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Factors associated with ruminal pH at herd level

T. Geishauser,*[1] N. Linhart,† A. Neidl,† and A. Reimann†
*19 Varden Drive, Guelph, Ontario N1G 1W8, Canada
†Milch-Land GmbH, 98669 Veilsdorf, Germany

ABSTRACT

The objective of this study was to evaluate factors associated with ruminal pH at herd level. Four hundred and thirty-two cows of a Thuringian dairy herd were sampled before claw trimming using a rumen fluid scoop. Volume and pH of the rumen sample were measured, and lactation number, percentage of concentrates in the ration, days in milk (DIM), time of day, and daily milk yield were recorded. Rumen sampling was successful in 99.8% of the cows. The average sample volume was 25 mL. Rumen sample pH decreased with increasing percentage of concentrates in the ration. Ruminal pH decreased from calving to 77 DIM, and grew subsequently to 330 DIM. During the day, rumen pH followed a sinus curve, with maxima in the morning (0915 h) and afternoon (1533 h), and a minimum around noon (1227 h). Ruminal pH decreased with increasing daily milk yield. Lactation number interacted with daily milk yield on rumen pH. The percentage of concentrates in the ration, DIM, time of day, and daily milk yield were significant factors affecting ruminal pH at the herd level.
Key words: rumen, pH, dairy, herd

INTRODUCTION

Studying ruminal pH at herd level may help to identify risk factors of subacute ruminal acidosis in dairy herds (Oetzel, 2004). Nevertheless, studies on rumen pH at herd level seem to be scarce, whereas rumen pH has been studied intensely at the individual cow level (Kaufmann, 1972; Morgante et al., 2007; Kleen et al., 2009). Ration composition, time of feed intake, and sampling location may determine ruminal pH in individual samples (Kaufmann, 1972; Duffield et al., 2004). However, it seems unclear when to expect low ruminal pH along lactation. It was hypothesized that ruminal pH may be low at onset and in midlactation (Kleen et al., 2003). In individual cows, the highest rumen acidosis incidence was reported in the first month after calving with a subsequent decrease (Gröhn and Bruss, 1990).

Rumen samples may be taken via the esophagus or via the abdominal wall (Geishauser, 1987). Among ororuminal procedures, the ones by B. Hofírek (Hofírek, 1970) and R. Hamburger (Zwick and Klee, 1997) seem practical for serial sampling. Acquisition of rumen samples via abdominal wall (rumenocentesis) requires more effort in preparing the animal and may constitute a health risk (Hollberg, 1984; Garrett et al., 1999; Duffield et al., 2004; Strabel et al., 2007).

To ease rumen fluid acquisition in cows, Hofírek (1970) used a head with lateral openings screwed onto a Thygesen probe. Without applying any vacuum, rumen fluid entered the head on its own through the openings. This rumen fluid scoop was inserted via the esophagus into the rumen and left there for 10 to 20 s. After withdrawal of the scoop, the head was unscrewed and emptied. In 565 applications, 551 (98%) rumen samples were collected this way. With a capacity of 95 mL, on average, 71 mL of fluid was sampled. The pH of rumen fluids sampled in this manner did not differ significantly from fluids acquired with the rumen sampling device by V. Sørensen and P. Schambye (Thygesen, 1939; Sørensen and Schambye, 1955; Hofírek, 1970). The Sørensen-Schambye samples were, on average, 0.51 units higher in pH than the rumenocentesis samples (Hofírek and Haas, 2001). Saliva contamination and differing sampling location may explain the higher pH in ororuminal samples (Wagner and Elmer-Englhard, 1988; Duffield et al., 2004).

To lower saliva contamination of the rumen sample, R. Hamburger added a mechanism to shut the scoop head: a short piston with a rubber lip distal to the openings and a pressure spring closed the entry to the inner head. Access to the inner head was given by pulling a wire running through spring and scoop proximally and attached to the piston. In 20 applications, the head was located in 85% of the cases in the ventral ruminal sac; in 10% of the cases it was in the reticulum, cranial ruminal sac, and proximal part of the ventral ruminal sac; and was not located, despite use of a magnet and compass, in 5% of the cases. With a capacity of 40 mL, more than 20 mL of rumen fluid was collected in 98% of 117 applications. The pH in these samples did not differ

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[1]Corresponding author: tgeishauser@sentex.net

Figure 1. Rumen fluid scoop.

significantly from the pH of samples acquired with the rumen sampling device by G. Dirksen (Dirksen, 1975; Zwick, 1996; Zwick and Klee, 1997). The present study used an all-metal piston long enough to cover all openings and a handgrip attached to the wire. The scoop had a total length of 2.7 m. The head was 21 cm long, had a diameter of 30 mm, and 18 openings of 8-mm each. The capacity of the head was 40 mL (Figures 1, 2, 3, and 4).

The objective of this study was to evaluate the effects of age, ration composition, stage of lactation, time of day, and daily milk yield on ruminal pH in a dairy herd. It was hypothesized that age (first research hypothesis), ration composition (second research hypothesis), stage of lactation (third research hypothesis), time of day (forth research hypothesis), and daily milk yield (fifth research hypothesis) affect ruminal pH.

MATERIALS AND METHODS

This study was conducted in a Thuringian dairy herd with 1,147 cows (Milch-Land GmbH, Veilsdorf, Germany) before claw trimming. This herd was selected because it was large enough, the general management was willing to cooperate, and a claw trimming date was pending. All rumen samples were collected with the cows fixed in a claw-trimming chute, right before claw trimming. Eight workers of a claw-trimming company (Klauenpflege Findeisen GmbH & Co. KG, Woldegk, Germany), trimmed the claws of all cows using 4 chutes, on 5 consecutive days, and throughout each day. The workers allowed access to each cow in turn, thus making sampling systematically random (Dohoo et al., 2003). The cows were presented for claw trimming in groups.

The herd was kept in 16 groups put together by age, DIM, milk yield, and health. Fifteen groups were offered a total of 4 rations that differed in the percentage of concentrates (23.5–38%) on a DM basis. The basic feed of the TMR was corn silage, to which the cows had free access. The TMR was allocated 4 times during the day at 0715 to 0750 h, 0825 to 0900 h, 1005 to 1050 h, and 1300 to 1340 h, and correspondingly, 4 times during the night. One group was kept on pasture without any access to concentrates.

The following data were recorded from each cow: number of examination day, breed (0 = Holsteins; 1 = others), age (n calvings), ration composition (% of concentrates in the ration), calving date (day, month, year), examination date (day, month, year, hours:minutes), stage of lactation (examination date minus calving date; DIM), daily milk yield on previous day (kg), increased salivation (saliva discharge from the mouth) during rumen sampling (0 = no; 1 = yes), head openings unclosed (at least partially) after scoop withdrawal (0 = no; 1 = yes), rumen fluid sample volume (mL), and rumen fluid sample pH.

