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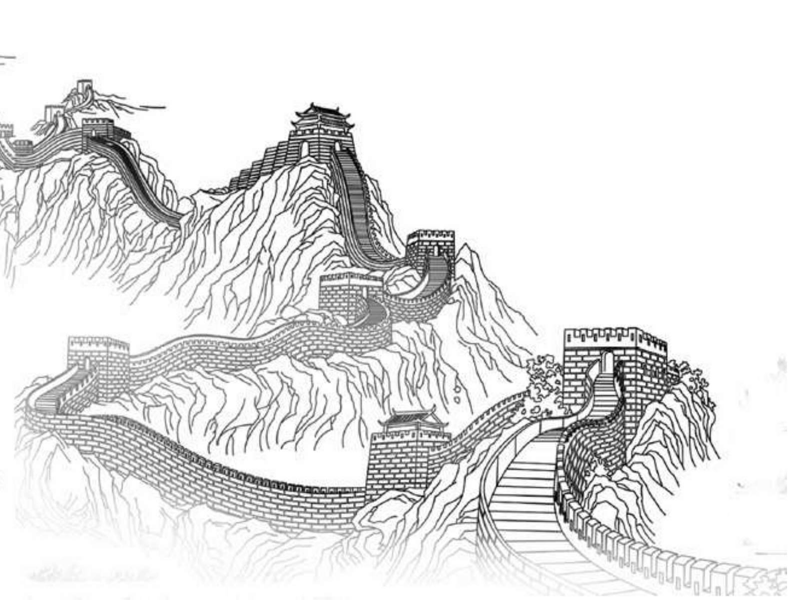

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FEED INTAKE IN REPRODUCTIVE RABBIT DOES: ANIMAL'S VIEW

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ABSTRACT

To study the animal nature of feed intake in multiparous rabbit does and its relations with live weight, 146 multiparous rabbit does with a total of 383 lactations were used. These animals belonged to three (genetic types (GT) that differed greatly on their breeding goals. Permanent correlations among feed intake records at different points of the reproductive cycle were positive but moderate (ranging from 0.4 to 0.7). On the other hand, differences among GT varied throughout the reproductive cycle. Both facts suggest that there are different strategies among animals for resources acquisition. Live weight was highly repeatable (0.797; P<0.001), with negative environmental correlations with feed intake at two points of the reproductive cycle (on av. -0.35; P<0.001), suggesting that animals adapt their intake to defend a kind of 'characteristic weight'. The moderate values of repeatability obtained for feed intake at different points of the reproductive cycle (around 0.4; P<0.001) indicate that theoretically it would be possible to select animals for a greater intake, which has been proposed by some authors as a possible solution to cope with negative balances. However, positive permanent correlations of feed intake with live weight advise that negative side effects would likely appear. Therefore, given the negative side effects and considering that there are animals with different strategies, the goal should not be to get animals with a higher feed intake, the goal should be to obtain animals that adapt their energy intake to their transitory requirements. In such scenario, hyper-functional long-lived criterion may be a more realistic way to achieve this goal.

Key words: Resources acquisition, strategy, permanent correlation, environmental correlation.

INTRODUCTION

Modern breeds have increased litter size, milk production and consequently nutrient requirements. Undesirably, feed intake has not always been increased proportionally and likely it could have compromised body condition or lifespan. To avoid this phenomena, different nutritional strategies have been proposed (increasing the amount or changing the source of energy of the diet), but none of them improved considerably energy intake and many times, when it was reached, energy was only driven to higher milk yield (Lebas and Fortun-Lamothe, 1996; Pascual et al., 1998). On the other hand, it seems that genetics plays a role on energy intake (Savietto et al., 2015). That is the reason why some authors have proposed selection for appetite as a possible solution to cope with this problem (Xiccato et al., 1995; Castellini et al., 2010). However, little is known about the nature of feed intake in the animal (genetic plus permanent environment) and how it is related to other traits such as live weight. An animal's view could help to better understand the results of the nutrition strategies, differences among genetic types and the possible consequences or side effects of selection (Pascual et al., 2013). The aim of this work was to study the feed intake throughout the lactation of different genetic types, the animal nature of feed intake in multiparous rabbit does and its relations with live weight.

