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Milk production and composition in captive Iberian red deer (*Cervus elaphus hispanicus*): Effect of birth date[1]

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ABSTRACT: This study describes milk production and milk composition of Iberian red deer (*Cervus elaphus hispanicus*) females (hinds) and the effect of calving date and BW change of hinds by milking over 34 wk. All hinds produced milk throughout the 34-wk study period, well over the standard lactation period. Total milk yield was 224.1 ± 21.1 L, and daily production was 0.91 ± 0.06 L. Milk yield decreased with lactation stage ($P = 0.01$) and the later a calf was born ($P = 0.008$), and it was greater in posterior quarters ($P < 0.05$). Milk yield was unaffected ($P > 0.10$) by side position or milking order of the udder. Milk production did not correlate with hind BW ($P > 0.1$). Hinds lost 4.4% BW during lactation ($P < 0.001$); losses increased the later a calf was born ($P = 0.012$). Iberian red deer milk had 11.5% fat, 7.6% protein, 5.9% lactose, and 26.7% DM. Stage of lactation affected fat ($P < 0.001$), protein ($P = 0.002$), DM ($P < 0.001$), and protein:fat ratio ($P < 0.001$), but not lactose ($P > 0.1$). These constituents became concentrated as lactation proceeded, and protein was substituted by fat. Calving date had a similar concentrating effect on fat ($P < 0.001$) and DM ($P < 0.001$), whereas it decreased lactose ($P = 0.015$) and protein ($P = 0.002$), thus producing a substitution of protein by fat (ratio of protein to fat, $P < 0.001$). Milking order of quarters or their position had no effect on milk composition ($P > 0.10$). Results suggest that milk production and milk energetic quality might increase by advancing calving date in red deer hinds.

Key Words: Lactation Curves, Milk Composition, Milk Production, Red Deer

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Introduction

Lactation in red deer (*Cervus elaphus*) usually lasts 4 mo (Clutton-Brock et al., 1982a,b). Milk production and composition have rarely been studied in detail in deer or any other species other than cattle (Cameron, 1998). In deer, milk production has been assessed often by the double-weighing technique (Arman et al., 1974; Loudon et al., 1983; Garcia et al., 1999) and seldom by milking (Arman et al., 1974; Krzywinski et al., 1980). Results from double weighing are more variable than from milking (Beal et al., 1990), and the two methods can produce differing lactation curves (Landete-Castillejos et al., 2000).

Milk is known to become concentrated as lactation proceeds in cattle (Auldist et al., 1998), although it does not affect all components in the same way. Deer milk contains from 6 to 11% fat, 6 to 10% protein, 3 to 5% lactose, and 19 to 26% DM (Robbins et al., 1987).

A number of factors should be considered when assessing lactation performance, and changes in maternal BW and milk composition are the most important (Oldham and Friggens, 1989). In deer, one of these factors is birth date: Hinds shift from BW gains to losses during lactation, the later they breed, and their calves gain more weight at the peak of lactation, the earlier they are born (Adam and Moir, 1987). In addition, the heaviest calves at birth are those born earliest (Fisher et al., 1989). Nevertheless, there are no data describing the effects of birth date on milk production or composition in deer.

Our objective was to estimate the daily milk production and composition in Iberian deer by milking up to wk 34 (well beyond natural weaning) and to assess milk

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production and composition differences among udder quarters. Other objectives were to assess the effect of birth date, mean hind weight, and its change over lactation. Reported experiments complied with current animal welfare legislation and other welfare guidelines (ASAB, 1991).

Methods

Subjects were 14 Iberian hinds (*Cervus elaphus hispanicus*) with 12 at 5 yr of age and two at 2 yr of age. Animals were kept in a 5,000-m^2 open-door enclosure, in conditions similar to those mentioned in Garcia et al. (1999). Two-year-old hinds were included in the analysis to increase sample size, as the number of successfully gestating hinds was lower than expected. Also, although their body size was close to the lower limit of the 5-yr-old weight range (74.6 ± 2.9 vs 83.5 to 108.8 kg), their total milk production and percentage of weight lost during lactation were well within the range shown by the 5-yr-old hinds (165.7 ± 1.9 vs 64.2 to 361.5 L; and 4.5 ± 1.9 vs 0.8 to 9.4%, respectively). Calving took place between June 4 and August 12, 1998. Hind weight after calving was 94.1 ± 3.3 kg. Both during gestation and throughout lactation, hinds were fed diets based on suggestions by Brelurut et al. (1990), using barley straw and hay from barley, alfalfa, oat, and sweet beetroot (16% CP).

