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INFLUENCE OF SOLID FEED INTAKE AND AGE AT WEANING ON CAECAL CONTENT CHARACTERISTICS AND POST-WEANING PERFORMANCE

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ABSTRACT : This study examined the effects of the feed/milk ratio at weaning time on caecal content characteristics at weaning and on post-weaning performances. Twenty-seven primiparous New-Zealand White does were used in this study involving with standardized litters of 8 kits at birth and a minimum of 7 kits alive at weaning. During lactation, all does were mated and fertilized 12 days after kindling. Litters were caged separately from their mother and fed according to the following scheme: Group A (n = 8), litters fed *ad libitum* and weaned at 35 days; Group B (n = 10) litters fed 60% *ad libitum* and weaned at 35 days; Group C (n = 9) litters fed *ad libitum* and weaned at 30 days. At weaning one animal per litter was slaughtered to study caecum characteristics, while 50 other rabbits per group were raised during 5 weeks in cages of 2 rabbits in order to evaluate post-weaning performance. At weaning, litters of Group A, besides weighing more (6141, 4693 and 4729 g in Groups A, B and C, respectively), showed as expected the highest feed/milk intake ratio (8.35, 4.05 and 1.53; P < 0.01, in Groups A, B and C, respectively). At weaning, caecal content of Group A rabbits recorded a lower pH (5.67, 6.40 and 5.97, P < 0.01, in Groups A, B and C, respectively), a lower concentration of ammonia (7.3, 10.1 and 9.5 mMol/l in Groups A, B and C, respectively) and a lower C_3 proportion in VFA (5.8, 9.5 and 10.2% in Groups A, B and C, respectively). Group A also,had the highest levels of total volatile fatty acids (57.4, 51.2 and 46.0 mMol/l in the A, B and C Groups, respectively). During the fattening period, rabbits of Group A showed a higher feed intake (127, 115 and 100 g/d, P < 0.01, in Groups A, B and C, respectively) and a poorer food conversion ratio (3.50, 3.12 and 2.78 in Groups A, B and C, respectively). Weaning age also exerted some specific effects, for example, on caecal content weight or post-weaning daily growth rate (36.5 g/d for C rabbits weaned at 30 days and 38.2 for B rabbits weaned with the same live weight but at 35 days; P<0.05). In conclusion, the feed/milk intake ratio at weaning influenced some characteristics of caecal contents and some post-weaning performances of rabbits.

