EFFECT OF REMATING INTERVAL AND DIET ON THE PERFORMANCE AND ENERGY BALANCE OF RABBIT DOES

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Abstract - Eighty-nine hybrid rabbit does at their first parturition were used in a bifactorial experiment: 3 remating intervals (NP: non-pregnant does; 10P: pregnant does remated 10 days *post-partum*; 28P: pregnant does remated 28 days *post-partum*) x 2 diets (C diet: DE 10.44 MJ/kg; F diet: DE 11.22 MJ/kg, with 30 g/kg of added animal fat). An initial group of 13 does (preliminary slaughter group) was slaughtered immediately after their first parturition. The NP does of the 10P group were slaughtered at the end of their first lactation, whereas the pregnant does of the 10P and 28P groups were slaughtered immediately after their second parturition. The 28 NP does were excluded from the experiment. Energy and material balance were performed by the comparative slaughter technique.
Effect of remating interval: on the entire experiment, the 28P does showed the highest liveweight at slaughter (P<0.01) and the lowest food and energy consumption (P<0.001). Milk production (208 g/day, on average) and consequently the litter weight at weaning were not significantly influenced by the remating interval. At the second parturition, the 10P and 28P does body showed higher fat and energy contents than NP does, but they were still in negative energy balance (NP does: -31.1%; 10P does: -26.5%; 28P does: -15.3%; P<0.001). The 28P does showed a higher *corpora lutea* number than the 10P does (P<0.001), but the litter size at birth was similar. *Effect of diet*: the F diet increased milk production (215 *vs* 201 g/d; P<0.05) stimulating the litter growth (P<0.05), but it caused a lower number of pups born alive at the second parturition (7.0 *vs* 8.8, P<0.05). Both the diets were unable to avoid the energy deficit of the body's does. Significant remating interval x diet interactions were found: in the 10P does the energy deficit was higher in F group, while in the 28P does the F diet permitted a higher fat and energy recovery.

INTRODUCTION

At the end of the first lactation, the energy balance of primiparous rabbit does is strongly negative. In fact, the body composition changes definitely during lactation, with a significant loss of body lipids and energy (on average -40% and -20% of the initial content, respectively). If the does are concurrently pregnant, the energy deficit is even greater and the nitrogen and mineral balances may become negative as well (PARIGI BINI and XICCATO, 1993). It has been suggested that these results are due to the low voluntary feed intake of the primiparous does. However, any attempt to prevent or reduce this deficit by increasing the dietary digestible energy (DE) concentration was not successful (PARIGI BINI and XICCATO, 1993; FORTUN and LEBAS, 1994).
The adoption of intensive remating systems does not permit the total recovery of the energy and material losses, due to the continuous succession of concurrent pregnancy with lactation. For this reason, the majority of Italian rabbit breeders follow a semi-intensive (10-12 days *post-partum*) remating program. In addition, some technicians and researchers are now suggesting that a longer remating interval (20-30 days after parturition) can improve reproductive performance and total income, if correct management of the breeding stock is applied.
The aim of the present research was to verify whether different remating intervals and diets can affect the performance and reduce the energy deficit of young reproducing does.

MATERIAL AND METHODS

Eighty-nine pregnant hybrid rabbit does (Provisal female parent line, based on the New Zealand White breed) were used. The does had their first parturition at 148 days of age and an average liveweight (LW) of 3696 ± 298 g. Each doe was kept in an individual cage and her nest was situated in an identical cage alongside. Within a few hours after parturition 13 does and their litters were slaughtered (preliminary slaughter group) to estimate

Table 1 : Ingredients, chemical composition and nutritive value of the experimental diets

	Diet	
	Control (C)	Fat (F)
Ingredients, g/kg		
-Dehydrated lucerne meal	380	350
-Wheat middlings	300	210
-Barley (two rows) meal	160	184
-Soya-bean meal (CP 44)	110	180
-Sugar cane molasses	20	20
-Dibasic calcium phosphate	4.0	3.0
-Limestone	9.5	7.0
-Salt	3.2	3.0
-Vitamin and micro-mineral pre-mix	10.0	10.0
-DL-methionine	1.3	1.0
-Cycostat (premix)	2.0	2.0
-Animal fat(1)		30.0
Chemical composition:		
-Dry matter	917	919
-Crude protein	186	198
-Ether extract	33	60
-Crude fibre	133	126
-Ash	91	87
-Gross energy MJ/kg	16.41	17.19
Nutritive value:		
-Digestible energy (DE) MJ/kg	10.44	11.22
-Digestible protein (DP) g/kg	137.8	148.1
-DP/DE g/MJ	13.2	13.2

(1) 600 g/kg pork lard + 400 g/kg beef tallow

the initial empty body composition of the 76 remaining does, according to the comparative slaughter technique (PARIGI BINI *et al.*, 1992).