Hinds were milked during wk 2 of lactation and then every 4 wk up to wk 34. Weaning was enforced simultaneously in all hinds in order to keep social conditions constant throughout the experiment. Hinds were separated from their calves for 6 h (0800 to 1400) in a handling facility. Individuals were hand-milked under anesthesia until the four quarters of the udder were totally emptied, which was achieved within 10 to 60 min. Daily milk production was considered to be four times the amount collected in each trial. Milking frequency was therefore reduced to the minimum considered essential to prevent stress and potential damaging effects of the anesthesia. This was achieved using a low-dose combination of xylazine (0.5 mg/kg BW; Seton 2%, Calier, Barcelona, Spain) and ketamine (1 mg/kg; Imalgene 100, Menial, Lyon, France) delivered by i.v. injection. After inducing anesthesia, 10 I.U. of oxytocin were injected in the right jugular vein 1 min before milking was started. After milking was finished, anesthesia was reversed with a yohimbine injection (0.25 mg/kg BW; Sigma Chemical Co., St. Louis, MO). Hinds were weighed weekly in a ±50-g electronic balance.

A 30-mL sample of milk from each quarter was collected for chemical analysis. Milk analyses were carried out in an automatic milk analyzer Milkoscan series 4000 (Foss Electric, Hillerød, Denmark) based on infrared spectrophotometry, which uses traditional regression equations for fat, protein, and lactose. Samples were diluted by 50% to adjust their composition to the calibration range of the analyzer.

Statistical Analysis

A repeated measures ANOVA was performed to test the effect of stage of lactation on milk production, each of the milk components separately, and hind BW on the date of milking. The test also examined effects of the following factors and covariables: order of quarter milked, their anterior/posterior and left/right position (except when analyzing hind weight), and calving date with respect to the first calf born. Data were controlled for sex (factor) and birth weight (covariate) of calves. Consecutive milkings were analyzed with the appropriate orthogonal contrasts.

Production data were fitted to a gamma production curve as described by Wood (1967) in order to obtain estimates for a standard period of 105 d (which may be considered a standard lactation in natural conditions).

Differences between calving dates for each stage of lactation were assessed by classifying hinds into early (d 1 to 20) and late calvers (d 33 to 70). These differences were determined using Student's *t*-tests. The effect of hind weight on milk production and other pairs of variables were analyzed using bilateral Pearson correlations.

Results

Milk Production and Hind BW Change

All hinds produced milk for the 34 wk of the study period (i.e., longer than the standard length of lactation in natural conditions). One of the hinds continued producing milk during the whole period despite losing its calf at wk 7. This hind's data were included in the analysis because her milk production (258.9 L, estimate from gamma function for 34 wk) was above the mean and thus, representative of the species.

Total milk production for 34 wk (computed by the Fleischmann method, i.e., yield for period i to i + 1 = (yield $week_i$ + yield $week_{i+1}$)/2) was 224.1 ± 21.1 L (215.5 ± 20.5 L estimated by fitting data to a gamma function), whereas daily milk production was 0.91 ± 0.06 L (mean ± pooled SE). The milk production for a standard period of 105 d was 147.0 ± 13.1 L (approximately the length of the lactation period in Iberian red deer in natural conditions), which may be considered as the amount of milk available for calf growth during a standard lactation. The correlation between total milk production and mean BW was not significant (r = 0.31, $P > 0.1$), nor was the correlation between hind BW after calving and birth date (r = –0.13, $P > 0.1$). Hinds lost BW during lactation in all cases, with a mean value of 4.0 ± 0.6 kg ($P = 0.02$), which constituted 4.4 ± 0.8% of their BW (mean BW during lactation 92.7 ± 2.9 kg). Body weight of hinds was greater from wk 2 to 14 than at wk 34 ($P = 0.04$), and BW was affected by calving date ($P = 0.02$). Thus, BW losses were smaller in hinds calving early than in those calving late (–3.4 vs –4.9 kg). In addition, calving date and total milk production showed a strong negative correlation (r = –0.87; $P < 0.001$).

