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The effects of individual weaning based on birth weight on growth performance and milk yield in dairy goats

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Abstract: The aim of this study was to determine the effects of using birth weight of kids for weaning on growth and milk yield characteristics of Saanen and Alpine goats. A total of 24 does and their 40 kids were assigned to weaning groups when the kids reached three (X3) or four times (X4) their individual birth weights. The experimental design was a 2 × 2 factorial design with two weaning stages (X3 vs. X4) and two breeds (S: Saanen; A: Alpine). The averages of weaning age of the SX3, AX3, SX4, and AX4 kids were determined as 42.75, 42.21, 53.15, and 65.81 days, respectively. The weaning groups and the interaction between weaning and breed had effects ($P < 0.001$ and $P < 0.05$, respectively) on weaning age of the kids. The average daily weight gain before weaning was different in weaning groups ($P < 0.001$). On the contrary, the growth performances of the kids until breeding age were not different between groups. The milk yield characteristics of dams in groups were not different. The results indicated that weaning at a predetermined weight based on birth weight can be done successfully in dairy goats under intensive conditions.

Key words: Alpine, birth weight, Saanen, weaning criterion, weaning time

1. Introduction

In dairy goats, weaning time of kids has a critical importance for kid growth and marketable milk production. Commonly used criteria for weaning are age (days), body weight, and/or average daily concentrate consumption of the kids. Growth characteristics of goat kids are affected by health, nutrition, and other management techniques that include weaning management (1,2). Changes in the amount and value of consumed feed and separation from their dams may emerge as psychological stress factors for weaned kids (3,4). Mistakes that were made during the growth period could affect the lifetime productivity of kids by decreasing or stagnating weight gain, increasing the risk of disease, reducing the breeding value, and even leading to the death of kids (2–4). However, it has been reported that weaning stress can be reduced by appropriate weaning techniques (5,6).

To ensure the profitability of the weaning process is also important for dairy goat breeders. It has been reported that early weaning increases the marketable quantity of milk without causing a negative impact on the growth of kids and thus provides economic benefits to the farm (7,8). Feeding milk to kids would be expensive when there is a great demand for milk and cheese. From this perspective, the period is extended, kids drink more milk than they need, and this leads to economic losses. Thus, early weaning of kids would be beneficial in terms of economic profitability (9). The aim of a dairy goat farm is to obtain the highest marketable milk without causing problems both in health and growth of the kids. Early weaning is especially important to utilize the advantage of the high-yielding periods in early lactation of dams. Mistakes related to weaning practices and time may also cause mastitis in does. Moreover, more intensive labor is needed, which is an economic burden on the farm (8). In addition, on account of the prolonged suckling period, the economic dimension of weaning mistakes is not limited to less marketable milk gain. Late weaning also has a negative effect on rumen development of kids (5). Therefore, weaning has to be performed at an appropriate time without generating any adverse effects on the future productivity of dams and kids.

The commonly considered criteria to deciding a dairy goat kid's weaning are age, body weight, and/or average daily consumption of concentrate (3,10,11). Abebe (12) reported that the age of kids alone is not a sufficient criterion for weaning and that in many instances weight is a better indicator than age. However, body weight of kids at weaning is not a certain indicator, because it can be negatively correlated with the development of stomach

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compartments (3). Birth weight used as a weaning criterion was proposed in some nonexperimental reports (6,11,12). Özkan (6) claimed that it is possible to wean kids when they reach 3 or 4 times their birth weights. This claim is yet to be experimentally proved. In the present study we aimed to determine the effects of kids' being at 3 or 4 times their birth weights at weaning on growth and milk yield characteristics in Saanen and Alpine goats under intensive farming conditions.

2. Materials and methods

The present study was approved by the Ethics Committee of Adnan Menderes University (ADÜ-HADYEK 050.04/2011/029).

2.1. Animals and feed

This study was carried out in the Research Unit of the Adnan Menderes University Çine Vocational School in the Çine district (28°06′N, 37°61′E) of Aydın Province, Turkey. Twenty-four Saanen and Alpine goats, at 2–5 years of age and weighing an average of 56.3 kg, and their 40 kids (24 Saanen and 16 Alpine) were used. All goats were subjected to an estrus synchronization program consisting of 11 days of progestagen (20 mg FGA, Intervet, France) impregnated sponge insertion plus eCG and prostaglandin injections at 48 h before sponge withdrawal in September 2013. Following the pregnancy period after synchronized matings in the flock, kids were weighed within 24 h after birth and numbered with ear tags. Kids were kept continuously with their mothers during the first week and thereafter only at nights. Hand milking of the does (once a day) started 4 days after parturition. Does were grazed in a pasture from 0800 to 1600 hours. After 1 week of age, concentrate mixture and alfalfa hay were offered to the kids between these hours. During the preweaning period, concentrate consumption of the kids was recorded.