MATERIALS AND METHODS

The experiment involved 146 multiparous rabbit does (between the 3rd and the 5th reproductive cycle, RC), with a total of 383 lactations. Three lines (genetic types, GT) of the Institute for Animal Science and Technology of Universitat Poltècnica de València, which differed greatly on their breeding goals, were used. Line H, founded by hyper-proipificacy at birth and selected during 17 generations by litter size at weaning. Line LP, founded by hyper-functional longevity (founder does with more than 25 parturitions and 8.8 born alive on average) and selected during 7 generations by litter size at weaning and characterized by a higher robustness. Line R, founded and selected during 38 generations by average daily gain from 4 to 9 weeks of live. Females were inseminated 11 days after parturition. When they did not get pregnant, they were re-inseminated each 21 days until a maximum of 3 negative palpations. Litters were standardized at birth to 9 and 11 kits. Weaning was performed 30 days after parturition. Diet (11.3 MJ of digestible energy per kg of dry matter and 117 g of digestible protein per kg of dry matter) was offered ad libitum to females at the beginning of their reproductive life. Female's feed intake was recorded from parturition to day 18 of lactation (early lactation, EL), from day 18 of lactation to weaning as female plus litter intake (late lactation, LL) and from weaning to the next parturition (weaning-parturition interval, WPI). Live weight (LW) was studied as the average of weight at parturition, day 18 of lactation and weaning. Available energy for production was estimated discounting the energy for maintenance (430 $kJday^{-1}\,kg^{-1}LW^{0.75}$; Xiccato and Trocino, 2010) from the total digestible energy intake.

For feed intake and available energy, each one of the within RC records was considered as a different trait and records throughout RC as repeated measures of each one of these traits. Feed intake during different periods of the RC and live weight were analysed in a unique four-trait mixed model with repeated measures (SAS, 2009), using the restricted maximum likelihood (REML) to estimate variance components. The model for each single trait was:

$$\boldsymbol{y = GT + RC + T + p + e}$$

where GT, diet and RC are fixed effects, T (inner temperature of the farm) is a covariate and β its coefficient of regression, ***p*** is the permanent random effect of the animal (genetic plus permanent environment; ~$\mathbf{N}$ $(0, \sigma_p)$), and ***e*** is the residual random effect (temporary environment; ~$\mathbf{N}$ $(0, \sigma_e)$) which was assumed to be correlated with other traits but not among RC. Similarly, available energy and live weight were also studied in another multi-trait mixed model. This kind of analysis allows studying, not only the means of the fixed effects, but also the repeatability of each trait and the permanent and environmental correlations among traits within a model.

RESULTS AND DISCUSSION

In Figure 1, it is shown the feed intake during different periods of the RC of the three GT. During EL, LP females had a feed intake 5.3% higher than R females (P<0.05) and 13.7% than H females (P<0.05), whereas R females had a feed intake 7.9% higher than H females (P<0.05). During LL, there was an increase of feed intake records, but it was partially confused with the feed intake of the litter. Anyhow, it seems reasonable that differences among GT during LL would be related to female intake, instead of litter intake. Under such assumption, LP females had an average feed intake (+40.7g; P<0.05) higher than H and R females. During WPI, R animals presented the highest feed intake (+17.1% respect to H and LP females; P<0.05). However, considering the differences in live weight of the animals from the three GT (H 4.03±0.054kg; LP 4.12±0.047kg; R 5.54±0.055kg), the previous result could be related to scale effects. For example, if we try to estimate the available energy for production by discounting energy for maintenance from digestible energy (Figure 1.B), no differences among lines during WPI were found. Moreover, during EL, LP animals continued having the highest available energy for production (*on av.* +23.4% respect to H and R does; P<0.05), but no differences between H and R animals were found. Despite it was not possible estimate available energy during LL (as feed intake was measured as doe plus litter intake), it would be expected that LP animals were the ones with the highest income of energy available and R animals the lowest. Therefore, it seems clear that animals from the three GT present different dynamics of resources acquisition and allocation. On the one hand, LP animals, that have been characterized by a greater ability obtaining resources (Savietto et al., 2015), presented a great appetite only during lactation (which allows obtaining much more resources for production during lactation). On the other hand, R animals, which were assumed to have a great appetite but it was shown only during WPI, used feed intake to maintain their bigger body. These results highlight the need for discriminating between appetite and the ability to get energy for production.

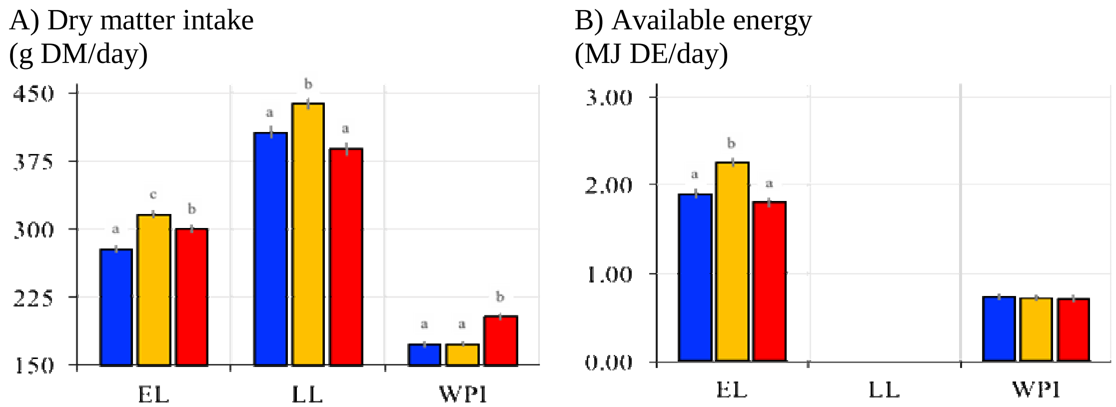

Figure 1. Dry matter (DM) intake (A) and digestible energy (DE) intake minus energy for maintenance (B) of rabbit does at different moments of the reproductive cycle depending on the genetic type (Blue: line H, Golden: line LP and Red: line R). EL: Early lactation, LL: Late lactation (doe + litter), WPI: Weaning to parturition interval. Means in a time control not sharing letter significantly differ at P<0.05.