Table 1. Milk collected (oxytocin-induced milking under anesthesia) from Iberian red deer measured by milking each udder separately (mL; mean ± pooled SEM)

Week of lactation	Udder quarter[a] AL	PL	AR	PR	Daily total[d]
2	379 ± 26[b]	673 ± 61[c]	437 ± 48[b]	616 ± 72[b,c]	2104 ± 125*
6	306 ± 45	399 ± 46	299 ± 42	433 ± 43	1439 ± 91
10	246 ± 30	381 ± 52	263 ± 37	361 ± 43	1251 ± 87*
14	198 ± 39	248 ± 33	174 ± 30	236 ± 28	842 ± 65
18	162 ± 26	226 ± 29	151 ± 27	216 ± 27	755 ± 55*
22	117 ± 24	173 ± 22	125 ± 21	168 ± 24	583 ± 47
26	98 ± 19	145 ± 17	108 ± 19	159 ± 23	509 ± 40
30	96 ± 21	130 ± 22	91 ± 21	135 ± 23	432 ± 44*
34	59 ± 15	83 ± 14	52 ± 13	82 ± 11	264 ± 26
Overall[e]	178 ± 12[b]	286 ± 20[c]	180 ± 14[b]	280 ± 19[c]	914 ± 61

[a]AL, anterior left; PL, posterior left; AR, anterior right; PR, posterior right.
[b,c]Within a row, means with different superscripts differ ($P < 0.05$). Row values without superscripts do not differ ($P > 0.10$).
[d]Contrasts the difference between current and cell below. *Indicates total differences at $P < 0.05$.
[e]No interaction between udder quarter and week of lactation was found.

Table 1 shows the change in daily milk production throughout lactation specified for each quarter. Daily milk production decreased continuously during lactation ($P = 0.01$) from 2,104 mL at wk 2 to 264 mL at wk 34. Differences in milk production achieved significance ($P < 0.05$) between wk 2 and 6, 10 and 14, 18 and 22, and 30 and 34 (Table 1). These decreases in milk production did not remain stable during lactation and were greatest at the beginning (31.6%, wk 2 to 6), between wk 10 and 14 (32.7%), and at the end of the study period (38.9%; wk 30 to 34).

Anterior quarters (AR and AL) produced less milk ($P < 0.05$) than posterior quarters (PR and PL; Table 1), although within-week differences were only detected at wk 2 of lactation. There were no differences ($P > 0.10$) between sides or due to milking order ($P = 0.09$).

Milk yield decreased as calving date was delayed (introduced in the analysis as a continuous variable; $P = 0.008$). Figure 1 shows the effect of calving date, classifying births in two classes: early (d 1 to 20) and late births (d 33 to 70). Milk production was 83.7% greater in hinds calving early ($P < 0.05$ for all within-week comparisons). This difference increased as lactation proceeded (48.2%, wk 2; 127.1%, wk 34).

Milk Composition

Table 2 shows the evolution of the main milk components for the 34-wk study period. Fat averaged 11.5% over the 34-wk period and 9.5 ± 0.2% (mean ± pooled SE per hind) for a 14-wk standard lactation (i.e., the first 14 wk of the study). Fat increased significantly with lactation stage ($P < 0.001$; Table 3). Percentage fat increased, after a slight decrease from wk 2 to wk 4, from 9.0% (wk 2) to 14.4% (wk 34). Milkings differed ($P < 0.05$) in fat percentage between wk 6 and 10, wk 18 and 22, wk 22 and 26, and wk 30 and 34.

Milk protein also increased with stage of lactation ($P = 0.002$), showing a similar trend to that for fat (6.8%, wk 2; 8.8%, wk 30). Mean protein percentage averaged 7.6% for the 34-wk period (Table 2) and 6.7 ± 0.1% for a 14-wk standard lactation. Protein values differed ($P < 0.05$) between wk 6 and 10, and wk 26 and 30.

The protein:fat ratio was affected ($P < 0.001$) by lactation stage, and protein was substituted by fat over the lactation period (protein:fat × 100: wk 2, 78.0; wk 34, 61.5). There were significant differences between wk 2 and 6, wk 18 and 22, wk 22 and 26, wk 26 and 30, and wk 30 and 34. Protein:fat ratios averaged 65.3 for the 34-wk period, and 72.3 ± 1.5% for a 14-wk standard lactation.