The kids were housed in separate weaning groups (X3 and X4: described below) until the beginning of the full grazing period at the beginning of May 2014. Ad libitum concentrate containing 89% dry matter and 2700 ME kcal/kg and 100 g alfalfa hay per day/animal were offered to the kids after weaning. Nutritional content of the commercially available concentrate is given in Table 1. Clean drinking water was provided during this period. The kids were kept in the paddocks throughout the day, except for 1–2 h in the pasture located near the fold. Thus, opportunities with regard to fundamental movement were given to the kids. The feeding program was continued until 75 days of age. After this period, all kids were grazed together in the pasture until the targeted breeding age (7 months of age). Although the pasture quality can be considered above the average of Anatolian pastures, its yield was not assessed in this study. The pasture area contains a significant woody component and comprises shrubland, woodland, maquis, *Lolium*, *V. ervilia*, *P. elaeagrifolia*, *P. rhoeas*, *L. stoeshas*, *E. sphaerocephalus*, *O. europaea*, *Quercus ithaburensis* subsp. *macrolepis*, etc.

Table 1. The nutrient content of the concentrate mix given to the goat kids until 75 days of age.

Concentrate contains	%
Crude protein	20
Crude fat	3
Crude ash	8
Crude cellulose	9.5

2.2. Weaning groups and experimental design

From the beginning of the kidding period, the live weight of each kid was recorded every 4 days. The weaning weights of kids were predetermined by considering their individual birth weights. When a kid reached its predetermined weaning weight it was weaned individually. Kids were weaned when they reached three or four times their individual birth weights. Thus, X3 and X4 weaning groups were formed. The experimental design was a 2 × 2 factorial design with the two factors of breed and weaning groups: 1) Saanen and X3 (SX3), 2) Alpine and X3 (AX3), 3) Saanen and X4 (SX4), and 4) Alpine and X4 (AX4). The birth type and sex of the kids were balanced within the groups. After the individual weaning of all kids, live weights of weaned kids were determined every week to calculate the growth performances in later periods. Individual milk yields of dams were recorded every 14 days. Does were milked by hand once a day until weaning and then twice daily until the dry period. The milking records were used to calculate the milk yield characteristics of the dams.

2.3. Statistical analysis

Data analysis was performed using the GLM procedure of SAS (13) according to a 2 × 2 factorial design for kid growth characteristics to determine the main effects of weaning group, breed and weaning × breed. Daily feed consumption for weaning groups was calculated on a group basis. The data related to milk yield characteristics were calculated only for the weaning groups (X3 and X4) using the GLM procedure of SAS. The growth curves of the kids were calculated and presented separately for the weaning and the breed groups. Data are presented as least squares means and RMSE.

3. Results

3.1. Concentrate consumption and growth characteristics

Average concentrate consumption in weaning groups is presented in Table 2. Feeding opportunities of the kids from hay and the pasture near the fold were not included

Table 2. Average daily feed consumption in weaning groups of the goat kids.

Traits	X3[1]	X4[2]
Average concentrate consumption before weaning (kg/day)	0.136	0.136
Average concentrate consumption until pasture period (kg/day)	0.265	0.415

[1] Weaning weight = individual birth weight of a kid × 3.
[2] Weaning weight = individual birth weight of a kid × 4.

with these data. Concentrate feed consumption of X4 kids tended to be higher than that of X3 kids.

The means of birth weight (BW), weaning weight (WW), weaning age (WA), daily weight gain before weaning (ADG-B), daily weight gain after weaning (ADG-A), and total weight gain (TWG) of the kids are presented in Table 3.

As shown in Table 3, there were no differences in BW between breeds or weaning groups ($P > 0.05$). The average BW of the kids in the weaning and breed groups was balanced at the beginning of the study. X4 kids had heavier WW than that of the X3 kids ($P < 0.001$). There were no differences in WW between the Saanen and Alpine breeds in our study. The WA was also affected by weaning group ($P < 0.001$) and there were some interactions between weaning group and breed ($P < 0.05$).

