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Early weaning and high feeding level in post-weaning period did not impact milk production in Alpine dairy goats

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The experiment reported in this Research Communication aimed to determine the combined effects of early weaning and post-weaning feeding level on growth, reproductive parameters and milk yield in Alpine goats. Sixty-four Alpine goat kids were weaned abruptly at either 12·2 (±1·40) kg (40 d of age, E) or 17·7 (±2·30) kg (60 d of age, No). After weaning, E and No goats were subjected to 2 feeding strategies ($n = 16$): *ad libitum* concentrate until 130 d of age and then 620 g DM/d/goat until 200 d of age (EC and NoC) or *ad libitum* concentrate until 200 d of age (EAL and NoAL). Goats were weighed twice a month until 200 d of age. Pregnancy rate and litter size were recorded. Daily milk yield was measured by milk meter during the first lactation. Up to 60 d of age, average daily gain (ADG) of E kids was significantly lower than No kids. From 60 to 130 d of age, ADG of the four treatments were not different. After 130 d of age, EC and NoC kids had lower ADG than EAL and NoAL kids. Pregnancy rates of EAL and NoAL goats were lower than those of EC and NoC. Milk yield was not modified by weaning weight or feeding management. Milk quality was not affected by any treatment. To conclude, the age at weaning as well as the feeding level after weaning did not negatively impact growth and milk yield. We hypothesise that the establishment of the lactation function is not impacted by rearing management. Hence, decreasing the age at weaning could be an interesting way to reduce the cost of the rearing period in goat kids.

Keywords: Rearing, kids, ADG.

The milk feeding period is expensive for farmers and it would, therefore, be profitable to wean kids as early as possible. However, while milk feeding may promote a more rapid growth than a concentrate-forage diet, maintaining kids on milk replacer may not stimulate enough solid feed consumption and may negatively affect post-weaning growth. Compared to dairy calves, the literature on the weight at weaning in dairy goat is scarce and old. Palma & Galina (1995) compared two weaning weights: one with an abrupt early weaning at 10 kg and the other one with late partial weaning until the body weight reached 15 kg. The authors concluded that in both systems the animals were ready for breeding at 8–9 months of age and for kidding at 13–14 months of age. However, a long-term study on the effect of early weaning on reproductive parameters and milk production is needed.

From weaning to breeding, the objective is to produce a lactating goat with an appropriate body size, at a reasonable cost and in the shortest possible time without impairing its productive lifespan. Reproduction of goats begins with the onset of puberty which is related to animal size and development. The age at puberty largely depends on nutrition because nutrition plans or variations in feeding programs can accelerate or delay the onset of puberty. Moreover, the effect of feeding level during the rearing period and milk yield potential has been investigated in many experiments in heifers. Although not all results are in full agreement, it is the overall conclusion that high feeding level during the prepubertal period can cause a permanent reduction of the subsequent milk yield potential (Sejrsen et al. 2000). Since little attention has been paid to dairy goats, studies on optimal and adequate goat kids rearing programme are needed to generate productive animals with adapted body size.

Over the last few years, the weight of female kids at weaning has decreased in France from 20 kg to 15 kg (IDELE, 2014), for many reasons including the reduction of costs and management flexibility. Low weaning weight can be compensated by increasing feeding supply after weaning. The combination of these two strategies, decreasing weaning weight and increasing feed intake after

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weaning, could be an interesting way to reduce the cost of rearing and optimise the growth of the young. However, the impact of such rearing strategy on growth and lactation has scarcely been studied in goats. Thus, the objectives of our study were to determine the combined effects of early weaning and post weaning feeding level on growth, reproductive parameters and milk yield in Alpine goats.

Material & methods

All of the animal procedures were discussed and approved by the CNREEA No. 07 (Local Ethics Committee in Animal Experiment of Rennes) in compliance with French regulations (Decree No. 2013–118, February 07, 2013).