The litters were standardised to eight pups on the day of birth and were separated from their mothers. These were allowed to enter the nest and suck once daily in the morning. Milk yield was measured 3 times per week during the entire lactation of 28 days by weighing the doe immediately before and after suckling. The day of parturition, the does were divided into two main groups of 38 animals each, fed *ad libitum* with the experimental pelleted diets: C diet (control diet with a moderate DE concentration: 10.44 MJ/kg) and F diet (added-fat diet, 30 g/kg of animal fat, with a high DE concentration: 11.22 MJ/kg) (table 1). The formulas of C and F diets were very similar to the corresponding diets (named M and F) used in a previous research (XICCATO *et al.*, 1995). The only differences in the present experiment were the higher inclusion of fat in the F diet (30 *vs* 25 g/kg) and the higher protein concentration due to the different batches of raw materials employed. The energy concentration of the experimental diets resulted clearly different: F diet had 10% more DE than C diet but the same DP/DE ratio (i.e. 13.2 g/MJ). Food intake was recorded daily.

Twenty does per diet were remated (artificial insemination) 10 days *post-partum* (10P group), while the other 18 does were remated 28 days after kindling (28P group). The 13 non pregnant does belonging to the 10P group (7 fed with the C diet and 6 fed with the F diet) were slaughtered at the end of their first lactation (NP does). Consequently, the experimental design was bifactorial: 3 remating intervals (NP, 10P pregnant and 28P pregnant) x 2 diets (C and F). Eighteen does were excluded from the experiment: 9 from the 28P group (non pregnant) and 9 from different groups (mortality or health problems).

The litters were weighed every 7 days before sucking. At the 18th day of lactation, the pups were allowed to eat the maternal diet from a trough separated from that of the mother. The food intake of the litters was also recorded. The pups were weaned at 28 days of age.

The second parturition occurred 41 days after the first parturition for the 10P does and 59 days after the first parturition for the 28P remated does. Immediately after the second parturition, all the does and their new-born litters were slaughtered. The ovaries were observed and the *corpora lutea* (CL) counted to calculate the prenatal mortality: (CL-pups born)/CL*100.

The dietary DE content and the apparent digestibility of nutrients was determined in a digestibility trial carried out on 20 growing rabbits (10 animals per diet), according to the EGRAN method (1994). The empty bodies of the does (EB) and their complete new-born litters were frozen separately and then ground and freeze-dried to determine water content. The chemical analyses of empty bodies, feeds and faeces and the energy and material balances of the does were determined as described by XICCATO *et al.* (1995). Statistical analysis was performed using the ANOVA (HARVEY, 1987), with a bifactorial model accounting for the fixed effects the diets, the remating interval and their interactions.

RESULTS AND DISCUSSION

The statistical analysis showed significant effects of interaction between the experimental factors only for lipids and energy balance. Consequently the following results will concern the two main effects: remating interval and diet.

Effect of the remating interval

The performance of the does during lactation (table 2) was not influenced by the remating interval. This result is not surprising as the NP and 28P does were, during lactation, in the same remating interval (i.e., non pregnant) while the 10P does were at the beginning of their second pregnancy, when the influence of pregnancy on milk production is still scarce. Therefore, the litter weight at weaning and litter food intake were not significantly influenced. The only differences among reproducing state concerned the entire period: the 28P does showed the highest liveweight at slaughter (P<0.01) and the lowest food and energy consumption (P<0.001), because of the different interval between the first parturition and slaughter (28, 41 and 59 days for the NP, 10P and 28P groups, respectively).

The most important effect of remating interval concerned the weight (EBW) and composition of empty body and the energy and material balances between the first parturition and slaughter (table 3). The NP and 10P does showed a loss of EBW (-184 g on average), while the 28P does had their EBW slightly increased (+76 g). The body composition changed strongly during lactation with large losses of fat (from 157 g/kg of the preliminary slaughter group to 72 g/kg of the NP does), compensated by an increase in water (from 617 to 680 g/kg). At their second parturition, the 10P and 28P does showed higher fat (86 and 104 g/kg) and energy (8.01 and 8.65 MJ/kg) contents than NP does. Therefore, at the end of the experimental period, all does showed a negative energy balance, even though the deficit decreased from NP does (-31.1%) to 10P (-26.5%) and 28P (-15.3%) does (P<0.001). The energy recovery was proportional to the time between the end of lactation and the second parturition (13 days for the 10P does and 31 days for the 28P does) and consequently to the total DE intake.

