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The effects of size of suckled litter on intake behaviour, performance and health status of young and reproducing rabbits

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Abstract — We compared feed intake, performance and health status of females and their young reared in litters of 4 (group L4; *n* = 18) or 10 kits (group L10; *n* = 20) between 16 and 32 days of age. Between days 16 and 25, the individual milk intake was lower (–15.7%; $P = 0.08$) and the solid feed intake per kit was higher (+117%; $P < 0.01$) for the L10 than for the L4 litters. Between days 26 and 32 (weaning), milk and solid feed intake were similar among groups. Live weight of the young was 10% lower in the L10 than in the L4 group at weaning ($P < 0.05$) but was similar in both groups at 70 days of age. Mortality rate around weaning (16–42 days) was higher in the L10 than in the L4 group (29% vs. 17%; $P < 0.05$). Thirty-five days after parturition (day of slaughter), females showed a body condition and reproductive performance (conception rate, ovulation rate and litter size) which were similar in both groups, except for the weight of adipose tissues which was 35.8% lower in the L10 females ($P < 0.01$). These results suggest that the growth and survival of young rabbits are weaker if the rabbits are reared in large-sized litters in spite of an earlier and higher solid food ingestion which only partially compensates for the low milk availability.

mortality / growth / feed intake / milk intake / rabbit

Résumé — **Effets de la taille de la portée allaitée sur le profil d'ingestion, les performances et le statut sanitaire des lapereaux et de leurs mères.** L'objectif de ce travail était d'étudier l'influence de la taille de la portée allaitée sur le profil d'ingestion (lait / aliment solide), les performances et le statut sanitaire des lapereaux et des femelles. Du 16^{e} au 32^{e} jour de lactation (sevrage), les portées ont été égalisées à 4 (lot L4, *n* = 18) ou 10 lapereaux (lot L10, *n* = 20) afin de moduler la disponibilité en lait pour les lapereaux. Les femelles ont été sacrifiées au 35^{e} jour post-partum afin d'étudier l'état corporel et les performances de reproduction. Entre 16 et 25 jours d'âge, l'ingestion individuelle de lait était plus faible (–15,7 % ; $P = 0,08$) et l'ingestion d'aliment sec par lapereau plus élevée (+117 % ; $P < 0,01$) chez les lapereaux du groupe L10. Pendant cette période, l'ingestion totale d'ED (lait + aliment sec) était plus faible dans le lot L10 que dans le lot L4 (2,15 MJ vs. 2,42 MJ ;

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P < 0,05). L'ingestion de lait, d'aliment solide et d'énergie n'étaient pas significativement différente entre les 2 lots entre le 26e et le 32e jour de lactation. Au sevrage les lapereaux L10 étaient plus légers que les lapereaux L4 (–10 % ; P < 0,05), mais à 70 jours d'âge le poids vif des lapereaux était similaire dans les 2 lots. La mortalité était plus élevée dans le lot L10 que dans le lot L4 durant la période qui entoure le sevrage (16–42 jours d'âge ; 29 % vs. 17 % ; P < 0,05). À l'abattage, l'état corporel des femelles était similaire dans les 2 lots, excepté le poids des tissus adipeux qui était plus faible chez les femelles L10 (–35,8 % ; P < 0,01). Les performances de reproduction pour la seconde gestation (taux de gestation, nombre d'ovules pondus et taille de portée) n'ont pas été affectées par le traitement expérimental. Ces résultats suggèrent que les lapereaux élevés dans des portées de grande taille compensent la faible disponibilité en lait par une ingestion d'aliment solide plus précoce et plus élevée. Toutefois, cette compensation ne permet pas une croissance optimale des lapereaux et est associée à une mortalité plus élevée durant la période qui entoure le sevrage.

mortalité / croissance / ingestion de lait / ingestion d'aliment / lapin

1. INTRODUCTION

Digestive disorders are frequently observed in rabbit breeding around weaning (21–42 days of age). These disorders are supposed to be due to an incomplete maturation of the digestive processes (either from caecal flora or from host) at the time of weaning [9]. Therefore, factors able to influence the maturation of digestive capacity in the rabbit before weaning, and their relationship to performance and health status, before and after weaning, need to be better known.