Animals and treatments

Sixty-four female French Alpine goat kids, born between 29 January and 17 February, were used over 2 years. Immediately after birth, kids were separated from their dam. Goat kids received 100 ml/kg of body weight (**BW**) good quality colostrum during the first day of life. Afterwards, kids were first randomly assigned to a 12 kg (**E**, Early) or 18 kg (**No**, Normal) weaning weight treatment ($n = 32$ per treatment) balancing the groups according to birth weight; 4·4 (±0·14) kg and 4·4 (±0·15) kg respectively. Until weaning, kids were housed in the same straw bedded pen and fed *ad libitum* with milk replacer. Concentrate, hay and water were provided at 2 weeks of age. However, kids did not eat concentrate before weaning. One week before weaning, the ad libitum milk feeding was stopped and goat kids received 2 meals per day of 2 litres of milk replacer for three days, then one meal per day of 2 litres of milk replacer for 4 d. The average age at weaning was 40 (±0·6) d of age for weaning at 12 kg (early weaning) and 60 (±0·6) d of age for weaning at 18 kg (normal weaning). At 40 d of age, No and E kids were randomly assigned to two feeding treatments: *ad libitum* concentrate (19·4% crude protein and 11·3 MJ/kg DM of metabolisable energy) and hay until 130 d of age (**NoC and EC**) or *ad libitum* concentrate and hay until 200 d of age (**NoAL and EAL**) balancing groups according to ADG between birth and 40 d of age and weight at 40 d of age ($n = 16$ per treatment). More precisely, they were 202·3 (±6·28) g/d and 12·1 (±0·33) kg for EC; 201·5 (±5·90) g/d and 12·0 (±0·37) kg for EAL; 209·7 (±7·43) g/d and 12·7 (±0·47) kg for NoC; and 203·7 (±9·23) g/d and 12·3 (±0·54) kg for NoAL.

Kids were housed on straw bedding and in four pens (one pen for each of the four treatments and 0·65 m^2 at least per kids). From 130 d of age to 200 d of age, NoC and EC kids were fed with a controlled level of concentrate (620 g DM/d/kid) and *ad libitum* hay. From 200 d of age to the end of mating, all kids received the same diet and were fed with hay *ad libitum* and 620 g DM of concentrate. After mating, all kids were fed according to INRA recommendations (INRA, 2010) with hay *ad libitum* and 700 g DM of concentrate until the end of lactation.

The breeding management was flock mating during 9 weeks from 200 (±0·4) d of age. The heats were not synchronised and one billy goat was used for each treatment. At parturition, goats delivered naturally. In this study, the term 'goat' refers to an animal over 200 d of age and 'goat kid' to younger animals.

Measurement of growth and milk production

Growth. Goat kids were weighed every week until 200 d of age. ADG was calculated on five periods: **P1** (between birth and early weaning (40 ± 0·6 d of age)), **P2** (between early weaning and normal weaning (60 ± 0·6 d of age)), **P3** (between normal weaning and 130 (±0·4) d of age), **P4** (between 130 (±0·4) d of age and breeding period (200 ± 0·4 d of age)) and **P5** (between birth and breeding period).

Milk production. Goats were milked twice a day from parturition to 140 d in milk. MY was measured at each milking by milk meter. Milk samples were collected twice (76 ± 0·7 d and 139 ± 0·7 d in milk) for milk composition measurement (fat and protein contents). The protein and fat contents were determined by an independent laboratory using an infrared method (Lillab, Chateaugiron, France).

Statistical analysis

Data are presented as means ± SEM. All the statistical analyses were performed on R software.

The BW from birth to 130 d of age was analysed by age with an analysis of covariance (**ANCOVA**) according to the following model:

$$Y_{ijk} = \mu + W_i + \mathrm{CovA} + W_i \times \mathrm{CovA} + \varepsilon_{ij}$$

The BW after 130 d of age was analysed by age with an ANCOVA according to the following model:

$$Y_{ijk} = \mu + W_i + F_j + \mathrm{CovA} + W \times F_{ij} + F_j \times \mathrm{CovA} + W_i \times \mathrm{CovA} + \varepsilon_{ijk}$$

The ADG before 130 d of age was analysed with an analysis of variance (**ANOVA**) according to the following model:

$$Y_{ij} = \mu + W_i + \varepsilon_{ij}$$

The ADG after 130 d of age, litter weight, milk production and milk composition were analysed with an ANOVA according to the following model:

$$Y_{ijk} = \mu + W_i + F_j + W \times F_{ij} + \varepsilon_{ijk}$$

For all the models, Y_{ijk} is BW or ADG, μ is the overall mean, W_i is the fixed effect of the weaning weight, F_j is the fixed effect of feeding management, CovA is the covariable effect of age, $W \times F_{ij}$ is the weaning x feeding interaction effect, $F_j \times \mathrm{CovA}$ is the feeding x age interaction effect and $W_i \times \mathrm{CovA}$ is the weaning × age interaction effect. The interactions were excluded from the model when they were not