All rumen samples were collected with 1 single scoop. One hand was positioned across the cow's nose into the tooth-free rim of the jaw and tickled the palate until the cow opened its mouth. The rumen scoop was inserted via the mouth and esophagus into the rumen, its head opened by pulling the handgrip, and closed again after 20 s by releasing the grip. After withdrawal, the head of the scoop was unscrewed, all rumen fluid present was emptied into a measuring cup, and its volume and pH was measured. The pH was determined right after sampling with a portable pH meter [pH 315i; Wissenschaftlich-Technische Werkstätten (WTW) GmbH, Weilheim, Germany]. The scoop was cleaned with tap water after each use. The head was empty of water before being inserted. Cow selection, rumen sampling and examination, data recording, and storage were performed by 2 veterinarians (N. Linhart and A. Neidl).

The data were described with the help of medians, fifth and 95th percentiles, minima and maxima, or frequency distributions. Minutes were transformed into decimal units. The findings of stage of lactation, time of day, daily milk yield, rumen fluid volume, and rumen fluid pH were categorized for description (descriptive statistics; Kreienbrock and Schach 2005). Regression analysis was used to evaluate the univariable effect of breed, age, ration composition, stage of lactation,

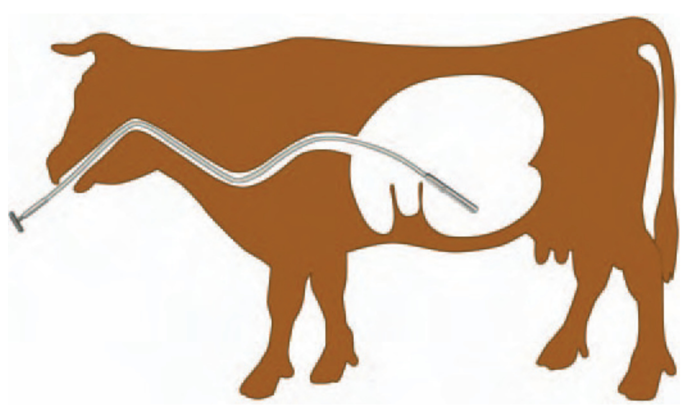

Figure 2. Rumen fluid scoop inserted via the esophagus into the ventral ruminal sac.

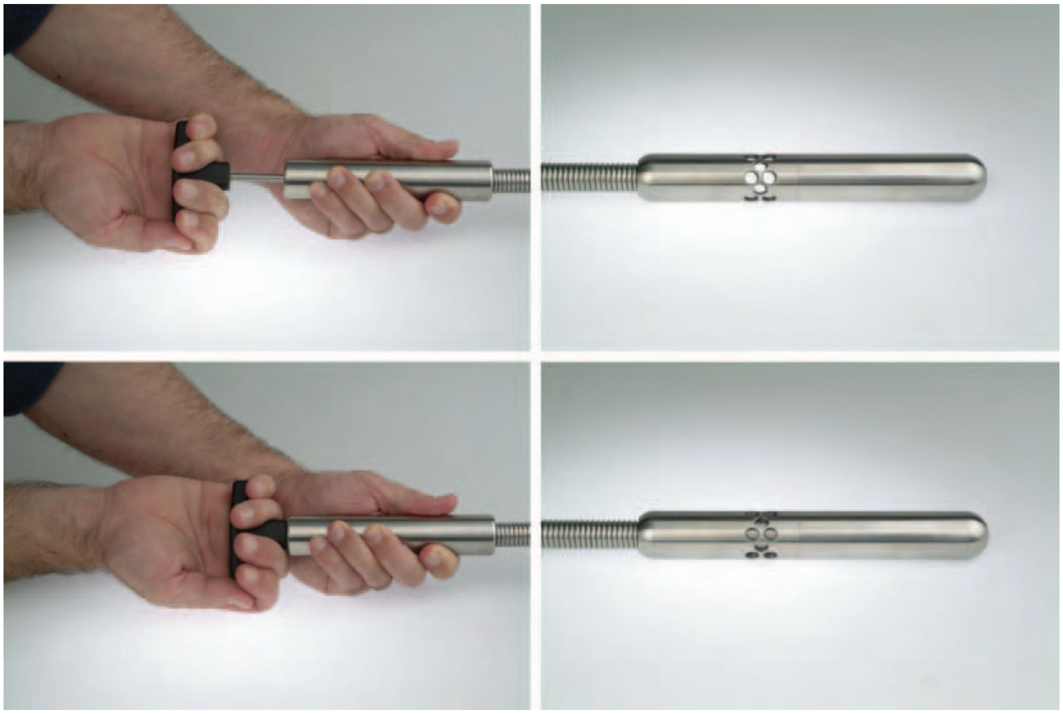

Figure 3. Pulling the handgrip opens the head openings; releasing the grip closes them.

time of day, daily milk yield, increased salivation, and unclosed head openings on rumen fluid volume or pH. Breed, salivation, and unclosed head openings were regressed as binary variables; age, ration composition, stage of lactation, time of day, daily milk yield, rumen sample volume, and rumen sample pH were regressed as continuous variables. First-, second-, third-, and fourth-order effects were evaluated for continuous variables, with lower-order variables being retained in the model when higher-order variables were found to be significant. In the final model, the highest-order explanatory variable showed significant effect. Because age affects milk yield (Tocher, 1928), the interaction of age and milk was also regressed on ruminal sample volume and pH. A stepwise selection procedure in regression analysis was used to evaluate multivariate effects of first-order variables on ruminal sample volume and pH. Selection limits for entry and stay were set at an error probability of 10% ($P = 0.1$; inductive statistics; Dohoo et al., 2003). All calculations were performed using SAS and all regression analyses were performed using the REG procedure (SAS Institute, 2009). Error probability was limited to 10% ($P < 0.10$). Associations of second or higher order were graphed.

Figure 4. Head unscrewed. Capacity: 40 mL.

