Divergent Selection For Longevity In Breeding Does: Indirect Response For Energy Balance And Fat Stores

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Introduction

In French meat rabbit farming, the doe replacement rate is about 115 %. This replacement rate is partly explained by mortality (30 % in average) and by culling. Genetic improvement of longevity in breeding doe is interesting for both economic and ethic reasons. In many cases, the dead or culled females show poor body conditions often associated with nutritional deficit (Fortun-Lamothe, (2006)). Energy deficit leads indeed frequently to poor fertility, decrease of immunity defense and, in extreme cases, death of does. The aim of this study was to compare energy balance and evolution of fat stores of does divergently selected for longevity (Garreau et al., (2008)).

Material and methods

Animals. Females came from a divergent selection experiment (Garreau et *al*. (2008)). After one generation of selection, 120 does of high longevity line (L +) and 120 does of low longevity line (L -) were produced at the Pectoul INRA experimental farm and transferred to the EASM INRA experimental farm. (Garreau et al., (2008)). Does were artificially inseminated (AI) 7 times every 6 weeks from the age of 19 weeks without any culling. The difference of longevity between the 2 lines was 0.92 AI i.e. 39 days. For this study we retained only 89 does that gave litters for each of the 3 first inseminations.

Reproduction traits and weights.. Fertility, total number born, number born alive and number weaned per litter were recorded for each of the 3 first kindling. Does were weighed at second and third AI and also at first and second weaning, First and second litters were weighed at kindling (day 0) and at 21 days of lactation (day 21). Individual food consumption of does were recorded from day 11 to day 21

Energy balance evaluation. The energy balance of does from day 11 to day 21 was estimated in the two first reproductive cycles. Energy balance is calculated from the difference between the energy supply from the food and the various energy requirements of

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the animal: lactation, pregnancy, maintenance (Fortun-Lamothe, (2006)). Energy supply is estimated by multiplying the food intake by the level of digestible energy of food. Energy requirement for fetal growth is significant only during the last week of pregnancy. So we calculated energy requirements of does by adding energy requirements for maintenance and for lactation (Fortun-Lamothe, (2006)). Energy requirement for lactation between day 11 and day 21 was evaluated by the equation given by Fortun-Lamothe and Sabater (2003). Energy requirement for maintenance was evaluated from metabolic weight of does and from average daily requirements for lactating and pregnant does (470 j / g of metabolic weight, Xiccato, (1998)).

Evaluation of body energy content with TOBEC method. The TOBEC method (total body electrical conductivity) combines a measurement of body conductivity with the animals' weight to estimate their composition. (Fortun-Lamothe *et al.*, (2002)). This technique turns out to be precise for estimating energy content (R^2 = 0.89, CV= 11.5%). TOBEC measurement was recorded at kindling (first, second and third), at insemination (second and third) and at weaning (first and second).

Statistical analyses. Data were analyzed using the General Linear Model (GLM) procedure of SAS® software. Each trait was analyzed separately (i.e without any longitudinal analysis). The only significant effect included in the model was the line effect.

Results and discussion

Reproduction traits. Results of fertility and prolificacy are given in table 1. No significant difference was found in these traits between the two lines. Garreau et al. (2008) did not find either any difference in these traits between the lines for the seven reproductive cycles of all does of the divergent selection experiment (Garreau et al, (2008)).

Table 1: Fertility and litter size per AI in the high line (L+) and the low line (L-)

	L +	L -	Line effect
Fertility (%)	74.7	75.4	NS
Total number born / AI	9.3	9.2	NS
Number born alive / AI	8.5	8.1	NS
Number weaned / AI	6.9	6.3	NS

Statistical significance test: NS = Non significant

Evaluation of energy balance. As shown in table2, the litter weight gain between day 0 and day 21 and, consequently, the energy requirement for lactation, were similar in the two lines, despite a favorable tendency for L+ does. Thus, energy requirement for maintenance were also similar in the two lines because does weights did not differ. These results show that divergent selection for longevity did not affect energy requirement between day 11 and day 21. Energy balance of does was negative in the 2 reproductive cycles because energy requirements are usually higher than energy supply between the 11th and the 21st day of lactation (Fortun-Lamothe (2006)). Nevertheless the energy deficit was significantly lower in

L+ does than in L - does during cycle 1 (-6.10 MJ vs. -8.10 MJ; P<0.05. This result can be explained by the conjunction of energy requirement for lactation slightly lower (-0.28 MJ that is -13 % standard deviation of the trait) and energy supply higher (+ 1.63 MJ that is 33 % standard deviation of the trait) in L+. Nevertheless these components were not significantly different between the lines when analyzed individually.