RÉSUMÉ : **Influence de l'ingestion d'aliments solides et de l'âge au sevrage sur les caractéristiques du contenu cæcal et sur les performances de croissance des lapins après sevrage**. L'objet de ce travail est d'étudier l'influence du rapport aliment solide/ lait au moment du sevrage, sur les caractéristiques du contenu cæcal au sevrage et sur les performances de croissance des lapereaux. Vingt sept lapines primipares Néo-Zélandais Blanc ont été utilisées dans cette étude. Les portées ont été égalisées à 8 lapereaux à la naissance. Les lapines ont toutes été fécondées 12 jours après la mise bas et ont sevré au moins 7 lapereaux. Pendant la période d'allaitement, les portées, logées dans une cage différente de celle de leur mère, ont été réparties selon le schéma suivant : groupe A 8 portées alimentées à volonté et sevrées à 35 jours; groupe B 10 portées restreintes à 60% de la consommation du groupe A et sevrées à 35 jours; groupe C avec 9 portées alimentées à volonté et sevrées à 30 jours. Au sevrage, un lapereau par portée a été sacrifié pour étudier les caractéristiques du cæcum. Cinquante autres lapins par groupe ont été placés à raison de 2 par cage et engraissés pendant 5 semaines. Au sevrage les portées du groupe A étaient les plus lourdes : 6141g contre 4693 et 4729 g pour les groupes B et C. Elles avaient aussi le jour du sevrage le ratio aliment sur lait le plus élevé : 8,35 *vs* 4,05 et 1,53 (P < 0.01) pour les groupes B et C respectivement. Le pH cæcal était plus bas pour les lapins du groupe A : 5,67 *vs* 6,40 et 5,97 pour ceux des groupes B et C. Toujours dans le même ordre, le taux d'ammoniac des 3 groupes était le plus faible (P<0,01) pour les lapins du groupe A : 7,3 *vs* 10,1 et 9,5 mMol/l. Ce groupe A avait aussi la plus faible proportion molaire de C_3 parmi les acides gras volatils (AGV) : 5,8 *vs* 9,5% et 10,2% pour B et C. Enfin, chez les lapereaux du groupe A, le contenu cæcal avait aussi le taux d'AGV totaux le plus élevé : 57,4 vs 51,2 et 46,0 mMol/l pour ceux des groupes B et C. Au cours des 5 semaines d'engraissement, la plus forte ingestion alimentaire a été observée dans le groupe A :127 *vs* 115 et 100 g/jour pour B et C (P<0,01), de même que le plus mauvais indice de consommation : 3,50 *vs* 3,12 et 2,78 pour B et C. En conclusion, il apparaît clairement que le ratio aliment solide/lait constaté au moment du sevrage influence un certain nombre de caractéristiques du contenu cæcal ou de critère de la croissance post-sevrage. Toutefois l'âge au sevrage exerce aussi des effets propres, par exemple sur le poids du contenu cæcal ou sur la vitesse de croissance post-sevrage : 36,5 g/j pour le lot C sevré à 30 jours, contre 38,2 g/j pour les lapins des groupes B sevrés au même poids vif, mais à 35 jours (P<0,05)

INTRODUCTION

Young rabbits begin to consume solid feed around 3 weeks of age (MAERTENS and DE GROOTE, 1990; SCAPINELLO *et al.*, 1999). Intake increases rapidly with age and may be affected by milk availability. Rabbits that have less milk available compensate with a higher intake of solid feed (SZENDRÖ *et al.*, 1985; SCAPINELLO *et al.*, 1999; PASCUAL *et al.*, 2001). In this respect, SCAPINELLO *et al.* (1999) reported, from day 16 until weaning (32 d), that solid intake was 62% higher in litters with 10 kits than in litters with 4 kits (207 and 128 g, respectively). PASCUAL *et al.* (2001) also observed from the 21st to 28th day of the suckling period a higher solid feed intake (17 and 13 g/day, respectively), in young rabbits that consumed less milk (14 and 20g/day, respectively). In this study, rabbits with a higher pre-weaning intake of solid feed had a lower mortality rate (7.7 and 17.6%) during the following fattening period. Lower mortality in the post-weaning period was also observed by MAERTENS and DE GROOTE (1990) in rabbits showing earlier solid feed intake, probably due to improved maturation of the digestive process. According to LAPLACE (1978) or GIDENNE and PEREZ (1993) a lack of digestive maturation and a poor feed intake pattern (quality and quantity) may be the cause of the digestive disorders frequently observed during the post-weaning period. In

Table 1 : Composition and digestibility of the pelleted feed used for does and for litters

Nutrients (g/kg as fed)	**Does diet**	**Litters diet**
• NDF	306	322
• ADF	185	210
• ADL (lignin)	41	45
• Crude proteins	175	148
• Digestible energy (MJ/kg)	10.4	9.8
Digestibility coefficients (%)		
- organic matter	65.6	63.8
- proteins	73.2	72.1
- energy	65.8	64.0

this respect, PADILHA *et al.* (1996) suggested that evolution of the caecal microbial activity plays an important role in the development/control of enteritis after weaning. However, regardless of when solid feed intake begins, it might be useful to obtain information on the quantity of solid feed intake close to weaning and the milk/solid feed intake ratio at the same time. This study aimed to measure the effects of the milk-to-feed ratio at weaning on caecal content characteristics at that time and on post-weaning performance.

MATERIAL AND METHODS

Twenty-seven primiparous New-Zealand White does were used in this study involving standardized litters of 8 kits at birth and a minimum of 7 kits alive at weaning. All does were mated and fertilized 12 days after kindling. Litters were caged separately from their mother.