RESULTS

The study was performed from June 8 to 12, 2009, between 0746 and 1656 h. An average of 84 (60–110) cows were rumen sampled per day immediately before claw trimming. Rumen fluid was collected from a total of 432 cows (38% of all cows in the herd) over 35:43

Table 1. Anamnesis of 432 cows from whom rumen samples were sampled [parameters, categories, and percentages (%) are given]

			Time of day (h)	
Parameter	Category	%	From	To
Examination day (no.)	1	14	1106	1558
	2	22	0755	1634
	3	21	0746	1546
	4	25	0756	1656
	5	18	0751	1400
Breed (0 = Holsteins, 1 = others)	0	98		
	1	2		
Age (n calvings)	1	38		
	2	28		
	3	18		
	4	9		
	5	5		
	>5	2		
Percentage of concentrates in the ration (%)	38.0	35		
	33.0	19		
	29.5	33		
	23.5	8		
	0.0	5		
Stage of lactation (DIM)	<30	21		
	30 to <60	6		
	60 to <90	5		
	90 to <120	8		
	120 to <150	6		
	150 to <180	8		
	180 to <210	11		
	210 to <240	10		
	240 to <270	6		
	270 to <300	8		
	300 to <330	3		
	330 to <360	5		
	360 to <390	2		
	390 to <420	1		
	≥420	2		
Time of the day (h)	0700–0800	2		
	0800–0900	13		
	0900–1000	13		
	1000–1100	12		
	1100–1200	5		
	1200–1300	12		
	1300–1400	17		
	1400–1500	11		
	1500–1600	11		
	1600–1700	3		
Daily milk yield (kg)	<10	1		
	10 to <15	5		
	15 to <20	11		
	20 to <25	23		
	25 to <30	23		
	30 to <35	18		
	35 to <40	12		
	40 to <45	5		
	≥45	2		
Salivation (0 = no, 1 = yes)	0	70		
	1	30		
Head openings (0 = closed, 1 = open)	0	45		
	1	55		

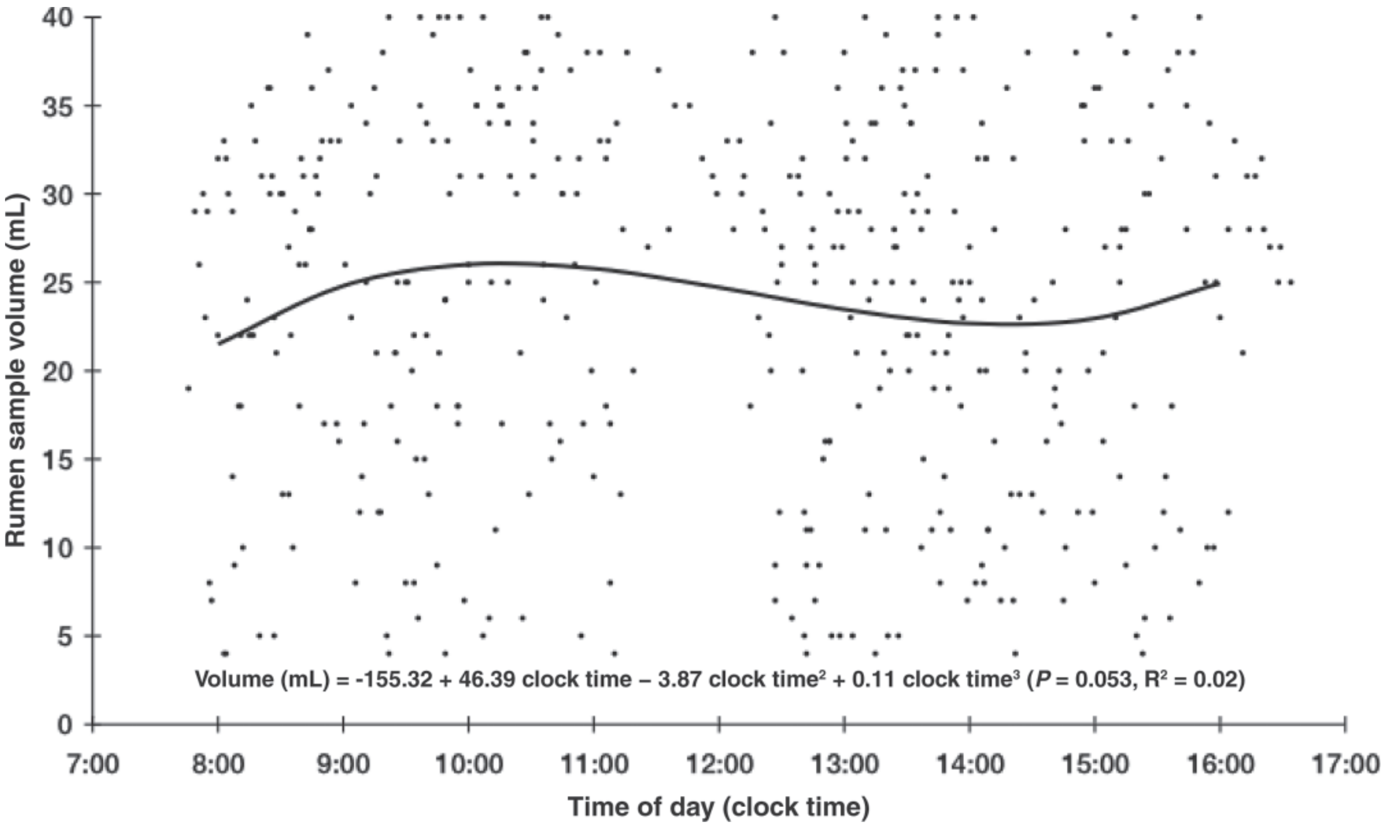

Figure 5. Rumen sample volume versus time of day. Note: Particularly high volumes sampled between 1000 and 1030 h, particularly low volumes between 1330 and 1500 h.

h (an average of 12 cows per hour). In 9 cows (2%), the scoop head initially entered the trachea. After correcting its position, rumen fluid was collected. In 1 cow (0.2%), no rumen fluid was withdrawn, even after correction. This cow was removed from the study. Studied cows were 98% Black Holsteins, and 98% had calved 1 to 5 times. Ninety-five percent of the cows studied were fed concentrates. Ninety-five percent of rumen fluids were sampled between 0800 and 16:00 h (5 to 17% per hour). Twenty-one percent of the cows studied were in mo 1 of lactation. Cows had yielded, on average, 26.8 kg of milk on the previous day (5–95th percentiles: 14.5–41.7, minimum–maximum: 8.1–52.2 kg). Thirty percent of the cows showed increased salivation during rumen sampling. In 55% of the samplings, the head openings were unclosed (at least partially) after withdrawal of the scoop (Table 1). On average, 25 mL of rumen fluid was collected (5–95th percentiles: 6–38, minimum–maximum: 4–40 mL). In all cases, the volume was sufficient to determine the pH. The average pH was 6.635 (5–95th percentiles: 6.29–7.08, minimum–maximum: 5.94–7.42).