Table 2: Energy balance and its components between 11th and 21st day of lactation for the 2 first reproductive cycles according to the lines (L+: high longevity line; L- : low longevity line; Std: Standard deviation)

	Variable	N	Std	L +	L -	Difference	Line effect
Cycle 1	Maintenance requirement (MJ)	91	0.72	14.01	14.10	-0.09	NS
	Litter weight gain (g)		332	1878	1903	-25	NS
	Lactation requirement (MJ)		3.63	29.74	30.01	-0.28	NS
	Feed intake (g)		454	3416	3268	148	NS
	Energy supply (MJ)		5.00	37.65	36.02	1.63	NS
	Energy Balance (MJ)		**3.93**	**-6.10**	**-8.10**	**2.00**	*****
Cycle 2	Maintenance requirement (MJ)	89	0.78	14.33	14.47	-0.14	NS
	Litter weight gain (g)		520	2463	2383	80	NS
	Lactation requirement (MJ)		5.68	36.13	35.25	0.88	NS
	Feed intake (g)		505	4193	4162	31	NS
	Energy supply (MJ)		5.57	46.22	45.88	0.35	NS
	Energy Balance (MJ)		**3.41**	**-4.34**	**-3.69**	**-0.65**	**NS**

Statistical significance test: NS =Non significant, * = P<0.05

Evaluation of body energy content with TOBEC method. As shown in figure 1, body energy content was significantly higher in L+ does than in L- does at first and second weaning (41.2 MJ vs. 38.2 MJ and 37.3 MJ vs. 35.0 MJ, respectively), at third AI (39.3 MJ vs. 37.0 MJ) and at third kindling (34.3 MJ vs. 32.0 MJ). In both lines body energy content increased between each kindling and the following AI (from day 0 to day 11) with higher amplitude in L+ line demonstrating a better ability for energy storage. Body energy content decreased then between each AI and the following kindling (from day 11 to day 42). The decrease of body energy content between AI and the following kindling was already described by Fortun-Lamothe (2006) using the same method. The author reported an average mobilization of 22 % of total energy stores during the first lactation, in response to energy requirement. Theilgaard et al. (2007) analyzed the evolution of body stores in breeding does of two Spanish lines (V and LP) from ultrasound measurements of perirenal fat thickness. The authors showed also a mobilization of fat reserves between the 10th day and the 25th day of lactation calculated as the difference in perirenal fat thickness. The deposition of fat reserves was also demonstrated as the gain in perirenal fat thickness from day 1 to day 10 as similarly observed in our study for both lines using TOBEC method.

In the first reproductive cycle, the evolution of body energy content is consistent with the energy balance previously discussed: the larger energy deficit observed in L- between day 11 and day 21 (-8.10 vs. -6.10) is related to a higher fat mobilization between AI (day 11) and weaning (day 28) (-3.08 vs. -1.87). There was no significant difference in both energy balance and energy deficit for the same period in cycle 2.

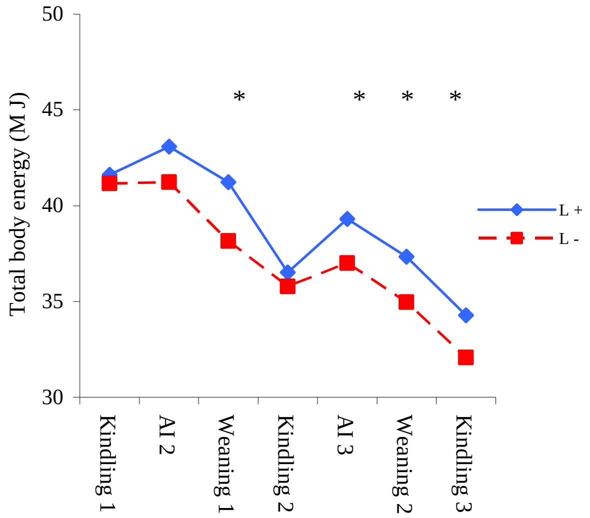

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Figure 1: Body energy content of females according to the lines. (L+: high longevity line; L- : low longevity line; *: P<0.05)

Conclusion

This study provides useful information for a better understanding of the influence of selection for longevity on the ability of females to face energy requirements for reproduction. Higher body energy content in the L+ line after each of the 2 first kindling illustrated a better ability for fat deposition that could explain a better longevity. Nevertheless a better energy balance was demonstrated only during the first reproductive cycle. A study of energy balance on a larger period than between day 11 and day 21, at least including the fat deposition period from day 0 to day 11, may have explained better the difference between lines.

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