Litters were distributed in 3 groups according to the following scheme: Group A (n = 8) litters fed *ad libitum* and weaned at 35 days; Group B (n = 10) litters fed 60% of the *ad libitum* (by a daily intake control of A Group) and weaned at 35 days; Group C (n = 9) litters fed *ad libitum* and weaned at 30 days when they reached the same daily solid feed intake as Group B at 35d of age. The feed distribution in Group B litters was restricted on the basis of average daily feed intake per kg live weight of Group A litters. Thus, the various litters of Group B received different quantities of solid feed if their current weight was different. Group C began the trial 2 weeks after the other two groups, when Group B feed intake was actually measured. All litters were administered solid feed *ad libitum* starting from the 20th day; Group B litters received limited quantities of feed from 25th day onwards.

Until the 21st day of lactation, the following weekly measurements were recorded: weight of litter, feed intake and milk intake. From Day 22, the above parameters were recorded on a daily basis. Milk intake was measured by weighing the litters before and after the daily suckling.

Rabbit does were given *ad libitum* a feed described in table 1. Litters received another pelleted feed with a higher proportion of fibre and a lower content of proteins (table1)

Chemical analysis of diets followed the method of the ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (1984). Gross energy was determined by adiabatic bomb calorimeter. Apparent digestibility coefficients of the 2 diets were determined using 12 rabbits between 2 and 2.5 kg of live weight. For this determination, rabbits were kept in individual metabolism cages and after a 7-day adaptation period their faeces were collected individually for 5 days and analysed.

At weaning, one rabbit of each litter was slaughtered to obtain data regarding caecal characteristics. Caecal contents, after measurement of the pH, were frozen at -18° C until ammonia was determined (Boehringer UV urea/ammonia kit method) as well as volatile fatty acid (VFA) (Perkin Elmer 841 Gas chromatograph with column 80/120 Carbopack B-DA/4% Carbowax 20M-2m x 2mm id). Fifty other rabbits per group were raised during 5 weeks to estimate post-weaning performance and health. Hence, animals were housed in two cage places, kept in an experimental room with artificial ventilation and a 12h light-12h dark schedule. Rabbits were given *ad libitum* the same feed used before weaning. Individual rabbits weight and feed consumption per cage were recorded weekly.

Data were analysed by analysis of variance, using the general linear procedure (GLM; STATISTICAL ANALYSIS SYSTEMS INSTITUTE, SAS, 1989). Parameters of mortality and kits/litter were analysed with the χ^2 method.

Table 2 : Litter parameters at weaning time (*means and residual standard deviation : rsd)*

Groups		**A**	**B**	**C**	***rsd***
Weaning age (days)		**35**	**35**	**30**	
Number of litters		8	10	9	
Rabbits/litter		7.75	7.60	7.67	0.294*
Litter weight (LW) (g)		6141^{A}	4693^{B}	4729^{B}	255
Milk intake	G	63.4^{B}	58.0^{B}	154.0^{A}	12.2
	% LW	1.03^{B}	1.23^{B}	3.26^{A}	0.23
Feed intake	G	502^{A}	231^{B}	235^{B}	20
	% LW	8.17^{A}	4.92^{B}	4.97^{B}	0.25
Feed/Milk intake		8.36^{A}	4.05^{B}	1.53^{C}	1.19

A, B = P<0.01; *: value χ^2

RESULTS AND DISCUSSION

Pre-weaning period

First of all, it must be pointed out that live weight, feed and milk intake of A and C Groups were identical until weaning of Group C at 30 days (figures 1 to 3). This means that the delay of 2 weeks between the 2 groups included in the experimental design did not induced any bias, and that kits studied at 30 days in the Group C can be considered as representative of the situation of kits of the Group A at the same age.