Sample volume was not affected by examination day, breed, or percentage of concentrates in the ration. Stage of lactation had little effect. Volume, however, increased with each calving by 0.7 ± 0.4 mL, and with each kilogram of daily milk yield by 0.1 mL. Age did not interact with milk yield on volume. Over the course of the day, sample volume followed a sinus curve, increasing until 1020 h, decreasing until 1420 h, and increasing subsequently. Particularly high volumes (>26 mL, on average) were sampled between 1000 and 1030 h. Particularly low volumes (<23 mL, on average) were sampled between 1330 and 1500 h (Figure 5). If the cow salivated increasingly during sampling, fluid obtained was reduced by an average of 4.3 ± 1.1 mL. If the head openings were unclosed after scoop withdrawal, the yield was 4.2 ± 1.0 mL less (Table 2). Along rumen sample pH, sample volume followed a sinus curve, increasing to pH 6.40, decreasing to pH 7.12, and increasing subsequently (Figure 6). Accounting for all variables studied, unclosed head openings (partial R^2 = 5.2%), increased salivation during rumen sampling (partial R^2 = 3.4%), rumen sample pH (partial R^2 = 1.9%) and age (partial R^2 = 0.8%) had the greatest effect on rumen sample volume (Table 3).

Sample pH was not affected by examination day, breed, increased salivation during sampling, or

Table 2. Univariate effects of parameters studied on rumen sample volume [parameters, estimates, standard errors, parameter error probability (*P*), model error probability (*P* model), and coefficient of determination (R^2 model) are given]

Parameter[1]	Estimate	SE	*P*	*P* model	R^2 model
Examination day (no.)					
Intercept	22.27609			0.13	0.005
Examination day	0.57123	0.37259			
Breed (0 = Holsteins, 1 = others)					
Intercept	24.04000			0.72	0.000
Breed	1.38857	3.90354			
Age (n calvings)					
Intercept	22.54947			0.056	0.009
Calvings	0.66513	0.34688			
Percentage of concentrates in the ration (%)					
Intercept	25.42513			0.46	0.001
Percentage of concentrates	−0.04449	0.05983			
Stage of lactation (DIM)					
Intercept	25.76239			0.16	0.009
DIM	−0.02257	0.01182	0.057		
DIM^2	0.00005	0.00003	0.089		
Time of day (clock time)					
Intercept	−155.31540			0.053	0.018
Clock time	46.39146	17.25688	0.008		
Clock $time^2$	−3.87738	1.45034	0.008		
Clock $time^3$	0.10512	0.03982	0.009		
Daily milk yield (kg)					
Intercept	21.15274			0.081	0.007
Daily milk mass	0.10631	0.06087			
Salivation (0 = no, 1 = yes)					
Intercept	25.34983			<0.0001	0.037
Salivation	−4.31108	1.05683			
Head openings (0 = closed, 1 = open)					
Intercept	26.58673			<0.0001	0.051
Head openings open	−4.62063	0.96471			
Rumen sample pH					
Intercept	−9,099.70	4,182.72		0.004	0.031
pH	4,072.35	1,879.71	0.031		
pH^2	−604.26	281.34	0.032		
pH^3	29.80	14.02	0.034		

[1]DIM^2, clock $time^2$, and pH^2 represent the second-order effects of DIM, clock time, and pH, respectively; clock $time^3$ and pH^3 represent the third-order effects of clock time and pH, respectively.

whether the head openings were closed or unclosed after withdrawal of the scoop. Age appeared to affect pH. After closer inspection, an interaction between age and milk yield explained the effect of age on pH (Table 4). An increase from 23.5 to 38% concentrates lowered the pH by 0.19 units (3%; Figure 7). Sample pH was equal on pasture (0% concentrates) and when fed 23.5% concentrates. Stage of lactation affected pH,

Table 3. Multivariate effects of parameters studied on rumen sample volume [parameters, estimates, standard errors, parameter error probability (*P*), and partial coefficient of determination (R^2 partial) are given]

Parameter	Estimate	SE	*P*	R^2 partial
Intercept	66.59	12.63		
Head openings (open vs. closed)	−4.65	0.94	<0.0001	0.052
Salivation (yes vs. no)	−3.88	1.02	<0.0001	0.034
Rumen sample pH	−6.06	1.90	<0.001	0.019
Age (n calvings)	0.66	0.33	0.047	0.008

with a decrease from calving to 77 DIM, growth until 330 DIM, and little change subsequently until 420 DIM. Particularly low pH (<6.560, on average), was measured between 55 and 100 DIM. The pH minimum was at 77 DIM (6.552). Particularly high pH (>6.741), was measured between 300 and 420 DIM. The pH maximum was at 330 DIM (6.748; Figure 8). Over the course of the day, pH followed a sinus curve, increasing until 0915 h (pH 6.787), decreasing until 1227 h (pH 6.680), and increasing until 1533 h (pH 6.797). The pH maximum was at 1533 h (Figure 9). The pH decreased with increasing daily milk yield, reaching a minimum at 42 kg (pH 6.590; Figure 10). With increasing sample volume, the pH first decreased and then increased, reaching a minimum at 24 mL (pH 6.600). The pH was 0.1 higher when the volume was 11 or 39 mL, and 0.2 units higher when the volume was 6 mL (Figure 11; Table 4). Increased salivation during sampling, unclosed head openings after scoop withdrawal, and their interaction did not affect the association between sample pH and volume. Accounting for all variables studied, stage of lactation (partial R^2 = 5.8%), time of day (partial R^2 = 3.5%), rumen sample volume (partial R^2 = 1.7%), and age (partial R^2 = 0.8%) had the greatest effect on rumen sample pH (Table 5). Although significant, associations were rather weak (low R^2).

DISCUSSION

The rumen scoop collected sufficient rumen fluid volumes to determine pH in 99.8% of the cows and 98% of the applications. This is in accordance with the findings of others who used rumen fluid scoops and yielded sufficient rumen fluid in 98% of applications (Hofírek, 1970; Zwick, 1996). Rumen fluid yield increased with age and daily milk yield. This seems explainable in so far as feed intake increases with age and milk yield (Piatkowski et al., 1990; Kramer et al., 2008). Sample volume followed a sinus curve during the day: particularly high volumes may be expected between 1000 and 1030 h, and particularly low volumes between 1330 and 1500 h. This is in line with earlier findings indicating that rumen fluid may be pumped off most rapidly around 1000 h (Geishauser, 1990) and the output may be lower at noon or in the evening than before morning feeding (Stöber and Tiefenbach, 1958). Increased salivation during sampling and unclosed head openings after scoop withdrawal lowered the rumen fluid yield. The degree to which salivation represents a surrogate