In most species, evolution of digestive capacity before weaning seems to be mainly determined by ontogenic factors (rats: [12]; piglets: [31, 8]; rabbits: [3, 5, 15, 38]). However, dietary changes before weaning may influence some digestive enzyme activities [31].

The influence of dietary factors before weaning on the development of digestive processes [15] and performance of rabbits after weaning [16] have been poorly studied in the rabbit. Previous results have suggested that an earlier intake of solid feed may improve the maturation of the digestive process and may result in decreased post-weaning mortality [20]. However, these results need to be confirmed.

Rabbit does can be mated immediately after parturition and throughout lactation. As a general rule, however, fertility and prolificacy are lower in lactating than in non-lactating females [7, 37]. But, the effect of intensity of lactation, i.e. the number of suckling young, on reproductive performance was poorly studied. Additionally, Fortun and Lebas [6] showed that mobilisation of body reserves during lactation is correlated to the number of kits nursed. A large depletion of body stores could be detrimental to subsequent reproductive life. Therefore, it seems interesting to study the effect of the number of suckling young on the survival of females and their reproductive performance at the following parturition.

The aims of this experiment were to study (1) the influence of milk availability (modulated by litter size) on the introduction of solid feed intake before weaning; (2) the relationships between feed intake pattern (milk and solid feed) before weaning, and performance and health status before and after weaning; (3) the influence of feeding pattern before weaning on digestive capacity after weaning; and (4) the consequences of modification of litter size on reproductive performance and body composition of females at the end of lactation.

2. MATERIALS AND METHODS

2.1 Animals and controls

To modulate the milk/feed intake pattern before weaning, thirty-eight litters (equalised to ten young per litter at birth, day 0) were subjected to low or high availability of milk, through a variation in litter size: on day 16, 18 litters were reduced to 4 pups per litter (L4 group), while the others were maintained at ten per litter (L10 group). Until the 16th day of lactation, the litter size was maintained constant (10 young) by the replacement of each dead rabbit. In the L4 group, we kept rabbits with either low, middle or high live weight in order to maintain live weight variability. For each litter, kits were sorted according to their weight at day 16 and the young rabbits of rows 2, 4, 7 and 9 were preserved. After day 16, the dead rabbits were not replaced. Litters were obtained from primiparous hybrid females (INRA strain A2066 × A1077) and males of a commercial line (Hyplus). The milk intake of suckling rabbits was measured individually at 16, 22, 25, 29 and 32 days of age, by weighing the kit before and after suckling.

To measure the solid feed intake of the litters before weaning, without separating the young from their mothers, cages were equipped with wire separations (on day 16) allowing only the passage of the young, thus creating a space reserved for them. From day 16 until weaning (day 32) a maternal commercial feed (Tab. I) was distributed ad libitum to the young in a specific feeder (located in an area reserved to the young), and to the females in feeders not accessible to the young. Solid feed intake of the litters was measured every two days from 16 days of age until weaning. After weaning, young from only 27 litters were randomly distributed into individual cages (n = 134 and 46 in L10 and L4 groups, respectively) for fattening up to 70 days of age (insufficient number of individual cages for all the young). They were fed an experimental diet (Tab. I) meeting recent nutritional recommendations [1, 10]. After weaning, feed intake was controlled weekly up until 70 days of age. Young rabbits were weighed at birth and at 16, 22, 25, 29, 32 days and weekly from weaning to 70 days of age. To study the influence of live weight on milk intake, we divided rabbits into three equal classes according to their live weight at day 16 (Light, L: [70–179 g]; Medium, M: [180–216 g]; Heavy, H: [218–320 g]).

Table I. Ingredients and chemical composition of feeds given to females and litters, or to growing rabbits after weaning.