Table 2 reports some parameters measured at weaning. In Group B, feed restriction to only 60% of the control produced litters that were 24% lighter at weaning than those of Group A. The litters' weight of Group B at 35 days was similar to that of the Group C litters weaned at 30 days.

Daily milk intake, which was still high at day 30 of lactation (150, 153 and 154 g/litter, for Groups A, B and C respectively) was low (Figure 3) on day 35 of lactation (63.4 and 58.0 g for Groups A and B). Overall, milk production reflects the findings of other authors (LEBAS, 1968; FRAGA *et al.*, 1989; XICCATO *et al.*, 1989; CASTELLINI and BATTAGLINI, 1993). At weaning, milk intake, expressed as a percentage of litters' weight, was 1.03, 1.23 and 3.26, respectively, for A, B and C Groups.

The solid feed intake of the litters was recorded from day 22 of lactation (Figure 2). During the first 3 days, control feed intake was very low and as previously mentioned, no dietary restriction was used for Group B during these few days. At weaning, the daily solid feed intake amounted to 502, 231 and 235 g/litter, equal to 8.17%, 4.92% and 4.97% of the litter weight, for Groups A, B and C, respectively. From day 28 to day 35 of lactation, the feed intake in Group A (fed *ad libitum*) increased from 3.3% to 8.2% of litter weight, while the milk intake decreased from 4.13 to 1.01%. As a result, until day 28 of lactation, the milk intake exceeded that of the feed, and ratio was inversed afterwards.

Figure 3 : Milk production

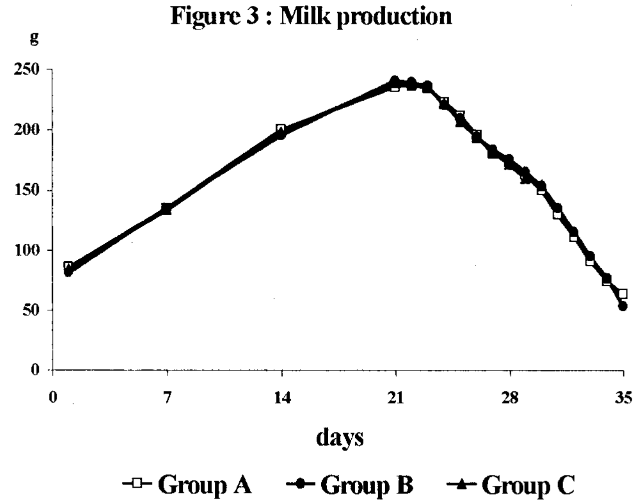


Figure 1 : Litter weight

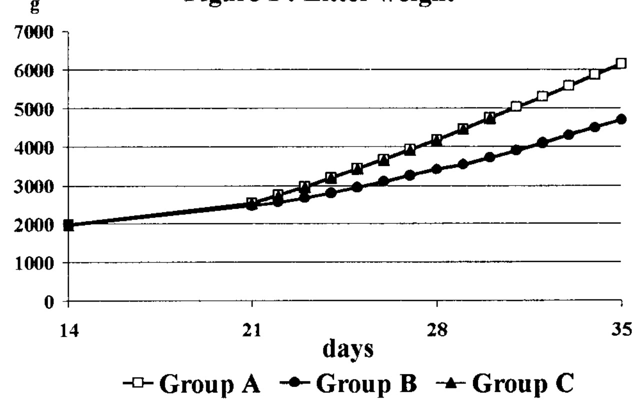
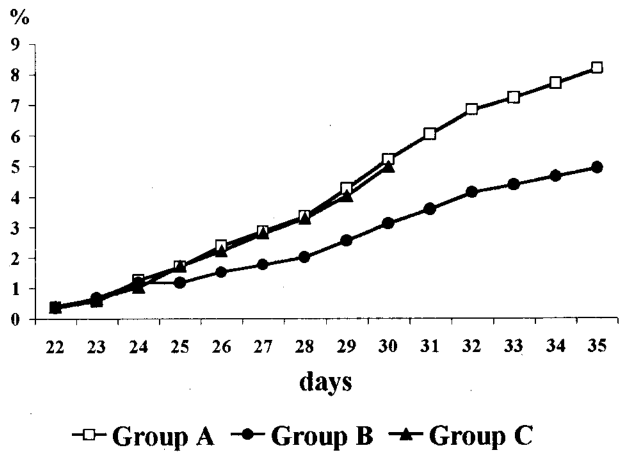