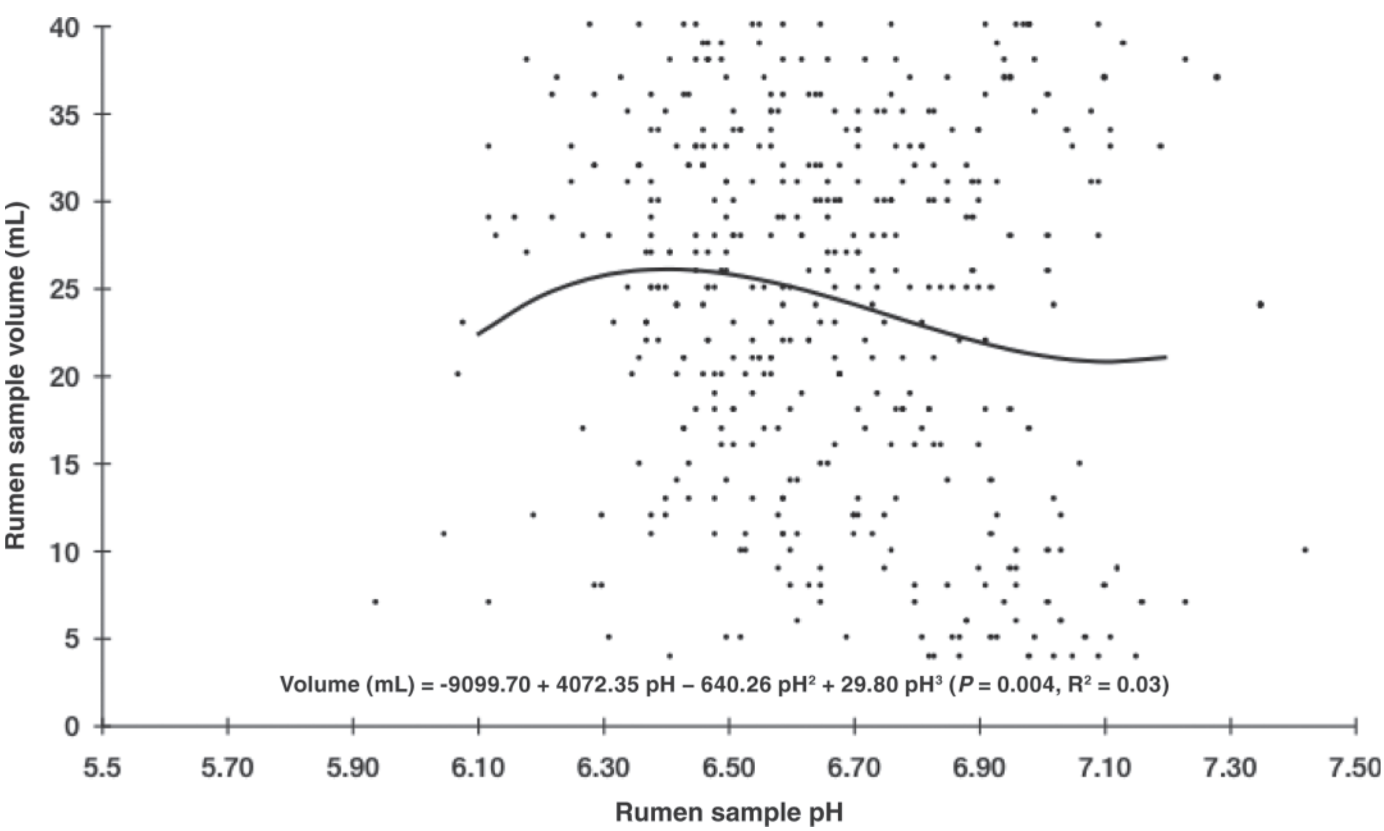

Figure 6. Rumen sample volume versus rumen sample pH. Note: volume maximum at pH 6.40, minimum at pH 7.12.

Table 4. Univariate effects of parameters studied on rumen sample pH [parameters, estimates, standard errors, parameter error probability (*P*), model error probability (*P* model), and coefficient of determination (R^2 model) are given

Parameter[1]	Estimate	SE	*P*	*P* model	R^2 model
Examination day (no.)					
Intercept	6.67412			0.49	0.001
Examination day	−0.00624	0.00902			
Breed (0 = Holsteins, 1 = others)					
Intercept	6.65454			0.97	0.000
Breed	0.00403	0.09433			
Age (n calvings)					
Intercept	6.62180			0.083	0.007
Calvings	0.01450	0.00840			
Age (n calvings)					
Intercept	6.95102			<0.0001	0.068
Calvings	−0.03993	0.02934	0.17		
Calvings × daily milk yield	0.00226	0.00106	0.034		
Daily milk yield	−0.01268	0.00304	<0.0001		
Percentage of concentrates in the ration (%)					
Intercept	6.75203			<0.0001	0.073
Percentage of concentrates	0.00876	0.00439	0.047		
Percentage of concentrates^2	−0.00035	0.00010	0.0003		
Stage of lactation (DIM)					
Intercept	6.67726			<0.0001	0.083
DIM	−3.77E-03	1.30E-03	0.004		
DIM^2	3.50E-05	1.15E-05	0.002		
DIM^3	−1.00E-07	3.53E-08	0.005		
DIM^4	9.30E-11	3.47E-11	0.008		
Time of day (clock time)					
Intercept	−17.10394			<0.0001	0.071
Clock time	8.24395	3.01501	0.007		
Clock time^2	−1.04417	0.38757	0.007		
Clock time^3	0.05745	0.02176	0.009		
Clock time^4	−0.00116	0.00045	0.010		
Daily milk yield (kg)					
Intercept	7.00448			<0.0001	0.051
Daily milk mass	−0.01954	0.00778	0.012		
Daily milk mass^2	0.00023	0.00013	0.087		
Salivation (0 = no, 1 = yes)					
Intercept	6.64812			0.40	0.002
Salivation	0.02173	0.02600			
Head openings (0 = closed, 1 = open)					
Intercept	6.66964			0.25	0.003
Head openings open	−0.02752	0.02388			
Rumen sample volume (mL)					
Intercept	6.93500			<0.0001	0.062
Volume	−0.02652	0.00531	<0.0001		
Volume^2	0.00052	0.00012	<0.0001		

[1]Percentage of concentrates^2, DIM^2, clock time^2, daily milk mass^2, and volume^2 represent the second-order effects of each of these parameters; DIM^3 represents the third-order effect of DIM; DIM^4 represents the fourth-order effect of DIM.

variable (Rothman and Greenland, 1998) for resistance of the cow and rumen fluid leaking through unclosed head openings needs further investigation. Salivation or unclosed openings after scoop withdrawal were of little relevance to rumen sample pH. This may indicate that a mechanism to shut the head openings is dispensable with regard to pH. An explanation for associations between rumen sample volume and rumen sample pH may be found in sampling location. Sampling location may vary when using a rumen scoop (Zwick, 1996). The pH and presence of liquid vary within the reticulorumen (Bryant, 1964; Lampila and Poutiainen, 1966;