Anyway it is quite surprising that the young rabbit does were unable to completely recover the lactation energy deficit, whatever the remating interval may be. In fact, immediately after weaning the food intake of the does decreased rapidly and this prevented the complete energy recovery. This finding is in contrast with the practice of restricting the feed in long term rebreeded does to avoid an excessive fattening of does.

The remating interval did not affect significantly the size and weight of new-born litters (table 4), but influenced the prenatal mortality (P<0.001). In fact, the 28P does had a higher number of *corpora lutea* than 10P does (P<0.001), but delivered the same number of pups. The composition of new-born litters was influenced by the remating interval, but it is not clear why the litters of 10P does were richer in fat and energy when their mothers had a higher nutritional deficit than the 28P does. On this subject, ELPHICK *et al.* (1975) found an increase of foetal fat, due to a more intense placental fatty acids transfer, when the rabbit doe was submitted to an important lipolysis.

Several studies have been carried out on the effect of remating interval on reproducing doe performance, but there are no information on energy balance. MENDEZ *et al.* (1986) comparing females remated 1, 9 and 25 days after parturition, found a positive effect of a longer remating interval on reproductive performance. In particular they observed that a semi-intensive breeding program (9 days PP *vs* 1 day PP) increased the conception rate, the litter weight at 21 days and the does weight. The only advantage of a long-term rebreeding schedule (25 days PP *vs* 9 days PP) was a higher litter size at birth. Similar results were reported by PARIGI BINI *et al.* (1989) and CERVERA *et al.* (1993), while FRAGA *et al.* (1989) observed a positive effect of a longer rebreeding system (9 days PP *vs* 1 days PP) on milk production but no influence on reproductive performance.

Effect of the diet

The data reported in table 2 show that the does fed on the F diet had a lower food intake (P<0.05), but a higher DE intake (not significant effect) than the animals fed the C diet. Consequently, they produced more milk (P<0.05). These results confirm those observed in previous works (PARIGI BINI and XICCATO, 1993; FORTUN and LEBAS, 1994; XICCATO *et al.*, 1995) and are ascribed to the fat inclusion into the F diet, as pointed out by FRAGA *et al.* (1989). The higher milk production of F does stimulated the litter growth (P<0.05), confirming our previous results (XICCATO *et al.*, 1995).

Table 2. Performance of does and litters (first parturition and lactation)

		Remating interval (RI)			Diet (D)		Significance			RSD
		Non pregnant (NP)	Pregnant (P) 10P	Pregnant (P) 28P	Control (C)	Fat (F)	NP *vs* P	10P *vs* 28P	D	
Does	No.	13	24	21	30	28				
Interval parturition to slaughter	d	28	41	59						
Live weight at:										
- first parturition	g	3721	3661	3752	3718	3705				296
- end of lactation (28 d)	g	3753	3914	3924	3895	3833	<0.10			300
- slaughter	g	3753	3649	3932	3839	3717		**		299
Food intake:										
- 0 to 28 days	g/d	349	345	344	355	337				35
- 0 to slaughter	g/d	349	295	271	315	296	***	**	*	29
Digestible energy intake:										
- 0 to 28 days	kJ/d	3776	3740	3718	3710	3780				382
- 0 to slaughter	kJ/d	3776	3192	2934	3283	3318	***	**		308
Milk production	g/d	212	206	206	201	215			*	23
Litters	No.	13	24	21	30	28				
Litter size at weaning (28 d)	No	7.3	7.6	7.5	7.4	7.6				0.8
Litter weight:										
- initial	g	436	452	446	443	446				53
- 28 days	g	4293	4284	4364	4162	4466			*	534
Litter growth rate	g/d	138	137	140	133	144			*	19
Litter food intake (18 to 28 d)	g	656	676	762	698	698				23

* : P<0.05; ** : P<0.01; *** : P<0.001.

Concerning the variation of EBW between the first parturition and slaughter and the energy and material balances (table 3), no significant diet effect was observed. Only a higher gut content was found in the C does that ingested more feed (P<0.01). It is clear that the dietary treatment was not able to reduce the energy deficit, confirming our previous results (XICCATO *et al.*, 1995).