The average daily weight gain before weaning (ADG-B) was higher in X4 kids than that of the X3 kids ($P < 0.0001$) (Table 3). There were no differences in ADG-B and average daily weight gain after weaning (ADG-A) between two breeds. The ADG-A results showed that X3 and X4 kids had similar growth performance before weaning ($P > 0.05$).

The growth performances of the kids were also evaluated considering the means of monthly live weights of the kids (Table 4). Although the live weight values of the weaning groups were similar, it can be seen in Table 4 that the live weights at the 3rd, 5th, 6th, and 7th months of the AX3 kids tended to be higher than those of the AX4 kids, but the differences were not significant ($P>0.05$).

Weaning at 42 days of age (X3 kids) did not have any adverse effects ($P > 0.05$) on the monthly growth performances of the kids, as in the X4 group. The body weight at 1 month of age was significantly ($P < 0.05$) different between the breed groups. In the later periods, no differences were present between the growth performances of Saanen and Alpine kids.

3.2. Milk yield characteristics

The means of lactation length, lactation milk yield, and average daily milk yield of the dams of the kids in weaning groups are shown in Table 5.

As shown in Table 5, lactation milk yield, daily milk yield, and lactation length of the dams were not significantly different between the weaning groups. Lactation milk yield and daily milk yield of X3 dams tended to be higher than in the X4 group.

4. Discussion

We tested the effects of weaning when the kids were 3 or 4 times heavier than their birth weights on growth and milk

Table 3. Effect of weaning and breeds of goat kids on birth weight (BW), weaning weight (WW), weaning age (WA), daily weight gain before weaning (ADG-B), daily weight gain after weaning (ADG-A), and total weight gain (TG) (least square means ± RMSE).

Breed	Saanen		Alpine			P-values		
Group	X3[1]	X4[2]	X3[1]	X4[2]	RMSE	B[3]	G[4]	I[5]
BW (kg)	3.45	3.26	3.31	3.63	0.413	0.426	0.665	0.077
WW (kg)	9.78	13.14	9.97	13.22	0.340	0.269	<0.0001	0.685
WA (day)	42.75	53.15	42.21	65.81	8.703	0.058	<0.0001	<0.040
ADG-B (kg)	0.133	0.193	0.135	0.195	0.0087	0.369	<0.0001	0.995
ADG-A (kg)	0.105	0.117	0.111	0.109	0.0249	0.906	0.706	0.466
TG (kg)	22.07	27.23	25.23	23.96	4.178	0.972	0.225	0.056

[1] Weaning weight = individual birth weight of a kid × 3, [2] weaning weight = individual birth weight of a kid × 4, [3] breed, [4] group, [5] interaction.

Table 4. Effect of weaning (X3 vs. X4) on monthly growth performances of Saanen and Alpine kids (least square means ± RMSE) (kg).

Breed	Saanen		Alpine			P-values		
Group	X3[1]	X4[2]	X3[1]	X4[2]	RMSE	B[3]	G[4]	I[5]
1st MoW[6]	8.34	8.80	7.98	7.49	0.970	<0.021	0.961	0.179
2nd MoW	11.77	12.73	12.53	12.04	1.500	0.949	0.646	0.175
3rd MoW	14.41	15.75	16.24	15.81	2.115	0.226	0.542	0.251
4th MoW	18.11	21.15	20.69	21.33	2.769	0.181	0.072	0.242
5th MoW	21.39	24.70	24.17	23.41	3.043	0.506	0.248	0.075
6th MoW	24.27	29.30	28.35	26.49	4.423	0.702	0.336	<0.043
7th MoW	25.36	30.52	28.52	27.25	4.178	0.972	0.225	0.056

[1] Weaning weight = individual birth weight of a kid × 3, [2] weaning weight = individual birth weight of a kid × 4, [3] breed, [4] group, [5] interaction, [6] 1st–7th MoW: live weights of the kids from 1st month to 7th month.