In contrast to fat and protein, lactose did not change with stage of lactation ($P > 0.1$), with a mean value of 5.9% for the 34-wk-period and 6.0 ± 0.0% for a 14-wk

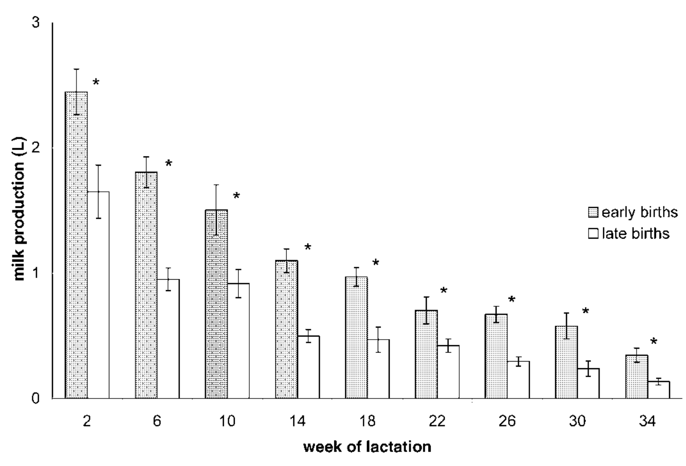

Figure 1. Effect of birth date on milk production. Hinds were classified by calving date in early (d 1 to 20 with respect to the first calf born) and late breeders (d 33 to 70). Differences ($P < 0.05$) between both groups within week are indicated by an asterisk. Milk was collected by oxytocin-induced hand-milking under anesthesia.

Table 2. Milk composition (%) of fat, protein, lactose, DM, and protein:fat ratio (× 100) during lactation. Milk was collected by oxytocin-induced hand-milking under anesthesia. Data are mean ± SE based on 14 Iberian hinds

Week of lactation	Component				
	Fat	Protein	Lactose	Dry matter	Protein:fat
2	9.0 ± 0.4	6.8 ± 0.2	5.8 ± 0.1	23.0 ± 0.5	78.0 ± 3.7*
6	8.3 ± 0.2*	6.3 ± 0.1*	6.2 ± 0.1	22.6 ± 0.3*	77.0 ± 1.5
10	9.8 ± 0.2	6.6 ± 0.1	6.0 ± 0.1	24.2 ± 0.2	67.5 ± 1.8
14	11.1 ± 0.4	7.2 ± 0.1	5.9 ± 0.1	26.1 ± 0.3	66.2 ± 2.8
18	12.2 ± 0.4*	7.6 ± 0.1	5.9 ± 0.1	27.5 ± 0.5*	63.4 ± 2.3*
22	13.2 ± 0.5*	7.9 ± 0.3	5.7 ± 0.1	28.7 ± 0.8	60.2 ± 0.9*
26	13.8 ± 0.4	8.5 ± 0.2*	5.7 ± 0.1*	29.7 ± 0.5	62.3 ± 2.6*
30	13.3 ± 0.4*	8.8 ± 0.2	5.8 ± 0.1	29.8 ± 0.5*	67.2 ± 2.5*
34	14.4 ± 0.6	8.7 ± 0.2	5.5 ± 0.1	30.5 ± 0.6	61.5 ± 2.6
Means	11.5 ± 0.2	7.6 ± 0.1	5.9 ± 0.0	26.7 ± 0.3	65.3 ± 1.0

*Indicates differences ($P < 0.05$) from the following milking.

period. There were differences ($P < 0.05$) only between wk 26 and 30.

Dry matter, as expected, showed a similar trend to that for fat and protein ($P < 0.001$), and achieved a mean value of 26.7% for the 34-wk period and 24.0 ± 0.3% for a standard 14-wk lactation. There were significant differences between wk 6 and 10, 18 and 22 and between wk 30 and 34.

Correlation coefficients were computed among milk constituents and production variables (Table 3). The most intriguing correlations were the negative relationship between daily production and fat content ($r = –0.54$; $P < 0.05$) and between fat and lactose percentages ($r = –0.66$, $P < 0.01$). Dry matter showed an obvious positive correlation ($P < 0.05$) with fat and protein and a negative correlation with lactose.

In addition to the effect of lactation stage on each of the milk constituents, we assessed the effect of udder quarter and calving date. There were no effects ($P > 0.10$) of milking order or quarter position on any milk component. In contrast, calving date affected content in fat ($P < 0.001$), protein ($P = 0.002$), protein:fat ratio ($P < 0.001$), lactose ($P = 0.015$), and DM ($P < 0.001$). Within stage of lactation, there were differences ($P < 0.05$) between early and late calvers in fat, lactose, and DM at wk 14 between protein and lactose on wk 26 (Figure 2). Late calvers had higher fat and DM and lesser lactose and protein.