Diets	Females and litters**	Growing rabbits
Ingredients		
Barley		10.00
Wheat		10.00
Soyabean cake		6.00
Sunflower cake		12.00
Lucerne meal		25.00
Dehydrated beet pulp		10.00
Wheat bran		20.35
Beet molasses		5.00
Mineral and vitamin mixture*		1.65
Chemical composition (% DM)		
Dry matter	89.4	90.2
Organic matter	90.1	91.6
Crude Protein (N*6.25)	19.2	19.7
Starch	14.2	19.1
N.N.C.C£	36.6	40.1
N.D.F.	34.3	31.8
A.D.F.	17.7	18.3
A.D.L.	4.3	4.6
Digestible energy ($MJ \cdot kg^{-1}$ DM)	11.6†	12.6‡
Digestible proteins ($g \cdot kg^{-1}$ DM)	133†	154‡

£: Non nitrogenous cellular content (OM – NDF – CP).
* Bicalcium phosphate –0.10%; Calcium carbonate –0.30%; Minerals, vitamins and salt–1.00%; DL_{40} Methionine –0.25%; Robenidine (66 ppm).
** Commercial feed, proximate ingredient composition (cereals 11%, vegetable protein source 30%, fibre source 52%, molasses 4%, minerals and vitamins 4%).
† Calculated according to Villamide and Fraga [39].
‡ Measured (see Scapinello et al. [33]).

Mortality was controlled daily from day 16 to day 70, while symptoms of digestive problems were controlled twice a week during this period. Morbidity was defined as visible digestive disorders (signs of diarrhoea) and/or severe disturbance in feed intake or growth assessed through a weekly control of intake and growth. The sanitary risk index (%) corresponds to the sum of mortality and morbidity rates for a given period. To study the influence of live weight at weaning on mortality during the growing period, we divided rabbits into three equal classes according to their live weight at day 32 (Light, L: [270–536 g]; Medium, M: [540–697 g]; Heavy, H: [700–1008 g]).

Whole tract digestibility of major nutrients of the feed was measured in two groups of 12 rabbits each (L4, L10), during two periods (42–46 and 56–60 days of age) according to the European reference method [28].

Digestible energy and protein intake before weaning were calculated from digestible energy and protein of milk and solid feed, based on the following results. The digestibility of milk was considered equal to 100% [24] and the energy and protein content of the rabbit milk were considered equal to 7.75 $kJ \cdot g^{-1}$ fresh weight, 9.84 $kJ \cdot g^{-1}$ fresh weight and 10.3 $g \cdot 100\ g^{-1}$ fresh weight and 14.3 $g \cdot 100\ g^{-1}$ fresh weight, during the 3rd and the 4th week of lactation, respectively [23]. The digestible energy and protein content of the feed are reported in Table I.

Females were presented to the male on day 10 post-partum and were slaughtered on day 35 post-partum in order to study body composition and reproductive performance. Ovulation rate was determined by counting the number of corpora lutea. Foetuses, divided into live and dead foetuses, were counted. Does were dissected in order to weigh carcass, skin, full digestive tract, full uterine tract, dissectable adipose tissues, liver, kidneys and heart plus lungs. Body whose guts were removed, defined as carcass plus skin plus adipose tissues plus liver plus kidneys plus heart plus lungs, represented the body condition of females. Feed intake and live weight of females were measured each week from parturition to slaughter, and on the days of mating and weaning.

2.2. Statistical analyses

The results were subjected to analysis of variance according to the general linear model procedure of the Statistical Analysis System [32]. For data concerning the growth and consumption of young after weaning, the group effect (L4 of L10) was the main effect included in the statistical model. All results included data from both healthy and unhealthy animals. To analyse data concerning the females, feed and energy intake of the litters before weaning, experimental group, diagnosis of gestation (pregnant or not) and the interaction between group and gestation were included as fixed effects in the model. Interaction between group and gestation was found to be non-significant. To analyse live weight and milk intake of suckling young, the mother effect (error to test the group and the gestation effects) was added to the previous model. Additional analyses of milk intake on day 16 were made using live weight (classes L, M or H) and the mother effect as fixed effect. Chi-square test was used to test the group effect on mortality and morbidity.