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Table 1. Effects of weaning weight and feeding management on body weight (kg) and ADG (g/d)

	E‡		No§			*P* > *F*			
	C‖	AL¶	C‖	AL¶	SEM	Weaning	Feeding	Age	Weaning × Feeding
Number of goat kids	15	15	16	15					
Weight (kg)									
At 40 d of age (early weaning)	12·2	12·2	12·3	12·3	0·24	ns	–	***	–
At 60 d of age (normal weaning)	16·1^{b}	16·1^{b}	17·7^{a}	17·7^{a}	0·31	***	–	***	–
At 85 d of age	23·0	23·0	23·4	23·4	0·38	ns	–	***	–
At 130 d of age (concentrate restriction)	31·9	31·9	32·6	32·6	0·52	ns	–	*	–
At 200 d of age (reproduction)	40·2^{b}	44·0^{a}	39·3^{b}	43·9^{a}	1·05	ns	***	**	ns
ADG (g/d)									
Birth–40 d of age (P1)	201·9	201·9	206·8	206·8	5·19	ns	–	–	–
40 d–60 d of age (P2)	183·3^{b}	183·3^{b}	254·8^{a}	254·8^{a}	6·75	***	–	–	–
60 d–130 d of age (P3)	228·7	228·7	215·3	215·3	4·99	†	–	–	–
130 d–200 d of age (P4)	108·9^{b}	177·0^{a}	106·5^{b}	149·8^{a}	7·11	ns	***	–	ns
Birth–200 d of age (P5)	178·7^{b}	197·9^{a}	175·9^{b}	198·2^{a}	4·92	ns	***	–	ns

‡E: early weaning (12 kg).
§No: normal weaning (18 kg).
‖C: controlled concentrate at 130 d of age.
¶AL: *ad libitum* concentrate until reproduction period.
This table shows lsmeans.
P-value: '–': undetermined effect, 'ns': $P > 0{\cdot}1$, '†': $P < 0{\cdot}1$, *: $P < 0{\cdot}05$, **: $P < 0{\cdot}01$, ***: $P < 0{\cdot}001$.
$^{a–c}$Means within a row with different superscripts differ ($P < 0{\cdot}05$).

Table 2. Effects of weaning weight and feeding management on milk production and milk composition

	E‡		No§			P > F		
	C‖	AL¶	C‖	AL¶	SEM	Weaning	Feeding	Weaning × Feeding
Number of goats	14	12	13	8				
Cumulated milk production in 140 d (kg)	355	365	323	368	16·52	ns	†	ns
Milk production per day (kg/d)	2·86	2·97	2·62	2·95	0·12	ns	†	ns
Milk fat (g/kg)	33·8	31·2	33·7	32·8	1·20	ns	ns	ns
Milk protein (g/kg)	29·5^{a}	27·9^{b}	29·7^{a}	28·1^{b}	0·69	ns	*	ns

‡E: early weaning (12 kg).
§No: normal weaning (18 kg).
‖C: controlled concentrate at 130 d of age.
¶AL: *ad libitum* concentrate until reproduction period.
This table shows means by treatments estimated by models.
P-value: '–': undetermined effect, 'ns': $P > 0{\cdot}1$, '†': $P < 0{\cdot}1$, *: $P < 0{\cdot}05$, **: $P < 0{\cdot}01$, ***: $P < 0{\cdot}001$.
$^{a–b}$Means within a row with different superscripts differ ($P < 0{\cdot}05$).

significant and Bonferroni test was performed as a post-hoc suitable for unbalanced data.

Result & discussion

Early weaning is traditionally recommended in the dairy industry to reduce the consumption of milk replacer and to accelerate rumen development by increasing starter intake. Early weaning is also interesting to reduce kid-rearing costs by decreasing milk and labour expenditures. While weaning age is extensively studied in calves, experiments on the effect of early weaning on growth and milk production are scarce in goats. The objectives of this study were (i) to test the feasibility of early weaning in goats (12 kg) and (ii) to evaluate the influence of feeding level after weaning on growth and lactation.