Discussion

Our results show that hinds continue lactation for longer than their natural period if they do not mate. Thus, the extension of lactation until the following rut reported by Clutton-Brock et al. (1982a,b) for some unmated hinds may be a general process that does not depend on the body condition or milk production capacity of the mother or on birth date or development stage of the calf. This strategy of continued milk production if the hind does not mate might serve to increase survival chances of the calf at little extra cost for the mother (Clutton-Brock et al., 1982a). Also, the fact that the hind whose calf died at 7 wk continued producing milk during the whole lactation seems to suggest that cross-suckling in deer might occur at relatively high frequen-

Table 3. Correlations between milk production and composition and calving date

Item		Daily production	Fat	Protein	Lactose	Dry matter	Protein:fat (× 100)
% Fat	r	–0.537					
	P	**0.048**					
% Protein	r	–0.059	0.318				
	P	0.840	0.268				
% Lactose	r	0.348	–0.661	–0.297			
	P	0.223	**0.010**	0.303			
% Dry matter	r	–0.503	0.918	0.641	–0.557		
	P	0.067	**0.001**	**0.013**	**0.039**		
Protein:fat (× 100)	r	0.468	—	—	0.455	–0.457	
	P	0.092	—	—	0.102	0.101	
Calving date	r	–0.873	0.405	–0.179	–0.274	0.268	–.486
	P	**0.000**	0.151	0.539	0.343	0.355	.078

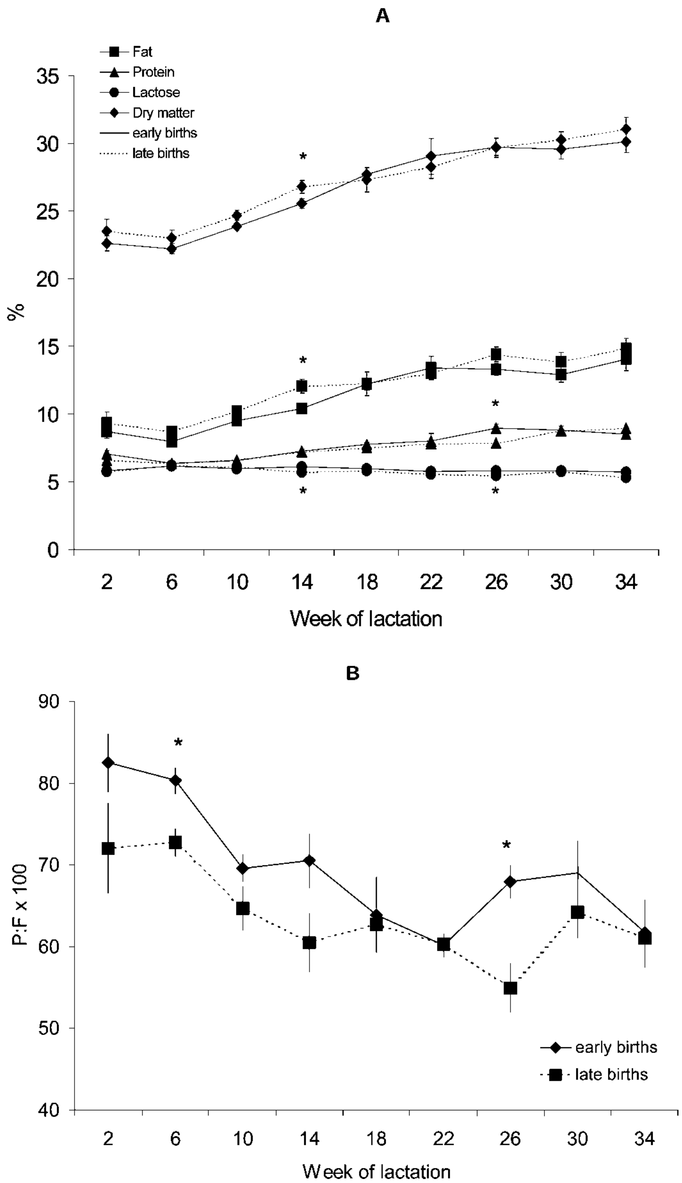

Figure 2. Changes in milk composition with stage of lactation in early (d 1 to 20 with respect to first birth) and late births (d 33 to 70; Panel A) and protein to fat ratio (P:F × 100; Panel B). Milk was collected by oxytocin-induced hand-milking under anesthesia. Differences ($P < 0.05$) between early and late breeders within week are indicated by an asterisk.

cies (a finding confirmed by our own observations, Landete-Castillejos et al. [2000]).