Figure 2 : Solid feed intake in rabbit kits as % of live litter weight



Due to the restriction adopted for Group B animals and the different weaning ages (30 or 35 days), the feed/milk intake ratios at weaning were very different ($P < 0.01$) between the 3 groups : 8.36, 4.05, 1.53 for Groups A, B and C, respectively.

Caecal status at weaning time

Table 3 shows the parameters observed in the animals slaughtered at weaning. Caecal content was significantly lower in Group C than in the other two groups (20.5 *vs* 26.7 and 29.4 g, respectively, for Groups C, B and A). Moreover, the proportion of caecal content to live weight and the relative empty caecum weight were also lower in Group C than in Group B rabbit, despite the same live weight and the same daily feed intake. These results suggest that these parameters were probably affected more by age than by the quantity of solid feed intake or feed/milk ratio. In any case, these values agree with those reported in the literature (LEBAS and LAPLACE, 1972; CANDAU *et al.*, 1978; PADILHA *et al.*, 1995).

Table 3 : Characteristics of caecum and caecal content at weaning *(means and residual standard deviations: rsd)*

Groups	A	B	C	*rsd*
Age in days	**35**	**35**	**30**	
Number of rabbits	8	10	9	
Live weight (LW) (g)	791^{A}	616^{B}	630^{B}	38
Caecal content weight (g)	29.4^{A}	26.7^{a}	20.5^{Bb}	5.0
Caecal content (%LW)	3.76^{AB}	4.32^{A}	3.25^{B}	0.73
Empty caecal weight (g)	10.0^{A}	10.3^{A}	8.3^{B}	0.87
Empty caecum (% LW)	1.27^{B}	1.66^{A}	1.35^{B}	0.14
Caecal content				
Dry matter (%)	27.3^{A}	25.7^{B}	26.4^{AB}	1.2
PH	5.67^{C}	6.40^{A}	5.97^{B}	0.11
Ammonia (mMol/l)	7.3^{B}	10.1^{A}	9.5^{A}	1.44
Total VFA (mMol/l)	57.4^{A}	51.2^{AB}	46.0^{B}	7.7
C_2 (%)	77.2	74.3	75.2	7.6
C_3 (%)	5.8^{B}	9.5^{A}	10.2^{A}	1.3
C_4 (%)	16.1	14.9	13.7	1.7

A, B, C = P<0.01; a, b = P<0.05

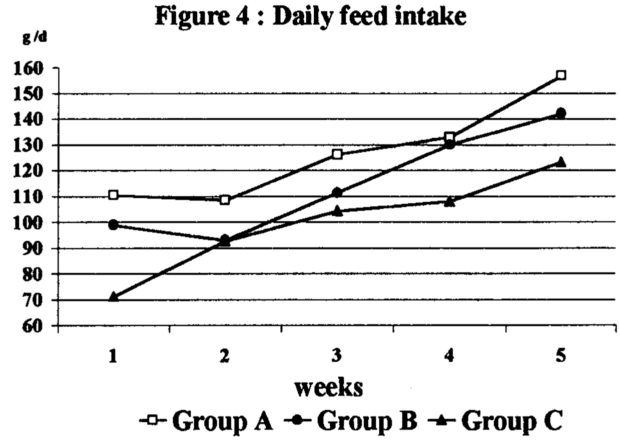
Noticeable differences were observed in the characteristics of the caecal contents. In particular, Group A animals had the lowest pH values (5.67) and those of Group B the highest (6.40). Caecal pH of Group C was intermediary, but significantly different from that of the 2 others (P<0.01). This means that caecal pH was not related to the feed/milk ratio. Rabbits of Group A also recorded a higher concentration of total VFA than those in Group C (57.4 and 46.0 mMol/l; P < 0.01), accompanied by the lowest level of ammonia (7.3 *vs* 10.1 and 9.5 mMol/l for groups B and C, respectively). The lowest proportion of C_3 (P<0.01) was also observed in the Group A rabbits : 5.8% of total VFA *vs* about 10% for the 2 other groups. The dietary restriction adopted in Group B probably had the effect of delaying the reduction in ammonia concentration that normally occurs between 30 and 35 days. The C_3/C_4 ratio observed in Group A (0.36) was in the range of that reported in the literature for adult rabbits (GIDENNE *et al.*, 1991; GIDENNE, 1995) and may be the result of well-established caecal fermentation with the use of solid feed. On the contrary, the higher C_3/C_4 ratio observed in Groups B and C (0,645 and 0,74) resembles more to that of unhealthy or fragile rabbits (LEBAS *et al.*, 1998).