The permanent effect of the animal, included in the models, is integrated by the genetic and the permanent environment effects (all the external factors affecting to the animal before starting the experiment that had an effect during the experiment). Repeatability is the ratio between the variance of the permanent effect and the total variance (values ranging from 0 to 1). The higher is the repeatability for a trait, the higher is the impact of the effect of animal and therefore more stable are the repeated measures of an animal. In Table 1 it can be observed that repeatability for live weight was quite high (0.797), which means that given a GT, diet and temperature of the farm, a multiparous female will not change very much its weight, because it is little influenced by the temporary environment. Repeatability for all the traits related to feed intake and available energy during different periods of the RC were significantly higher than cero and on average close to 0.4, meaning that the effect of the animal is relevant and therefore strategies such as genetic selection or rearing could impact on it. But it also means that not controlled temporary environment is relevant for the traits.

Table 1. Repeatability (main diagonals), environmental correlations (above the main diagonals) and permanent correlations (under the main diagonals) of feed intake (A) or available energy (B) at different moments of the reproductive cycle and live weight.

	A)				B)		
	Feed			Live	Available energy		Live
	IEL	ILL[1]	IWPI	weight	IEL	IWPI	Weight
IEL	0.436***	0.362***	-0.005	-0.167	0.376***	0.044	-0.298***
ILL[1]	0.711***	0.349***	0.293***	0.041	-	-	-
IWPI	0.500***	0.595***	0.429***	-0.124	0.390*	0.480***	-0.397***
Live weight	0.371***	0.423***	0.443***	0.797***	0.130	0.174	0.798***

IEL: Intake during early lactation, ILL: Intake during late lactation, IWPI: Intake during weaning to parturition interval. * P<0.05, *** P<0.001. [1] Doe+litter intake. – No available data.

Permanent correlations for feed intake among different periods of the RC were big enough to indicate that animals with higher feed intake tend to have a higher intake during the whole RC, but low enough to allow a certain degree of flexibility. Consequently, these correlations show that there were different strategies among animals for feed intake during the RC. On the other hand, permanent correlations higher than cero between feed intake during different periods of the RC and live weight of the females were found (Table 1.A). Contrary, no evidences of these correlations were found between available energy and live weight (Table 1.B). This result suggests that animals with a greater intake not necessarily have more available energy and therefore they could be less efficient. It was also interesting the negative environmental correlations between live weight and available energy, because animals with environmentally higher weight (above its 'characteristic weight') tend to have a lower amount of available energy and *vice versa*. It could suggest that animals tend to maintain a kind of 'characteristic weight', because when they are moved away from it, they adjust the availability of energy to return to the target. Therefore, if we consider that this kind of 'characteristic weight' of the animal is strongly defended, nutritional strategies addressed to improve body condition may have little effect in multiparous does' weight (Lebas and Fortun-Lamothe, 1996; Pascual et al., 1998).

Many times repeatability is related to heritability (repeatability is the theoretical maximum value for heritability before its estimation). However, repeatability and specially correlations (Table 1) are population dependent and thus their values could vary among populations or time, meaning that these considerations about genetic selection should be treated cautiously. Nevertheless, the results of the three genetic types indicate that breeding can change the way animals obtain and allocate resources (Figure 1). If we assume moderately stable repeatability and correlations, these results suggest that theoretically it is possible to select by appetite but likely associated with an increase on live weight of the animals and feed intake in non-productive periods. On the other hand, theoretically it is also possible to select by amount of available energy with less side effects, although another unexpected unfavourable side effects could appear. For example, it is unclear where energy would be allocated when animals with a great amount of available energy have low requirements (such as low litter size or long non-productive periods when not getting pregnant). Therefore, given the negative side effects and considering that there are animals with different strategies for resources acquisition, the goal should not be to get animals with a higher feed intake, the goal should be to obtain animals that adapt their energy intake to their transitory requirements. In such scenario, LP animals have showed the greatest feed and energy intake during lactation but not during WPI, and in previous experiments they have shown a greater ability to regulate energy intake during productive (Theilgaard et al., 2009) or nutritional (Savietto et al., 2013) challenges, indicating that hyper-functional long-lived criterion (LP animals) may be a more realistic way to achieve this goal.

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