between groups emerged in relation to viability and weight gain of young rabbits during nursing, from equalisation to weaning.

CONCLUSIONS

The findings of this experiment indicated that restricted feeding during rearing, from 11 weeks of age until 10 days before AI, resulted in young rabbit does that, inseminated later, weighed more, without any increase in body fat deposition. Although restricted females grew more slowly, they were heavier at first AI than those fed *ad libitum*. The higher body weight was related to higher body content in water and protein, to which there was a corresponding decrease in fat. The better body development of females, linked to their lower fat level, favoured an improvement in their reproductive efficiency at first AI, in terms of fertility and prolificacy, these latter being expressed as both embryo recovery rate and number of total born *per* litter. Even though the final culled rate was almost analogous between groups, during the activity period (160 days) restricted females showed a more gradual increase in culled rate than *ad libitum* females, indicating their tendency towards a longer life-span.

Table 2. Reproductive traits of females at first AI (means ± sd).

	Treatment		Prob >*f*
	AL-16.5	R-19.5	
Slaughtered females (n.)	10	10	
Females with corpora lutea (n)	10	10	
Corpora lutea (n/female)	6.5 ± 3.0	9.7 ± 1.1	0.003
Females with embryos (n)	6	9	0.19
Embryos (n/female)	4.7 ± 4.5	7.2 ± 3.1	0.14
Embryo recovery (%)	57.6 ± 49.8	75.6 ± 32.0	0.34
Living females (n)	31	31	
Sexual receptivity (%)	61.3 ± 49.5	71.0 ± 46.1	0.50
Kindling rate (%)	74.2 ± 44.5	77.4 ± 42.5	0.77
Body weight at AI (g)	3388 ± 300	3536 ± 199	0.015
Body weight at kindling (g)	3719 ± 272	3834 ± 236	0.26
Weight gain from AI to kindling (g)	340 ± 182	297 ± 102	0.36
Total born (n/litter)	7.2 ± 2.8	7.9 ± 2.8	0.41
Live-born (n/litter)	7.2 ± 2.8	7.0 ± 2.1	0.71
Still-born (n/litter)	0.0 ± 0.0	0.9 ± 1.7	0.13
Individual weight at birth (g)	66.9 ± 8.5	67.9 ± 9.8	0.80
Equalised litters (%)	82.6 ± 38.8	87.5 ± 33.8	0.33

Table 3. Body composition of females at 5 days after first AI (means ± sd).

	Treatment		Prob >*f*
	AL-16.5	R-19.5	
Slaughtered females (n)	10	10	
Body weight (g)	3478 ± 123	3629 ± 114	0.01
Empty body weight (g)	3150 ± 113	3273 ± 105	0.02
Water (g)	2006 ± 91	2113 ± 79	0.005
Ash (g)	97 ± 7.3	104 ± 10.6	0.19
Protein (g)	630 ± 45	669 ± 46	0.13
Fat (g)	417 ± 56	386 ± 63	0.30

The maintenance of a constant higher body weight from AI to litter weaning contributed to improving longevity in restricted females. Restricted feeding during rearing and late AI increased fertility of lactating does more evidently (+13.5%), but only slightly improved size and viability of their litters, and did not affect milk yield and growth performance of nursed litters. On the whole, restricted females gave superior productivity in terms of number and weight of weaned rabbits; this was principally linked to their longer reproductive period, higher fertility and litter size, and viability. Assuming the greater intake of 1.9 kg of feed, evaluated as equal to 0.70 €, to be the only additional cost involved in delaying the first AI of a single female by 3 weeks, it is evident that this cost is easily compensated by the potential profit, in terms of production of fattening rabbits, estimated as equal to 14.85 €.

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