Table 5. Effect of weaning time on the milk yield characteristics of the dairy goats (least squares means ± RMSE)

Traits	Weaning groups			P-values
	X3[1]	X4[2]	RMSE	
Lactation milk yield (L)	483.74	427.05	79.258	0.086
Daily milk yield (L)	2.099	1.835	0.3844	0.099
Lactation length (days)	231.29	231.67	11.730	0.938

[1] Weaning weight = individual birth weight of a kid × 3, [2] weaning weight = individual birth weight of a kid × 4.

yield characteristics in Saanen and Alpine goats in this study. The birth weights of the kids in the present study were consistent with the values reported for the same breeds (1,14). As expected, the X4 kids had higher WW than that of the X3 (Table 3). The higher concentrate feed consumption of X4 kids could be explained by their higher body weights at weaning than that of X3 kids (Table 2). Ugur et al. (10) reported lower WW in kids weaned at 45 days (12.4 kg) than those weaned at 60 days (14.6 kg) in Saanen goats. As seen in Table 3, there were no differences in WW between the Saanen and Alpine breeds, consistent with the results of some other researchers (1,2) who reported that weaning weights in Saanen and Alpine kids subjected to similar treatment or weaning management were not different. In the present study, while the SX3 and the AX3 kids reached 3 times their birth weights at 42.75 and 42.21 days of age, respectively, SX4 and AX4 kids reached 4 times their birth weights at 53.15 and 65.81 days, respectively (Table 3). These periods were similar to the findings of the study of Ugur et al. (10), who weaned Saanen kids at 45 and 60 days of age based on an age criterion. Similarly, Tolu and Savaş (15) reported that the average WW of Turkish Saanen kids at 60 days of age was 10.0 kg. In the same study, they also reported that weaning may be done without detrimental effects on growth of kids when they reached 20% (10.7 kg) of the adult body weight. The ages of the kids in that time varied between 39 and 80 days (15). The WW of X3 kids in the present study was lower than the values recommended by Tolu and Savaş (15). Atasoglu et al. (16) stated that weaning at 10.0 kg live weight did not negatively affect the behavior and serum parameters of kids. In another study (17), the WW of Saanen kids weaned at an earlier stage (5 weeks of age) was reported as 10.9 kg. The WW of X4 kids in this study was consistent with that of the WW reported by Kara et al. (18), who weaned Saanen kids at 60 days of age. In a previous study (19), the WW of Saanen kids at 60 days of age was reported to be around 11.81–12.38 kg. Additionally, in most of the previous studies, the weaning of dairy goat kids was done at 60 days of age. This period is similar to the period when the kids reached 4 times heavier weights than their birth weights in this study. The

differences in the WW could be attributed to factors related to preweaning maintenance conditions. The weaning time of dairy goats in some countries is generally longer (70–90 days of age) than 40–60 days of age (1,2). As a consequence of this, weaning weights of kids were also higher than 13.0 kg (1,2,14).

In this study, the ADG-A did not differ in weaning groups (Table 3). These findings are consistent with the study by Ugur et al. (10), who reported nonsignificant differences in the ADG-B and ADG-A of Saanen kids weaned at 45 and 60 days of age. In the same study, it was pointed out that Saanen kids could be weaned safely at 45 days of age. The differences in ADG-B of the X4 and X3 kids in the present study (Table 3) could be attributed to the duration of the preweaning period and physiological factors related to growth. Contrary to the our results, Paez Lama et al. (20) reported nonsignificant differences between kids weaned at 30 and 60 days of age for ADG-B (119.4 g vs. 129.5 g, respectively).

As seen in Table 3, in this study, there were no differences in ADG-B and ADG-A values between Alpine and Saanen kids. Similar results were reported by Rojo-Rubio et al. (2) for the same genotypes. However, the kids in the present study had lower ADG-B and ADG-A values than those reported in some previous studies for the same breeds (2,17), probably due to the different weaning age and other environmental factors. The most common criterion for the weaning time of goat kids that have been proposed in previous studies is the age of the kids. In the previous studies, the kids were weaned generally at 60 days of age. The growth rate of the X4 kids obtained in the present study was comparable with the values reported for Saanen kids weaned at 60 days of age (17–19). However, the result of the present study showed that the kids could be weaned earlier stages than 60 days of age.