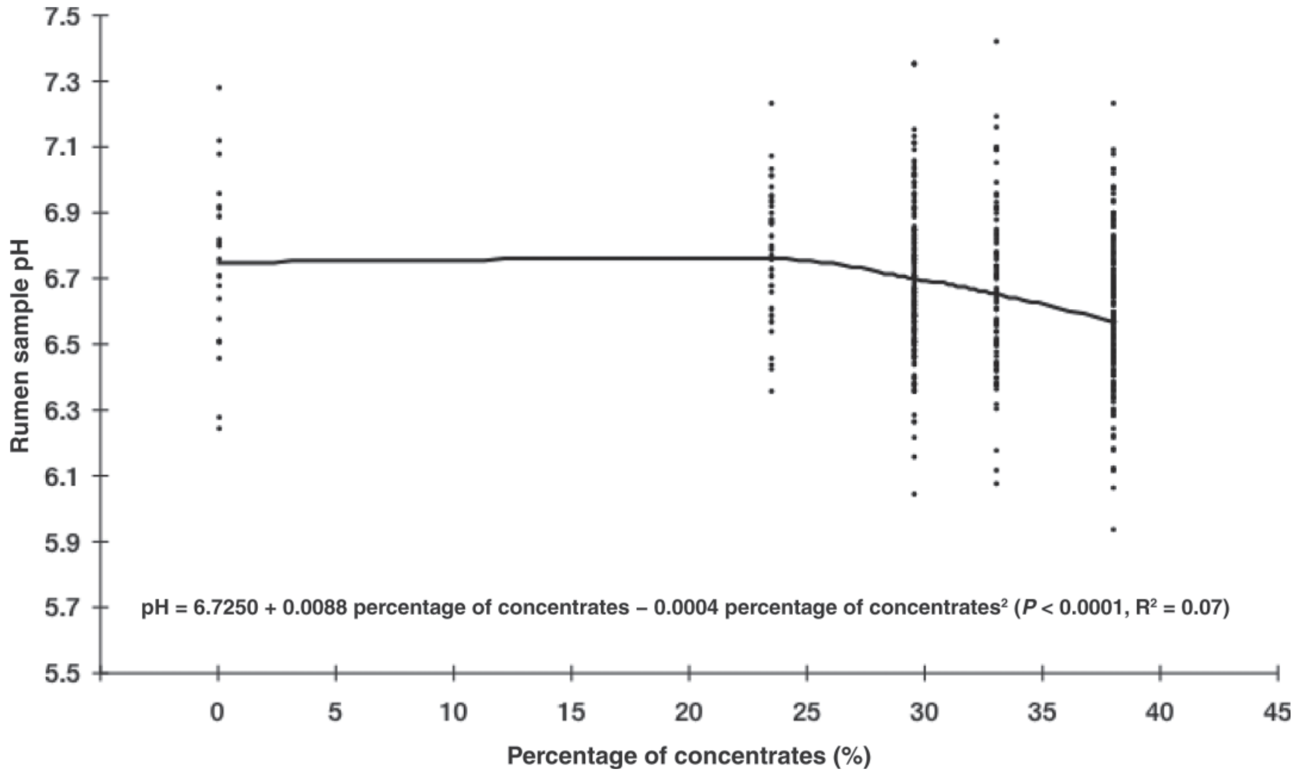

Figure 7. Rumen sample pH versus percentage of concentrates in the ration.

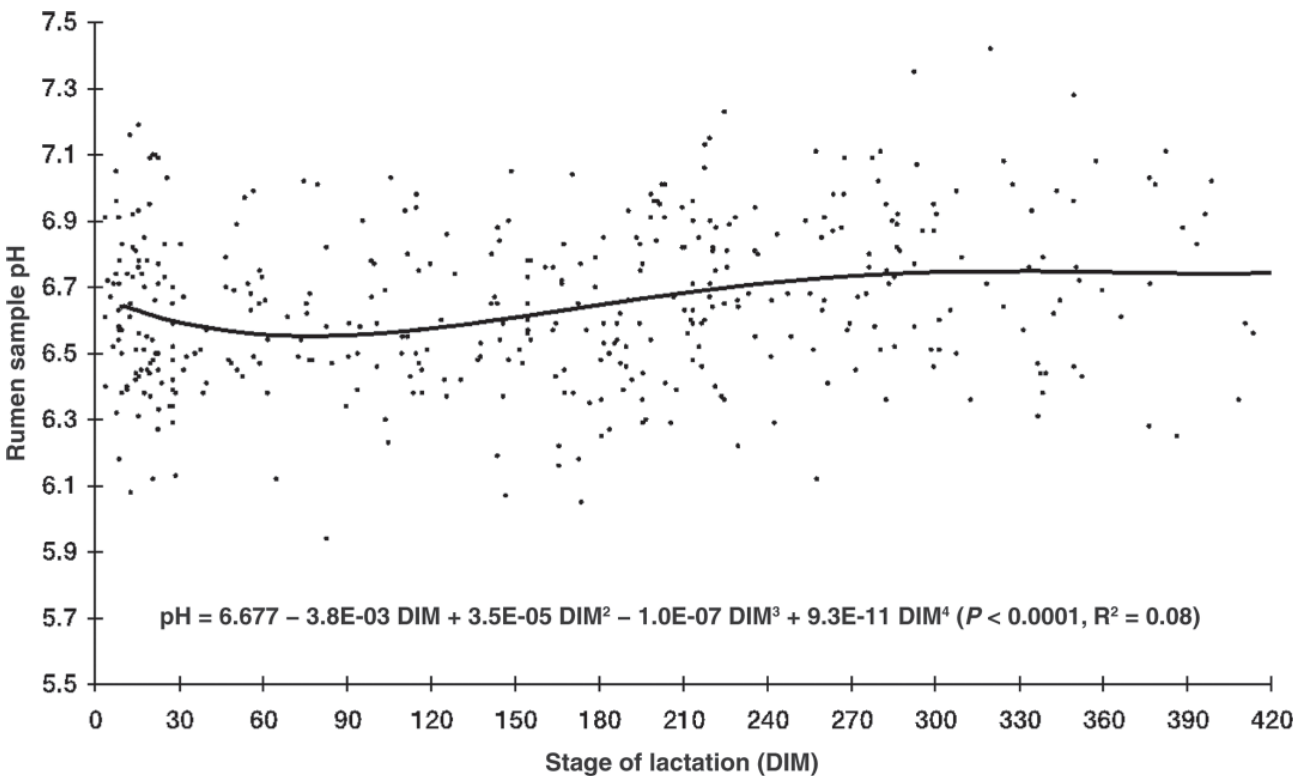

Figure 8. Rumen sample pH versus stage of lactation. Note: pH particularly low between 55 and 100 DIM; pH minimum at 77 DIM.