Post-weaning performances

Average growth performances observed during the 5 weeks following weaning are reported in Table 4. During the trial, the health of the rabbits appeared good and mortality was fairly low; only 5 of the kits died (3 in Group A and 2 in Group B). As previously mentioned for whole litters, individual weight at weaning was lower in Group B and C rabbits than in Group A, due to the feed restriction experienced by Group B rabbits and to the earlier weaning age (30 days) adopted for rabbits of Group C.

At weaning, the weight difference recorded between Groups B and C rabbits was not significant (table 4). But after 5 weeks of fattening, the live weight differed significantly (P< 0.01) among the three groups. Moreover, daily growth rate showed no significant difference between Groups A and B weaned at 35 days, but average daily gain in Group B rabbits was 4.1% higher (P<0.05) than that of group C rabbits weaned at the same weight, but 5 days earlier.

Figure 4 : Daily feed intake



The results regarding feed intake are worth noting (table 4, figure 4): Group A animals consistently consumed a higher quantity of feed than the other groups, probably because they were about 200 g heavier at weaning. Group C rabbits, despite having similar initial weights to those of Group B, recorded the lowest intake; this behaviour may well be attributed to the difference in weaning age between the two groups. The feed conversion ratio showed the same pattern than feed intake: higher values for Group

Table 4 : Post-weaning performance *(means and residual standard deviation: rsd)*

Groups	A	B	C	*rsd*
Number of rabbits	50	50	50	
Weight at weaning (g)	807^{A}	625^{B}	622^{B}	48
Weight 5 weeks later (g)	2124^{A}	1970^{B}	1899^{C}	121
Daily feed intake (g/day)	126.9^{A}	115.0^{B}	99.9^{C}	7.4
Weight daily gain (g/day)	37.6^{ab}	38.2^{a}	36.5^{b}	3.1
Feed conversion ratio	3.50^{A}	3.12^{B}	2.78^{C}	0.14
Mortality (%)	6.0	4.0	0.0	3.29*

A, B, C = P<0.01; a, b = P<0.05; *: value χ^2

A rabbits, and better feed efficiency for Group C animals, weaned at 30 days.

CONCLUSIONS

The results obtained in this survey, though derived from a limited number of cases, show that the feed/milk intake ratio at weaning affects the characteristics of the caecal content and also post-weaning performances of rabbit. These variables appear to have been also affected by the age at weaning (between 30 and 35 days). Clearly, the techniques designed to encourage earlier and higher solid feed intake in rabbit kits changed the feed/milk ratio and may consequently have affected post-weaning performance. In this respect, it appears important to evaluate, at weaning, the solid feed intake that could be correlated with milk production, which is in turn linked to the physiological state of the rabbit doe (pregnant, non-pregnant).