In the present study, the monthly growth performances of the X3 and X4 kids (Table 4) revealed that it could be possible to wean dairy goat kids when they reached three times their birth weights under intensive conditions. In the studies that investigated the relationship between weaning time and growth performance it was emphasized that the weaning age of kids is an important factor for the lifetime productivity of goats. Nagpal et al. (7) reported that age at weaning had a significant effect on body weight at the 2nd, 3rd, and 6th months and they observed that weaning at 60 days of age was more useful for farm profitability than at 90 days of age. Paez Lama et al. (20) reported that body weights after the 90th day were similar in kids weaned at 30 and 60 days of age. In addition to the findings of their previous study, in another study done by the same researchers, it was reported that weaning at 30 days of age caused weaning stress and growth characteristics of kids were affected negatively. Nevertheless, these animals showed a compensatory growth that enabled them to regain the body weight lost (21). Similarly, McGregor (22) pointed out a slow growth period in kids usually observed after weaning. Memiši et al. (3) reported that kids can successfully be weaned as early as 35 days of age; however, for economic concerns, weaning earlier than this age should not be done. However, in the same research, it was stated that weaning at 35 days of age caused partial stress accompanied by lower weight gain during the first few days after weaning. The researchers reported that kids at earlier ages are not physiologically capable to utilize other food except milk (3). Adebe (12) stated that when kids begin to eat solid food, it stimulates the rumen and leads to the development of the microbial population. The reticulorumen and the large intestine rapidly increase in size relative to the abomasum and small intestine. This change from preruminant to ruminant is a gradual process (12). The final weights of X3 and X4 kids were similar and the weight of the kids in that time is important for the first breeding age of the kids (Table 4). The growth rate of X3 kids in the present study was comparable with the values reported for dairy kids weaned at 60 days of age or later periods (19). Furthermore, the X3 kids had a better growth rate than those of Saanen kids weaned at the 60th day in another study (14).

The present results related to growth characteristics of the kids were supported by findings of Singh-Knights and Knights (5), who reported that weaning stress could be reduced by weaning of kids when they reached 9.0 kg of live weight, 8 weeks of age, and/or 30 g daily dry matter intake. In the study by Palma and Galina (23) on weaning time of different dairy breeds, it was reported that weaning at 10.0 kg live weight in Toggenburg, Saanen, and Alpine kids was possible in order to obtain the desired growth rates. Mass weaning or weaning in groups of kids considering the age and/or weight of kids is more common than individual weaning. However, the optimal weaning decisions require knowledge about each kid's body weight and condition relationships (24). The present study showed that birth weight is an appropriate criterion for the time of weaning in kids. Similarly, in review studies (11,12), it has been suggested that fixed weaning ages should be less desired compared to practice aiming to wean kids at 2 to 3 times the birth weight. Using this information, weaning management could be planned in a more accurate manner on a dairy goat farm and it may also help kids to be weaned in groups.

The weaning management has direct or indirect impacts on the amount of produced milk from dams (3). The dams in the present study were milked once a day until weaning and thereafter they were milked twice daily. Goetsch et al. (25) reported that milk yield of goats is affected by milking frequency. Torres et al. (26) showed

that goats had an increase of 14% in milk yield when they were milked twice daily compared to once daily. The dams in the present study were milked once a day until individual weaning. This may be a reason for the increase in milk yield of the X3 dams in this study, although the differences were not significant (Table 5). Researchers have reported that early weaning could provide more marketable milk in a dairy goat flock. Peixoto et al. (8) reported significant increases in marketable milk in dams whose kids were weaned at 50 days of age compared to 60 and 70 days of age. Similarly, Paez Lama et al. (21) reported that kids could be weaned at 30 days of age and with that a 32.7% increase in the amount of marketable milk was achieved. In another study, it was demonstrated that the milk yield of Norwegian dairy breed goats was significantly affected by the kid-rearing strategies in the preweaning period (27).

Mioč et al. (28) reported that the lactation milk yield in dams of Saanen kids weaned at 32 days of age was 724.4 kg. This value is higher than the values determined in the present study for the same breed. The milk yield of X3 and X4 dams seems to be at an acceptable level compared to the other studies for the same breeds. However, it is difficult to make a direct comparison of the present results with the results of the other studies. The differences could be attributed to several factors such as pre- and postweaning management, maintenance conditions, weaning age of kids, pasture conditions, milking frequency, and feeding. Weaning of the kids when they reached 3 times heavier weight than their birth weight seems to be useful for the purposes of producing more milk from their dams on dairy goat farms.

In conclusion, the present results showed that the kids weaned when they reached three times their birth weights had desirable growth characteristics until breeding age under intensive conditions. The weaning at that time also tended to generate positive effects on the milk yields of their dams. It seems that weaning at predetermined weights based on individual birth weight could be done successfully in dairy goat breeds. In other words, individual birth weight can be used as a good criterion to wean dairy goat kids. However, further studies are needed in order to clarify the possible effects of it on milk yield characteristics of dams.

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