Significant remating interval x diet interactions were found concerning lipids and energy balance. In particular in the 10P group the lipid mobilisation and then the energy deficit appeared to be higher in does fed on the F diet, while in the 28 P group the F diet permitted a better recovery of the lipids and energy lost during lactation. We can suggest that, with intensive or semi-intensive remating systems, the added-fat diet stimulates milk production and makes the deficit worse, but in long-term remating systems, it allows a greater recovery of body condition. Both diets were able to cover the requirements of protein and minerals. Those nutrients seem often to be limiting in the feeding of concurrently pregnant and lactating does (PARIGI BINI and XICCATO, 1993).

The weight and body composition of the new-born litters of the second parturition were not influenced by the diet (table 4). However, the number of pups born alive was lower (7.0 *vs* 8.8, P<0.05) and the pup weight higher with the F diet. This finding agrees with the results of some previous research (VIUDES-DE-CASTRO *et al.*, 1991; XICCATO *et al.*, 1995), but is in contrast with others (BARRETO and de BLAS, 1993; FORTUN and LEBAS, 1994).

CONCLUSIONS

This research confirmed the great difficulty that exist in avoiding the energy and material deficit in primiparous does whatever the nutritive level may be. In particular the most common rebreeding schedule used in Italy (remating 10-12 days after parturition) appeared to be unable to maintain the body condition in the interval between the first and second parturition, resulting in a body energy deficit of 26%. A longer remating interval (28 days PP) allowed only a partial recovery of the energy deficit (15%) and, at the same time, it did not show a definitely positive effect on the reproductive performance. Moreover, the energy metabolism of extensively

Table 3 : Empty body composition of does at slaughter and material and energy balance between the first parturition and slaughter[1]

		Remating interval (RI)			Diet (D)		Significance			
		Non pregnant (NP)	Pregnant (P) 10P	Pregnant (P) 28P	Control (C)	Fat (F)	NP *vs* P	10P *vs* 28P	D	RSD
Does, No	.	13	24	21	30	28				
LBW at 1st parturition,	g	3721	3661	3752	3718	3705				289
Gut content	g	223	214	227	222	220				41
EBW at 1st parturition	g	3498	3447	3525	3495	3484				247
LBW at slaughter	g	3753	3649	3932	3839	3717		**		299
Gut content	g	475	350	331	419	351	***		**	81
EBW at slaughter	g	3279	3299	3601	3419	3366		***		288
Composition of EB at slaughter[2] :										
- Water	g/kg	680	675	663	673	672				22
- Protein	g/kg	215	207	201	208	207	**	*		9
- Fat	g/kg	72	86	104	86	88	**	*		25
- Ash	g/kg	33	33	32	33	33				4
- Energy	MJ/kg	7.67	8.01	8.65	8.13	8.09	*	*		0.88
Material and energy balance:										
- Water	%	3.3	4.5	9.7	6.6	5.0		**		6.3
- Protein	%	4.0	2.3	6.2	5.1	3.3		*		6.2
- Fat[3]	%	-57.0	-47.6	-32.1	-45.7	-45.4	***	***		3.4
- Ash	%	-1.3	-0.8	3.7	0.5	0.6		*		6.0
- Energy[4]	%	-31.1	-26.5	-15.3	-23.7	-24.9	***	***		4.6

[1] The initial EBW and composition of the does slaughtered on the end of lactation (NP does) and on the second parturition (10P and 28P does) were calculated by linear equations (see text).

[2] Initial slaughter group (13 does at first parturition): LBW, 3706 g; gut content, 208 g; EBW, 3498 g. EB composition: water 617 g/kg; protein 194 g/kg; fat 157 g/kg; ash 32 g/kg; energy 10.44 MJ/kg.

[3] Significant interaction RI x D (P<0.001): NP does-C diet group (NP-C), -58.4%; NP-F group, -55.5%; pregnant 10P does-C diet group (10P-C), -44.1%; 10P-F group, -51.1%; pregnant 28P does-C diet group (28P-C), -34.6%; 28P-F group, -29.6%.

[4] Significant interaction RI x D (P<0.01): NP-C group, -31.1%; NP-F group, -31.2%; 10P-C group, -23.1%; 10P-F group, -29.8%; 28P-C group, -16.9%; 28P-F group, -13.7%.