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REFERENCES

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1984. Official Methods of analysis (14th). *Association of Official Analytical Chemists, Washington DC.*

CADAU M., DELPON G., FIORAMONTI J.,1978. Influence de la nature des glucides membranaires sur le dévelopment anatomofonctionnel du tracts digestif du lapin. *2èmes Journées de la Recherche Cunicole, 4-5 avril, Toulouse, INRA ed., Toulouse, 1.1-1.4.*

CASTELLINI C., BATTAGLINI M., 1993. Impiego di un mangime complementare durante la lattazione per coniglie inseminate post-partum. Primo contributo. *Zoot. Nutr. Anim., **19**, 151-160.*

FRAGA M.J., LORENTE M., CARABAÑO R.M., DE BLAS C., 1989. Effect of diet and of remating interval on milk production and milk composition of the doe rabbit. *Anim. Prod., **48**, 459-466*

GIDENNE T., SCALABRINI F., MARCHAIS C., 1991. Adaptation digestive du lapin à la teneur en constituants pariétaux du régime. *Ann. Zootech, **40**, 73-84.*

GIDENNE T., 1995. Effect of fibre level reduction and gluco-oligosaccharide addition ion the growth performance and caecal fermentation in the growing rabbits. *Animal Feed Science and Technology, **56**, 253-262.*

GIDENNE T., PEREZ J.M. 1993. Effect of dietary starch origin on digestion in the rabbit, 1. Digestibility measurements from weaning to slaughter. *Anim. Feed Sci. Technol., **42**, 237-247.*

LAPLACE J.P. 1978. Le transit digestif chez les monogastriques, III. Comportement (prise de nourriture, caecotrophie), motricité et transit digestif et pathogénie des diarrhées chez le lapin. *Ann. Zootech. **27**, 225-265.*

LEBAS F., 1968. Mesure quantitative de la production laitière chez la lapine. *Ann. Zootech, **17**, 169-182.*

LEBAS F., LAPLACE J.P., 1972. Mesurations viscérales chez le lapin. 1) Croissance du foie, des reins et des divers segments intestinaux entre 3 et 11 semaines d'âge. *Ann. Zootech, **21**, 37-47.*

LEBAS F.; GIDENNE T., PEREZ J.M., LICOIS D., 1998. Nutrition and Pathology. *In : De Blas C. and Wiseman J., The nutrition of the rabbit, CABI Publishing editeur, Oxon, GB, 197-213.*

MAERTENS L., DE GROOTE G., 1990. Feed intake of rabbit kit before weaning and attempts to increase it. *J. Appl. Rabbit Res., **13**, 151-158.*

PADILHA M.T.S., LICOIS D., GIDENNE T., CARRE B., FONTY G., 1995. Relationships between microflora and caecal fermentation in rabbits before and after weaning. *Reprod. Nutr. Dev., **35**, 375-386.*

PADILHA M.T.S., LICOIS D., GIDENNE T., CARRE B., COUDERT P., LEBAS S., 1996. Caecal microflora and fermentation pattern in exclusively milk-feed young rabbits. *6th World Rabbit Congress, Toulouse, Vol. **1**, 247-251.*

PASCUAL J.J., CERVERA C., FERNÁNDEZ-CARMONA J. 2001. Effect of solid food intake before weaning on the performance of growing rabbits. *2nd Meeting of workgroup 3 and 4. COST Action 848. Godollo, Hungary.*

SAS, 1989. User's Guide Statistics. Version 6.11. *Edition, SAS Inst., Inc., Cary, NC, USA.*

SCAPINELLO C., GIDENNE T., FORTUN-LAMOTHE L. 1999. Digestive capacity of the rabbit during the post-weaning period, according to the milk/solid feed intake pattern before weaning. *Reprod. Nutr. Dev., **39**, 423-432.*

SZENDRŐ Z.S., KUSTOS K., SZABO S., 1985. The study of feed consumption and weight gain in suckling rabbits. *Proc. 12th Conference On Meat Rabbit Breeding.*

XICCATO G., CINETTO M., PARIGI-BINI R., 1989. Influenza della gravidanza e del livello nurtitivo sulla produttività di coniglie fattrici in lattazione. *Atti S.I.S.Vet., **43**, 1665-1669.*