3. RESULTS

3.1. Feed intake pattern and growth performance of young before and after weaning

The weights of young rabbits at birth (48.8 g) and on day 16 (199.1 g), as well as their milk intake on day 16 (25.2 g per rabbit), were similar in both groups. On day 16, 8.9% of the rabbits consumed less than 5 g of milk (see Fig. 1), and individual milk

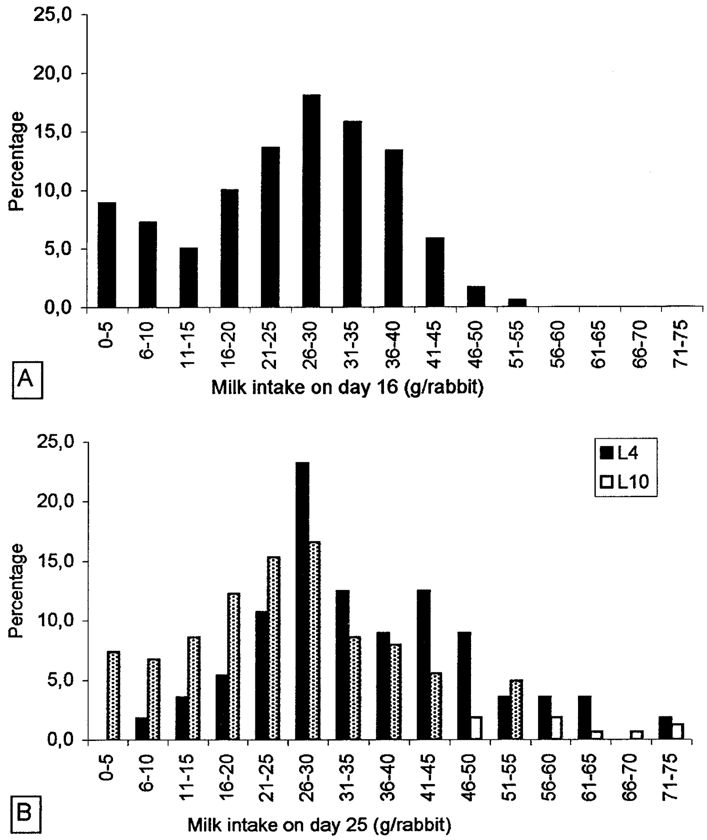

Figure 1. Distribution curve of milk intake, before modification of the litter size on day 16 (**A**), and according to experimental group on day 25 (**B**).

intake was related to live weight: low live-weight rabbits (70–179 g) consumed less milk than rabbits with a medium or high (> 179 g) live weight (20.6 g vs. 27.2 g; $P < 0.001$). On day 25, 7.4% of the L10 rabbits ingested less than 5 g of milk while all the L4 rabbits ingested at least 10 g of milk (mean milk intake on day 25: 26.5 g per rabbit and 35.5 g per rabbit in groups L10 and L4).

Between days 16 and 25, individual milk intake was 15.7% lower ($P = 0.08$) and solid feed intake per kit was 117% ($P < 0.01$) higher in the L10 group than in the L4 group (see Tab. II). On day 21, rabbits consumed more than 2.5 g per day per rabbit in 10 of the 20 litters in group L10, compared to two of the 18 litters in group L4 ($P = 0.01$). In the same way, on day 25, a feed intake higher than 5 g per day per rabbit was reached in 85% of the L10 litters (17/20) against 44% of the L4 litters (8/18; $P < 0.01$). Between days 26 and 32 (weaning), the difference between L10 and L4 groups in terms of milk (–25.3%) and solid feed intake (+22.9%) were not significant. Over the whole period (day 16 to day 32), solid feed intake reached 202 g per kit for L10 and 128 g per kit for L4 rabbits ($P < 0.05$).

The total DE intake between days 16 and 25 of lactation (milk + solid feed) was 11.2% lower in the L10 than in the L4 group

Table II. Daily weight gain (DWG), milk, feed, energy and protein intake between days 16 and 32 (weaning) according to litter size.