Hinds in this study had a type II (continuously decreasing) milk production curve. Loudon et al. (1984) found that type II lactation curves might be attributed to poorer nutrition than in hinds showing a type I (peak in their lactation curve). Both type I and II lactation curves were previously found in the same hinds used in this experiment (Garcia et al., 1999), under similar captivity and nutritional conditions when production was estimated by double weighing. In addition, milk yield was greater in our case than in the mixed curves estimated 2 yr earlier in the same individuals (147 vs 118.5 L up to d 105; Garcia et al., 1999).

The greater production in this study compared with Garcia et al. (1999) might be attributed to an increase in production from the second to the third lactation, as it has been observed in cattle up to the fourth lactation (Oldham and Friggens, 1989), to a lower estimate of double weighing compared with milking or to an increase in BW between studies (our unpublished data). However, the latter hypothesis does not seem very likely because milk yield reported here did not depend on hind BW.

Milk yield in this study was greater than that reported by Arman et al. (1974) in the Scottish subspecies (136.2 L in a lactation period of 150 d) and smaller than the values obtained by Loudon and Kay (1984) (171 L in 100 d), or that by Robbins et al. (1987), who reported 240 L in the North American subspecies, the wapiti. The greater milk production in the wapiti might be due to the greater size of this subspecies. Males of *C. e. hispanicus* and those of *C. e. scoticus* weigh about 120 kg, whereas *C. e. canadensis* can reach 450 kg (Haigh and Hudson, 1993). The maximum milk production recorded during the first period in this study was 2.10 L/d, which was greater than the milk production estimated for the first week in type II curves in the same individuals (1.91 L/d; Garcia et al., 1999). This is also within the wide range reported by Arman et al. (1974) for type II curves (1.2 to 2.5 L/d). Loudon et al. (1983, 1984), however, found initial production values ranging from 1.4 to 1.6 L/d in type II curves obtained from hinds feeding on poor pastures. The maximum value is even greater than the peak obtained by Loudon et al. (1983, 1984) type I curves of hinds feeding on good fertilized pastures (2.20 L/d), whereas it is within the wide range of peak values obtained by Krzywinski et al. (1980), also reporting type I curves.

Milk production by quarter was greater in rear than in anterior quarters, but there were no differences by side or due to milking order. The greater production in the posterior quarters is likely due to their greater size.

Hinds also showed a slight but significant trend to lose BW during lactation. This contrasts with results reported by Loudon et al. (1983), who did not find significant weight changes during lactation. Loudon et al. (1984) indicated, although no statistics were provided, that hinds lose BW at the beginning of lactation and recover it later, depending on available food resources. Clutton-Brock et al. (1982a) also found that hinds show a very apparent loss in body condition over lactation. The loss in BW compared with the last week of our study was only significant over the 14-wk period that lactation usually lasts. Contrary to what was expected, those hinds that produced less milk were those that suffered the greater body losses. This might be a side effect of calving date: The late-calving hinds produced less milk, yet suffered greater losses in BW, which suggests that they made a greater effort despite their smaller yield. This is consistent with findings by Adam and Moir (1987), who found that the hinds calving early increase weight during lactation whereas those calving late lose weight. They also reported greater calf gains in the first calves born (Adam and Moir, 1987; Fisher et al., 1989), which suggests that there was an effect of calving date on milk production.

A moderate variability in milk composition in *C. elaphus* is reported in the literature. Fat content in the milk has been reported to be 10.6% (Arman et al., 1974), 11.2% (Krzywinski et al., 1980), ranging from 9.5 to 12.8% in hinds under different nutrition planes (Loudon et al., 1984), and as low as 7.7% (Csapo et al., 1987). Our results averaged 11.5%. Our highest fat concentrations were found following the 14-wk milking, which was after the end of a normal lactation period, and ranged from 12.2% at wk 18 to 14.4% at wk 34. During the 14-wk early lactation period, fat content ranged from 8.3% (wk 6) to 11.1% (wk 14).