Table 4. Reproductive data, performance and body composition of litters (second parturition)[1]

		Remating interval (RI)		Diet (D)		Significance		RSD
		10P	**28P**	Control (C)	**Fat(F)**	**RI**	**D**	
Litters	No.	24	21	23	22			
Corpora lutea (CL)	No	11.36	15.10	13.54	12.96	***		2.46
Prenatal mortality[2]	%	26.9	43.7	32.8	40.6	***		19.5
Pups born per litter	%	8.3	8.5	9.1	7.7		<0.10	2.6
Pups born alive per litter	%	7.9	7.9	8.8	7.0		*	2.7
New-born litter weight	g	464	473	487	449			106
Weight of pups born alive per litter	g	444	443	475	413			129
Average weight of new-born pups	g	58.3	57.3	55.4	60.1		<0.10	8.5
Average weight of pups born alive	g	58.6	57.0	55.5	60.1			8.7
Body composition of litters[3]								
- Water	g/kg	793	802	798	797	**		10
- Protein	g/kg	123	119	122	120	*		5
- Fat	g/kg	61	56	57	60	*		8
- Ash	g/kg	23	23	23	23			1
- Energy	MJ/kg	5.11	4.84	4.93	5.03	**		0.32

[1] Initial litter data (11 litters): No. of pups born per litter, 8.8; No. of pups born alive per litter, 7.7; New-born litter weight, 456 g; Weight of pups born alive per litter, 405 g; Body composition: water, 800 g/kg; protein 120 g/kg; fat 58 g/kg; ash 23 g/kg; energy 4.98 MJ/kg.

[2] Prenatal mortality: (CL - pups born)/CL x 100.

[3] Pups born dead included

rebred does appeared to be directed towards anabolism, with a possible negative influence on future reproductive activity.

The use of added-fat diet induced an expected increase in milk production, with a positive effect on litter weight at weaning. Nevertheless, it reduced significantly the number of pups born per litter at the second parturition.

Finally, a significant interaction between remating interval and diet indicated that the added-fat diet seems to be more suitable for the long-term remating systems, because of its positive effect on body condition. On the contrary, this kind of diet increases the energy deficit when used in intensive remating programs.

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Effetto del ritmo riproduttivo e della dieta sulle prestazioni e sul bilancio energetico delle coniglie fattrici - Furono utilizzate 89 coniglie ibride al primo parto in un esperimento bifattoriale: 3 ritmi riproduttivi (NP: coniglie non gravide; 10P: coniglie gravide riaccoppiate 10 giorni PP; 28P: coniglie gravide riaccoppiate 28 giorni PP) x 2 diete (dieta C: 10,44 MJ/kg di ED; dieta F: 11,22 MJ/kg di ED, con 30 g/kg di grasso animale). Un gruppo iniziale di 13 coniglie venne macellato immediatamente dopo il primo parto (macellazione preliminare). Le coniglie NP del gruppo 10P furono macellate alla fine della loro prima lattazione, mentre le coniglie gravide dei gruppi 10P e 28P furono sacrificate subito dopo il loro secondo parto. Le coniglie non gravide 28P furono escluse dall'esperimento. Fu utilizzata la tecnica della macellazione comparativa per determinare i bilanci materiale ed energetico.

Effetto del ritmo riproduttivo: nell'intera prova, le fattrici 28P evidenziarono il maggiore peso vivo (P<0,01) e la minore ingestione di mangime ed energia (P<0,001). La produzione di latte (in media 208 g/d) e conseguentemente il peso delle nidiate allo svezzamento non furono significativamente influenzati dal ritmo riproduttivo. Al secondo parto, le coniglie 10P e 28P evidenziarono maggiori contenuti di grasso ed energia corporei rispetto alle coniglie NP, ma risultarono ancora in bilancio energetico negativo (NP: -31,1%; 10P: -26,5%; 28P: -15,3%; P<0,001). Le coniglie 28P presentarono un maggior numero di corpi lutei rispetto alle coniglie 10P (P<0,001), ma il numero di nati vivi al secondo parto non fu significativamente diverso. *Effetto della dieta*: la dieta F aumentò la produzione di latte stimolando l'accrescimento delle nidiate (P<0,05), ma ridusse significativamente il numero di nati vivi al secondo parto (7,0 *vs* 8,8; P<0,05). Entrambe le diete non permisero il recupero del deficit energetico corporeo. In proposito si evidenziò una significativa interazione « ritmo x dieta »: nelle coniglie 10P il deficit energetico fu maggiore con la dieta F, mentre nelle coniglie 28P tale dieta consentì un recupero energetico superiore.