	L10	L4	SEM	Pr > f
Number of litters	20	18		
Milk Intake (g per rabbit per period)				
days 16–25	237.6	282.0	6.4	0.08
days 26–32	126.3	169.0	4.7	NS
Feed Intake (g per rabbit per period)				
days 16–25	27.4	12.6	2.2	0.003
days 26–32	175.7	143.0	9.7	NS
Digestible energy intake (MJ per rabbit per period)				
From milk				
days 16–25	1.85	2.23	0.07	0.016
days 26–32	1.24	1.64	0.08	0.05
From feed				
days 16–25	0.30	0.14	0.02	0.001
days 26–32	1.80	1.52	0.09	0.24
Digestible proteins intake (g per rabbit per period)				
From milk				
days 16–25	24.6	29.6	0.95	0.016
days 26–32	18.0	23.9	1.22	0.05
From feed				
days 16–25	3.4	1.6	0.23	0.001
days 26–32	20.6	17.4	1.04	0.24
Live weight (g)				
day 16	200	198	2.1	NS
day 25	325	390	4.7	0.0007
day 32	595	661	8.3	0.048
DWG ($g \cdot d^{-1}$)				
days 16–25	13.6	21.3	0.4	0.0001
days 26–32	38.6	38.2	0.8	NS

NS: $P > 0.20$.

(2.15 MJ per kit vs. 2.42 MJ per kit; $P < 0.05$). During this period, 92.1% of the DE intake came from milk in the L4 group against 86.0% in the L10 group (see Tab. II). From 26 to 32 days of age, the total DE intake was similar in the two groups (3.04 MJ vs. 3.06 MJ; NS), but 40.8% of the DE intake originated from milk in the L10 group against 53.6% in the L4 group. During the whole period (days 16–32 of lactation), the total DE intake was 4.7% lower in the L10 compared to the L4 group (5.12 MJ vs. 5.37 MJ), but the difference was not significant. Similar trends were observed as regards digestible protein intake. From day 16 to 32, the total protein intake (milk + solid feed) was 7.4% lower in the L10 than in the L4 group (68.9 g vs. 74.4 g; NS) During the whole period, 75.1% of the intake came from milk in the L4 group against 65.1% in the L10 group.

From 16 to 25 days of age, the daily weight gain (DWG) was 36.2% lower for suckling rabbits in the L10 than in the L4 group ($P < 0.0001$). In contrast, from day 25 until weaning, DWG was similar in both groups (38.4 $g \cdot d^{-1}$; see Tab. II). However, at weaning, young rabbits were 10% lighter in the L10 than in the L4 group ($P < 0.05$).

After weaning, the feed intake was not significantly different among the two groups (see Tab. III). Average DWG was slightly higher in the L10 compared to the L4 group (42.2 vs. 40.8 $g \cdot d^{-1}$ from day 32 to day 70, respectively). Even if this difference was not significant, L10 rabbits which were 100 g lighter than L4 rabbits at day 42 (903 g vs. 1002 g) reached a similar live weight at 70 days of age in both groups (2217 g vs. 2248 g in L10 and L4 group, respectively). The feed conversion ratio was similar in the two groups between day 32 and day 70 (see Tab. III).

Whole tract digestibility remained similar among the 2 groups, except crude protein digestibility which tended to be lower in L10 rabbits than in L4 rabbits, either at 44 and 58 days of age (see Tab. IV). Besides, digestibility significantly decreased between 44 and 58 days of age for major nutrients, without interactions with litter size effect.

3.2. Mortality and morbidity of young

Before weaning, morbidity and mortality remained low (< 10%) and sharply increased after weaning, particularly between 32 and 42 days of age (see Tab. V). If we consider the period around weaning (day 16 to day 42), the sanitary risk index was higher in the L10 than in the L4 group (38% vs. 24%; $P < 0.05$). This can be explained by a higher mortality rate in the L10 group (29% vs. 17%; $P < 0.05$) during this period, while morbidity rate was low (< 10%) and similar among the two groups throughout the experiment. By and large, the sanitary risk index was relatively high after weaning, reaching 47% and 37% for the L10 and L4 group, respectively. During the growing period (32–70 days of age) and for both groups,

Table III. Daily weight gain (DWG), and feed intake between days 33 and 70 according to litter size during lactation.