Protein content in the milk of *C. elaphus* has been reported to be 7.5% (Arman et al., 1974), 7.4% (Krzywinski et al., 1980), ranging from 7.2 to 8.1% in hinds under different nutrition planes (Loudon et al., 1984), and as low as 7.1% (Csapo et al., 1987), compared with our results averaging 7.6% and ranging from 6.3 to 8.8%. Similar to fat content, our highest protein concentrations were found following the 14-wk milking, which was after the end of the normal lactation period, and ranged from 7.6% at wk 18 to 8.8% at wk 30. During the 14-wk early lactation period, protein content ranged from 6.3% (wk 6) to 7.2% (wk 14). Stage of lactation is an important variable, increasing both protein and fat content of the milk of *C. elaphus* during lactation, as it occurs in bovine (Auldist et al., 1998).

Milk lactose in *C. elaphus* has been reported to be 4.5% (Arman et al., 1974) and 4.7% (Krzywinski et al., 1980). Our results averaged 5.9% lactose and ranged from 5.5% (wk 34) to 6.2% (wk 6). There was no obvious influence of the stage of lactation on milk lactose in our experiment, yet milk lactose content was higher in our study than found by others.

Dry matter in the milk of *C. elaphus* has been reported to be 23.9% (Arman et al., 1974), 25.6% (Krzywinski et al., 1980), and as low as 19.6% (Csapo et al., 1987) compared with our results, averaging 26.7% and ranging from 22.6% (wk 6) to 30.5% (wk 34). Similar to our data for fat and protein content, DM content was highest following the 14-wk sample and ranged from 27.5% (wk 18) to 30.5% (wk 34). During the 14-wk early lactation period, DM ranged from 22.6% (wk 6) to 26.1% (wk 14). Stage of lactation again plays an important role in DM content of the milk of *C. elaphus*, as it should because protein and fat are principal constituents of milk DM and correlate positively with it.

The differences in milk composition and different trends of milk constituents during lactation found in the few studies published might be due to using a few individuals and the different housing and handling conditions for each study. Thus, Arman et al. (1974) used six hinds isolated in small enclosures, Krzywinski et al. (1980) and Csapo et al. (1987) used five hinds, and Loudon et al. (1984) used four hinds allocated on two types of pastures differing in their nutritional value. The small sample size might also explain the lack of statistical analysis conducted in most studies (Arman et al., 1974; Krzywinski et al., 1980) or lack of significant trends (Csapo et al., 1987).

The increase in percentages of fat, protein, and DM during lactation might be an attempt to counterbalance the reduction in energy transfer that would otherwise be derived from the reduction in milk production. A similar increase in fat, protein, and DM has been reported during a standard lactation (Arman et al., 1974), or after it, from September to March (Krzywinski et al., 1980).

In addition to the components mentioned above, the protein:fat ratio decreased with stage of lactation, in contrast to the lack of a similar trend in bovine (Auldist et al., 1998). Such a decrease is likely due to the greater protein needed at the beginning of calf growth, as muscles are developed earlier than fat tissues (Hammond, 1961), whereas, at the end of lactation, deer calves may have a greater need to accumulate fat reserves to face the winter. This pattern may have disappeared in cattle as a result of both artificial selection for a standard quality milk and the independence from external ecological factors.

Calving date increased milk component concentration, particularly that of fat and protein, which again suggests an attempt to counterbalance the loss in energy transfer arising from the reduction in milk yield due to calving delay. Thus, fat, the main energetic component of the milk, showed an overall negative correlation with milk production. One of the most interesting effects of calving date on milk composition is that of protein substitution by fat with increasing lactation period. Because of the protein needs of deer calves during their early growth, such substitution might explain the reduced growth observed in late born calves (our unpublished data).

Implications

The growth of deer calves during the first year of life is strongly correlated with the milk production of its mother, but this is not correlated with hind size. Therefore, using body weight as a criterion to select the best hinds for reproduction is not, at the moment, justified. In contrast, because milk yield is often highly heritable, the selection of hinds should be made based on production records estimated by milking. The effect of calving date on milk yield encourages advancing the breeding season in deer whenever possible. Moreover, the reduced milk production in the last weeks of lactation suggests that lactation should not be prolonged over three months. In addition, the supplement in protein for the dams during the first stages of lactation may be of primary importance to boost calf growth, as this is the time of greatest growth rates.

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