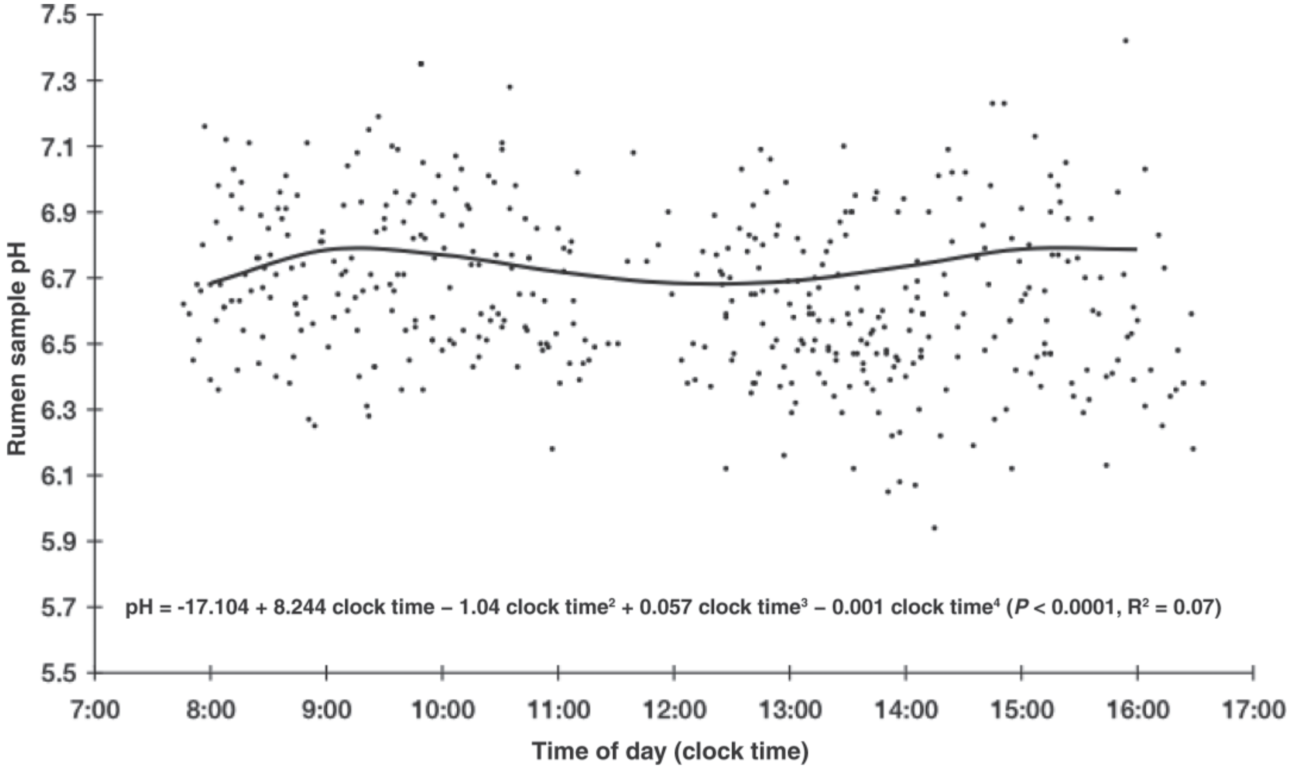

Figure 9. Rumen sample pH versus time of day. Note: pH maxima at 0915 and 1533 h, pH minimum at 1227 h.

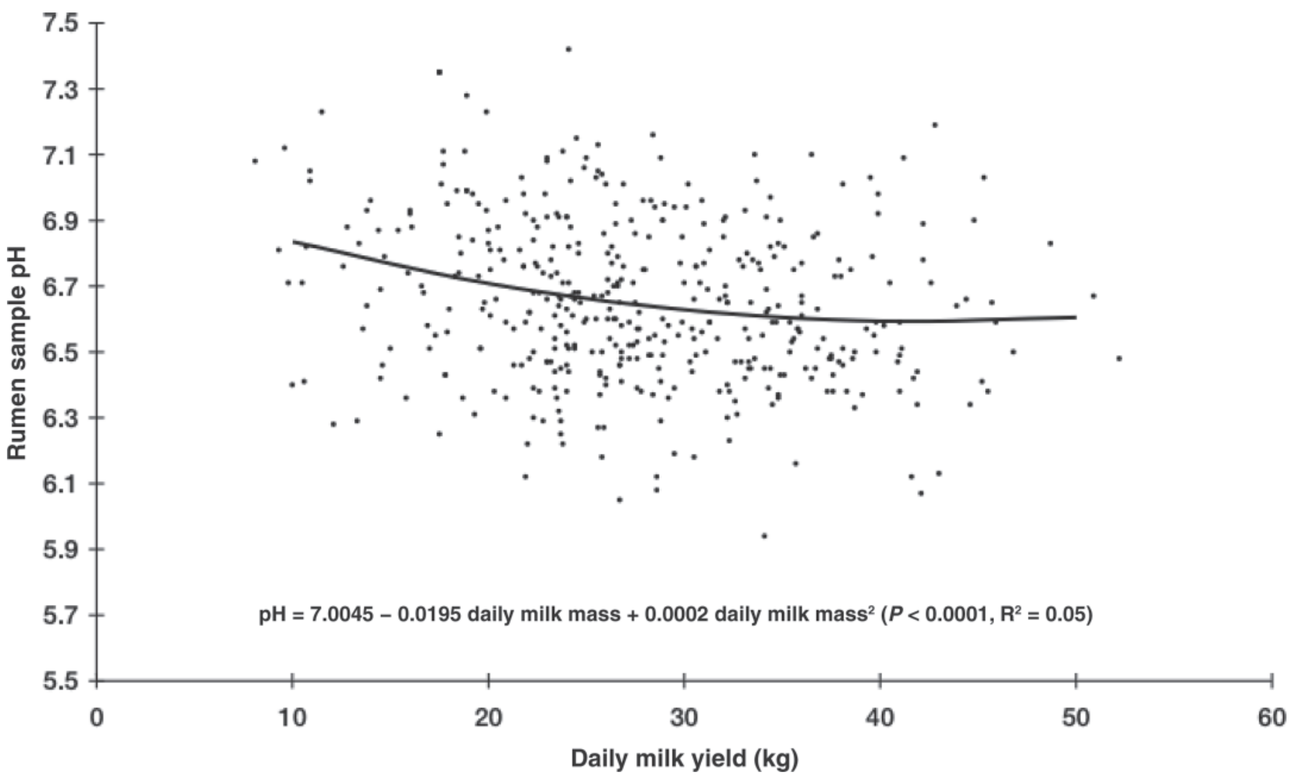

Figure 10. Rumen sample pH versus daily milk yield. Note: pH minimum at 42 kg.