Group	L10	L4	SEM	Pr > f
Number of rabbit	134	46		
Feed intake ($g \cdot d^{-1} \cdot kg^{-0.75}$)				
days 33–42	77.6	78.1	1.4	NS
days 43–70	76.0	74.4	0.6	NS
Live weight (g)				
day 32	598	676	10.9	0.001
day 42	903	1002	18.7	0.007
day 70	2217	2248	35.2	NS
DWG ($g \cdot d^{-1}$)				
days 33–42	30.1	32.3	1.2	NS
days 43–70	45.9	43.1	0.9	NS
Feed conversion ratio				
days 33–42	1.94	1.66	0.5	NS
days 43–70	2.37	2.57	0.04	NS

NS: $P > 0.20$.

Table IV. Whole tract digestibility of experimental feed (growing), measured on 44- and 58-day-old rabbits previously maintained in litters of four (L4) or ten rabbits (L10).

	Group		Age			Pr > f	
	L10	L4	44 days	58 days	SEM	Group	Age
Digestibility coefficients (%)							
Organic matter	69.6	69.3	70.7	68.1	0.52	NS	< 0.01
Crude protein	76.3	74.7	78.2	72.5	0.77	0.07	< 0.01
NDF	32.6	32.7	34.5	30.7	1.02	NS	< 0.01

Interaction between group and age effect was not significant.
NS: $P > 0.20$.

Table V. Mortality and morbidity rates from day 16 to day 70, according to litter size during lactation.

	L10	L4	Pr > f
Mortality rate % (n)			
16–32 days	8.0 (16 / 200)	5.6 (4 / 72)	NS
33–42 days	20.9 (28 / 134)	10.9 (5 / 46)	0.13
43-70 days	15.7 (21 / 134)	17.4 (8 / 46)	NS
Morbidity rate % (n)			
16–32 days	2.0 (4 / 200)	0 (0 / 72)	NS
33–42 days	7.5 (10 / 134)	6.5 (3 / 46)	NS
43–70 days	3.0 (4 / 134)	2.2 (1 / 46)	NS
Sanitary risk index % (n)			
16–32 days	10.0 (20 / 200)	5.6 (4 / 72)	NS
33–42 days	28.4 (38 / 134)	17.4 (8 / 46)	0.14
43–70 days	18.7 (25/ 134)	19.6 (9 / 46)	NS

NS: $P > 0.20$.

mortality was significantly higher for rabbits whose live weight is low at weaning (50% vs. 27% of mortality in rabbits of L or M + H class, respectively; $P < 0.01$). In the L10 group, mortality between days 32 and 70 decreased proportionally with mean live weight at weaning (49%, 33% and 28%, in rabbits of L, M and H class, respectively; $P < 0.05$).

3.3. Feed intake and performance of females

The total milk production between days 16 and 32 of lactation was twice as high in females in the L10 group as in L4 females (3436 g vs. 1788 g; $P < 0.0001$).

Before day 16, the feed intake of females was similar in the two groups (see Fig. 2). In contrast, after modification of litter size (from day 21 to day 32), L10 females consumed 15.0% more feed than L4 females (364 vs. 316 g·day^{-1}; $P < 0.05$). During the 3 days before weaning and slaughter (days 33–35), feed intake was 19.8% higher in the L10 group ($P < 0.001$). Live weight of females was similar in the two groups throughout the experiment. At slaughter (on day 35 post-partum) the body condition of females was similar in both groups, except

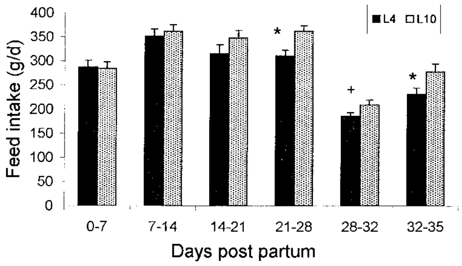

Figure 2. Evolution of female feed intake during lactation according to litter size. Values are means ± standard error of the mean (SEM). Within period, means differed significantly at the level $P < 0.1$ (+) or $P < 0.05$ (*).

for the weight of adipose tissues which was 35.8% lower in the L10 females ($P < 0.01$). Reproductive performance during the second gestation was not affected by the experimental treatment (see Tab. VI).