To determine the feasibility of early weaning in goats, we observed the effect of reducing weaning weight on growth performances. The results of BW and ADG of Alpine kids at weaning, 40, 60, 85,130 and 200 d of age are presented in Table 1. At 40 d of age (early weaning), the BW were similar between the E and No kids respectively 12·1 (±0·24) kg and 12·3 (±0·35) kg. At 60 d of age, E kids weighed 1 kg less than No kids and ADG of E kids between 40 and 60 d of age was 28% lower (Table 1). At 85 d of age, BW of E and No kids were similar (Table 1). After 130 d of age, BW was not reduced by weaning weight and no interaction between weaning weight and feeding management was observed. These results are consistent with results obtained in previous studies on early weaning in Saanen kids (Ferreira & Thornton, 2004; Ugur et al. 2004). Indeed, Ugur et al. (2004) showed that the BW at 4 months of age and the ADG from weaning to 4

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months of age were similar between kids weaned at 45 or at 60 d of age. It appears that early weaning did not affect growth performances of kids. Weaning kids at 12 kg or at 40 d of age is feasible without decreasing of the growth performances of kids.

Our second objective was to evaluate the influence of feeding level after weaning on reproduction and lactation. To determinate that effect, we applied two feeding strategies: *ad libitum* concentrate until either 130 d of age (before puberty) or 200 d of age (reproduction). In dairy goat farms, the objective is to achieve the first parturition at one year of age. Reproductive data are presented in the online Supplementary File. In our study, the 4 groups had similar age at first parturition which was on average 355 (±1·1) days of age ($P > 0{\cdot}1$, data not shown). Our results provided evidence that reducing age at weaning and modifying feed intake post weaning did not delay the onset of puberty. Zarazaga et al. (2009) showed that the level of feeding did not influence the onset of puberty in goats. In small ruminants, seasonal oestrous occurs when the day length decreases and this period is associated with resumption of oestrus and ovulation and an increase in the secretion of reproductive hormones (Chemineau et al. 2010). Here, the reproduction period was between August 20 and October 20, in decreasing day length. Hence, the day length seems to be the main factor influencing reproductive hormones compared with age at weaning or feeding level. Enhancing feeding level after early weaning did not advance age at first parturition, in contrast to dairy heifers (Le Cozler et al. 2008).

Here, weaning weight did not affect milk production (Table 2). During the 140 first days in milk, milk production was not different. In heifers, some studies showed that high feeding levels during the pre-pubertal stage did not affect negatively the subsequent MY (Van Amburgh et al. 1998). Sejrsen et al. (2000) hypothesised that the lack of effect on milk production could be due to the small difference in the growth rate between groups in heifers studies. In our study, the difference in ADG was only of 11·7% between the two feeding levels from birth to 200 d of age whatever the age at weaning. Those differences could indeed not be sufficient to influence MY and to induce significant effects. The duration of the *ad libitum* feeding period could also explain our results. Indeed, comparing *ad libitum* feeding to restricted feeding from weaning to breeding could be interesting to complete our knowledge on the effect of high feeding level during rearing period on milk production. Moreover, Aubry et al. (2012) highlighted the fact that in goats a high level of feeding from weaning to parturition induced a decrease of 13% in milk yield compared to a restricted feeding level. In the light of these observations and our results, we can hypothesise that is not only the duration of *ad libitum* feeding but also the period of application which seem to be important. It appears that *ad libitum* feeding during gestation seems more detrimental for milk production than during rearing period in goats. To confirm this hypothesis, more studies on the effect of feeding management during rearing period or first gestation on milk production are needed in goat kids.

To conclude, early weaning affected the growth of goat kids in the short term but not in the long term. No effects were observed on milk yield in first lactation after early weaning whatever the feeding management. In this study, weaning at 12 kg has proven to be effective in Alpine kids. Our results showed that advancing weaning is feasible without negative effect on production performances of kids. Early weaning appears to be a good way to reduce the cost related to the rearing period in goat kids.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S0022029918000377

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