Table 5. Multivariate effects of parameters studied on rumen sample pH [parameters, estimates, standard errors, parameter error probability (P), and partial coefficient of determination (R^2 partial) are given]

Parameter	Estimate	SE	P	R^2 partial
Intercept	6.859	0.069		
Stage of lactation (DIM)	0.00040	0.00009	<0.0001	0.058
Time of day (clock time)	−0.020	0.005	<0.0001	0.035
Rumen sample volume (mL)	−0.003	0.001	0.002	0.017
Age (n calvings)	0.021	0.008	0.010	0.014

Duffield et al., 2004). Rumen sample volume or rumen sample pH may be surrogate variables of sampling location here.

The research hypotheses may be accepted because ration composition, stage of lactation, time of day, and milk yield significantly affected ruminal pH at the herd level, and age affected pH via milk yield. Herd ruminal pH decreased with increasing percentage of concentrates in the ration. This is consistent with findings in individual cows indicating that increasing proportions of concentrates in the ration increase organic acid concentration in ruminal contents and lower ruminal pH (Orth and Kaufmann, 1957). Herd ruminal pH decreased until 77 DIM and grew subsequently to 330 DIM. It was particularly low between 55 and 100 DIM. An explanation for pH decreasing after calving and increasing again 11 wk later may be found in the course of feed intake along lactation (Kramer et al., 2009), and in the adaptation of the ruminal mucosa (Dirksen et al., 1997). The findings of the current study may not back the hypothesis of low ruminal pH at onset and in midlactation (Kleen et al., 2003). They are in discordance to the findings of others reporting highest rumen acidosis incidence in the first month after calving with a subsequent decrease (Gröhn and Bruss, 1990). An explanation for this discordance may be found in the fact that a normal dairy herd was studied in the current research, whereas veterinary reports of sick individuals were analyzed in their study. Herd ruminal pH followed a sinus curve during the day, with maxima in the morn-

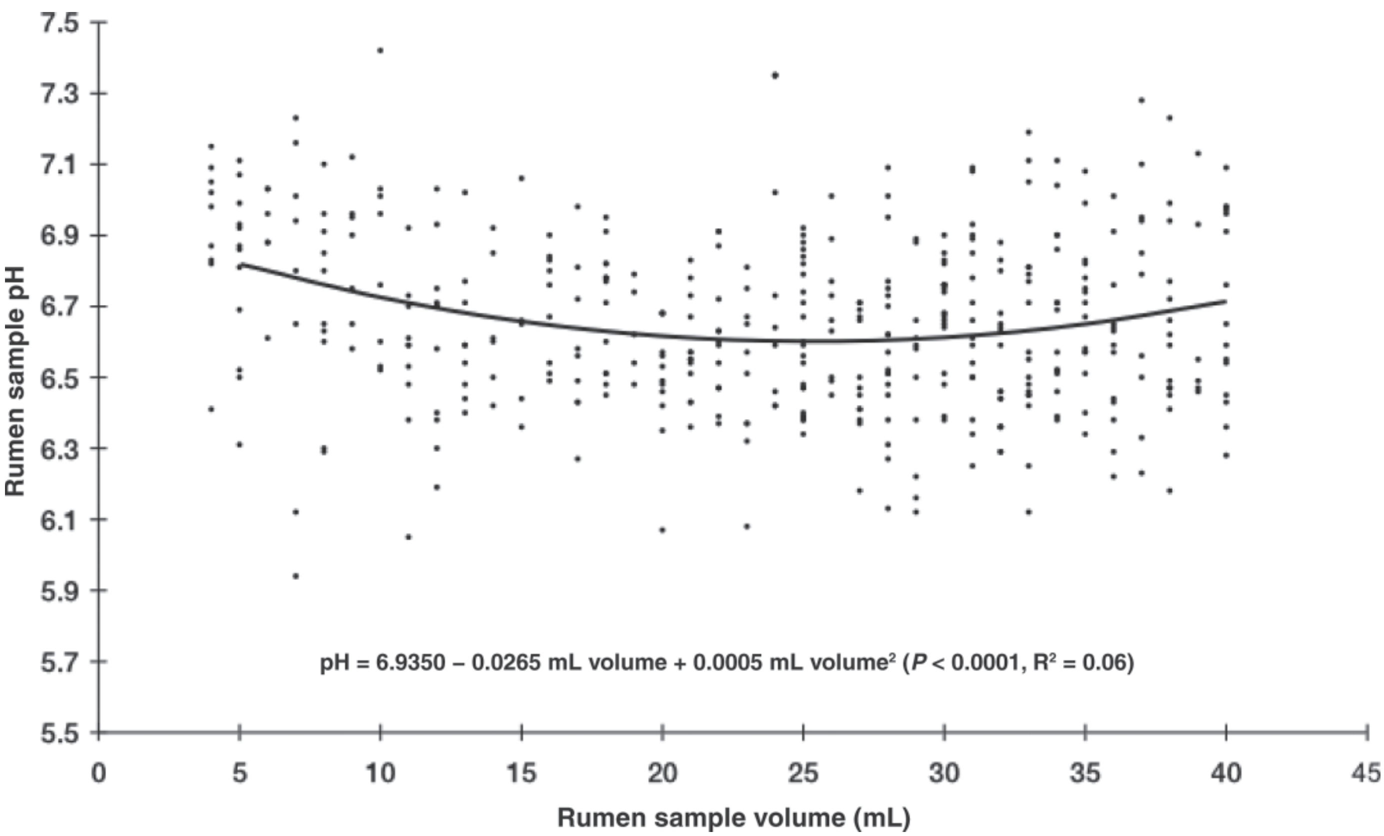

Figure 11. Rumen sample pH versus rumen sample volume. Note: pH minimum at 24 mL; pH 0.1 units higher at 11 or 39 mL.

ing and afternoon and a minimum around noon. Ruminal pH may fluctuate during the day depending on the time of feed intake and ration composition (Kaufmann, 1972). Our findings are in accordance with the findings of others who observed a sinus-shaped course of ruminal pH over 24 h in individual cows (Duffield et al., 2004). Herd ruminal pH decreased with milk yield. This seems explainable in so far as feed intake increases with milk yield (Kramer et al., 2008). Others report higher milk yields in the current lactation as a risk factor of ruminal acidosis (Gröhn and Bruss, 1990).

CONCLUSIONS

The percentage of concentrates in the ration, DIM, time of day, and daily milk yield are significant factors influencing ruminal pH at the herd level.

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