4. DISCUSSION

4.1. Performances of young before weaning

A drastic reduction of the litter size on day 16 of lactation led to a decrease of milk production by the doe and an increase of milk availability for suckling young. This is in agreement with Lebas [13, 14] and McNitt and Lukefahr [17] who showed that milk production increases with the number of suckling rabbits, but individual milk intake decreases. On days 16 and 25 of lactation, 8.9% and 7.4% of the rabbits from litters of 10 young ingested less than 5 g of milk. This clearly exhibits the great competition within a litter of ten for access to the udders. Since suckling occurs only once a day in rabbit species [40], these young rabbits will have to wait one day for the next one suckling.

Up until the age of 16 days, suckling rabbits exclusively consumed milk. They began to eat solid feed at around 18–20 days of age, and consumption became significant at around 22–23 days of age, in accordance with Maertens and De Groote [21]. At weaning, precisely at 32 days of age, rabbits ate 32 g per day per rabbit, in agreement with Szendrö et al. [35] and Scheele and Bolder [34]. The total solid feed intake before weaning was 180 g per rabbit, in agreement with De Blas et al. [4] and was 58% higher for litters of ten compared to litters of four.

Table VI. Body composition and reproductive performance of females at slaughter on day 35 post-partum.

	L10	L4	SEM	Pr > f
Number of does	20	18		
Body composition				
Empty body (g)[†]	2 995	3 065	50	NS
Carcass (g)	2 105	2 160	38	NS
Skin (g)	657	658	14	NS
Full digestive tract (g)	523	508	12	NS
Dissectable adipose tissue (g)	43	67	4	0.003
Liver (g)	144	138	4	NS
Reproductive performance				
Conception rate (%)	70.0	61.1	–	NS
Ovulation rate	13.1	12.3	0.3	NS
Total foetuses	11.5	11.5	0.4	NS
Live foetuses	11.1	10.9	0.4	NS

NS: $P > 0.20$.
[†] Empty body = carcass + skin + adipose tissues + liver + kidneys + heart + lungs.

The young from large-sized litters compensated for the lower milk availability by an earlier solid feed intake (3 days before) and a higher (+117%) solid feed intake during the 10 days following the modification of litter size. This is in agreement with the results of Maertens and De Groote [20] and Szendrö et al. [35], showing a higher feed intake for litters from does fertilised at post-partum mating and eating less milk than litters from non-fertilised does. However, the higher solid feed intake during this period did not ensure a similar total (milk + solid feed) digestible energy and protein intake, which were lower in litters of ten than in litters of four. This lower digestible energy and protein intake explain the lower DWG and thus the lower live weight of L10 rabbits at 25 days of age. From day 16 till day 25 of lactation, the differences among both groups was 11% for DE intake while it was 36% for DWG. This suggests an underestimation of differences in energy intake. Milk composition, which was supposed to be similar in the two groups for the calculation of DE from milk, may have been affected by the sudden modification of the size of the suckled litter. These hypotheses remained to be established.

From day 25 to day 32, the difference in feed intake among the two experimental groups was weaker (+23%) and not significant. Similar digestible energy and protein intake (milk + solid feed) were recorded during this period, leading to similar DWG among both groups. However, due to the delay of growth observed between days 16 and 25, the live weight of rabbits at weaning was lower in litters of ten. This is in agreement with results of Cervera et al. [2] and Szendrö et al. [36] who observed an inverse relationship between litter size and weaning weight. In the same way, McNitt and Moddy [18] reported a higher weaning weight in pups which consumed more milk during lactation.

4.2. Performance and health status of young after weaning

Ontogenic changes in digestive capacity before weaning, including gastro-intestinal changes and enzyme secretion, are little dependent on dietary factors, as observed for glucidic digestion in rats [12], piglets [8, 31] or young rabbits [33]. However, as mentioned by Sangild [31], dietary changes before weaning may influence the plateau levels of enzyme activities. The present results showed that the modification of the milk/solid feed intake pattern before weaning did not affect the overall post-weaning feed digestion just after weaning or during the fattening phase. Similarly, with data from the same experiment, Scapinello et al. [33] demonstrated that the feeding behaviour before weaning did not affect the post-weaning intestinal capacity to degrade starch or maltose. However, crude protein digestion tended to be lower in rabbits reared in litters of ten. That may be explained by changes in proteolytic enzyme secretion, or by a differential maturation of the intestinal mucosa. Further studies are thus necessary to more deeply explore maturation and the factors affecting digestive capacity in young rabbits around weaning. The present results showed that, after weaning, feed digestion decreased with age, in agreement with Gidenne et al. [11] or Maertens and De Groote [19].

The rabbits reared in litters of four maintained a higher live weight than rabbits reared in litters of ten from weaning up until 42 days of age. At that time, the live weight difference between both groups reached 100 g. After 42 days of age, a compensatory growth occurred in L10 rabbits which, although non-significant, led to a similar live weight in both groups at 70 days of age.

The period around weaning seems to be a key period for survival of growing rabbits. During this period, mortality was significantly higher in rabbits reared in litters of ten, more particularly during the 10 days following weaning, when mortality was twice as high in this group. This could be explained by the lower live weight of rabbits at weaning in this group, since we found a higher mortality during the fattening period in rabbits with a low live weight at weaning. More particularly, in the L10 group, mortality decreased proportionally with the mean live weight at weaning. This is in agreement with results of Morisse [22] showing that the mortality rate is inversely related to the weight of rabbits at weaning. On the contrary, Perez et al. [26, 27] and Rémois et al. [30] observed no effects of weaning weight on mortality during the fattening period. Besides, we cannot exclude the possibility of a harmful impact of the lower milk intake in rabbits with a large litter size on mortality. Indeed, rabbit milk is known to present a bacteriostatic effect, due to a high content of middle chain triglycerides [29], that may favour the resistance of young against pathogenic agent.

4.3. Performances of females

During lactation, nutrient requirements are very high and feed intake increases to supply needs for milk production. After modification of the size of the suckled litter, feed intake was higher in females lactating the larger litter. This is in agreement with the results of Lebas [14] showing that feed intake is correlated to the size of the suckled litter. However, the increase of feed intake which occurs during lactation is generally insufficient to supply the needs for milk production and the mobilisation of body reserves is necessary to meet the nutritional deficit [25]. The present results showing lower-weight adipose tissues in does that fed litters of ten compared to those that fed litters of four demonstrated that the extent of lipid mobilisation increases with the size of the suckled litter. This is in agreement with previous results obtained in primiparous does [6]. We can mention that the abrupt reduction of litter at the moment of the lactation peak did not involve pathological problems such as mastitis.

Our results did not demonstrate any effect of the number of suckling rabbits on the percentage of dead or eliminated does, nor on the reproductive performance of females during the second pregnancy, observed at the middle of gestation. These results suggest that neither a sudden modification of litter size after fertilisation nor the greater mobilisation of body reserves that occurred when does nursed large litters had a negative influence on the first half of pregnancy. The effects of the suckled litter size, modified in such conditions, on reproductive performance at second kindling, remain to be studied since Fortun and Lebas [6] previously showed that foetal growth and survival are linearly affected with the size of the suckled litter.

5. CONCLUSION

These results demonstrated that a drastic reduction of litter size in the middle of lactation involved greater milk availability for the suckling rabbits. Young from large-sized litters compensated for the lower milk availability by an earlier and a higher solid feed intake before weaning. However, this compensation did not make optimal growth possible and was associated to a higher mortality rate of young around weaning. Present data also confirm that a higher litter size reduces lipid body reserves.

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