

Supplemental Table S1. Summary of the 14 studies selected for model evaluations and parameter estimation based on the defined criteria¹

Variable ²	N	Mean	SD	Minimum	Maximum
BW, kg					
Initial (total, included assumed values)	61	564.90	67.34	398.00	649.00
Initial (reported)	54	564.61	71.44	398.00	649.00
Initial (used in model evaluation)	11	573.64	46.48	546.00	646.00
Final (reported)	11	577.85	44.06	548.97	646.63
BCS, 1 to 5					
Initial (total, included assumed values)	61	2.98	0.08	2.56	3.04
Initial (reported and used in model evaluation)	8	2.84	0.19	2.56	3.04
Final (reported)	8	2.83	0.04	2.74	2.87
DIM	61	169.90	49.00	61.00	264.00
Milk yield, kg/d	52	24.79	4.87	12.60	32.70
Milk fat, %	54	4.29	0.58	3.74	6.10
Milk protein, %	54	3.33	0.22	2.82	4.10
Milk lactose, %	25	4.63	0.17	4.36	4.97
Chemical composition of total diet, % of DM					
DM, %	61	19.66	3.88	14.60	31.43
CP	61	18.02	3.39	10.60	26.20
SP, % of CP	61	44.57	3.90	26.63	53.10
RUP, % of CP	61	27.38	3.84	16.73	37.43
NDF	61	42.88	4.97	33.10	53.73
ADF	61	20.87	2.49	18.81	29.16
Starch	61	5.25	3.64	2.00	17.19
WSC	61	14.27	4.00	7.60	27.10
Starch + WSC	61	19.52	5.51	10.41	35.82
Fat	61	2.73	0.25	2.13	3.83
Ash	61	9.51	1.07	6.20	11.60
Ryegrass, % of DM intake	61	86.36	9.38	56.36	100.00
Forage ³ , % of DM intake	61	86.36	9.38	56.36	100.00
Intake, kg/d					
DM	61	17.57	2.67	10.3	21.5
NDF	61	7.50	1.30	4.63	9.85
ADF	61	3.64	0.58	2.26	5.22
Starch + WSC	61	3.44	1.18	1.82	6.41
Total N	61	0.50	0.11	0.26	0.73
Rumen fermentation					
pH	21	6.11	0.20	5.80	6.60
Ammonia, mmol/L	21	11.31	6.56	0.90	22.90
Total VFA, mmol/L	21	122.77	13.16	95.00	147.40
Acetate, mmol/L	21	76.38	10.25	57.19	95.60
Propionate, mmol/L	21	25.76	3.21	20.05	32.08
Butyrate, mmol/L	21	16.11	2.54	12.21	22.84
Ruminal outflow, kg/d					
OM	11	5.68	1.06	4.10	7.24
Calculated NDF	61	2.25	0.55	0.89	3.10
Calculated ADF	61	1.11	0.21	0.64	1.64
Microbial N	18	0.23	0.06	0.11	0.34
Non-ammonia N	11	0.37	0.05	0.26	0.43
NANMN	11	0.13	0.03	0.08	0.16
Blood urea N, mg/dL	1	29.68	--	--	--
Nitrogen excretion g/d					
Urine	30	216.06	83.57	69.00	340.00

¹Fecal outflow values were not included because they are the same as those presented in Table 2.

²BW: Body weight, BCS: Body condition score; DIM: Days in milk; DM: Dry matter; CP: Crude protein; SP: Soluble protein; OM: Organic matter; RUP: Rumen undegradable protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; WSC: Water soluble carbohydrates; VFA: Volatile fatty acids; NANMN: non-ammonia, non-microbial N.

³Forage represents percentage of fibrous feedstuffs intake as pasture, hay, silage and supplementary crops.

Supplemental Table S2. Summary of the 11 additional studies included in model evaluations and parameter estimation

Variable ¹	N	Mean	SD	Minimum	Maximum
BW, kg					
Initial (All initial values were reported and used in model evaluation)	54	560.70	39.47	492.00	631.00
Final (reported)	54	564.88	41.98	498.38	644.78
BCS, 1 to 5					
Initial (total, including assumed values)	54	2.70	0.30	2.20	3.10
Initial (reported and used in model evaluation)	40	2.60	0.28	2.20	3.10
Final (reported)	40	2.66	0.26	2.10	3.24
DIM	54	137.53	64.00	54.00	287.00
Milk yield, kg/d	54	24.23	4.25	13.10	32.60
Milk fat, %	54	3.86	0.39	3.19	4.98
Milk protein, %	54	3.21	0.14	2.94	3.68
Milk lactose, %	17	4.57	0.09	4.32	4.68
Chemical composition of total diet, % of DM					
DM, %	54	33.40	7.48	15.35	52.06
CP	54	21.33	2.73	14.90	27.23
SP, % of CP	54	33.02	7.09	23.01	47.60
RUP, % of CP	54	19.71	1.89	15.84	25.05
NDF	54	39.84	6.00	28.71	51.30
ADF	54	21.26	3.84	15.05	31.48
Starch	54	10.59	5.07	1.96	24.04
WSC	54	10.87	3.27	3.23	16.20
Starch + WSC	54	21.46	4.59	14.02	32.76
Fat	54	3.12	0.32	2.50	3.86
Ash	54	8.10	1.13	4.97	10.50
Ryegrass, % of DM intake	54	65.98	17.90	27.74	100.00
Forage ² , % of DM intake	54	78.61	10.25	49.36	100.00
Intake, kg/d					
DM	54	15.69	1.84	11.10	19.60
NDF	54	6.24	1.31	3.44	8.98
ADF	54	3.31	0.74	1.90	5.15
Starch + WSC	54	3.37	0.82	1.93	5.59
Total N	54	0.53	0.06	0.36	0.66
Rumen fermentation					
pH	15	6.15	0.12	5.85	6.31
Ammonia, mmol/L	15	9.38	4.14	5.26	17.40
Total VFA, mmol/L	7	93.67	14.33	70.30	106.00
Ruminal outflow, kg/d					
Calculated NDF	54	2.34	0.66	1.13	4.04
Calculated ADF	54	1.26	0.44	0.62	2.59
Microbial N	7	0.25	0.01	0.22	0.26
Blood urea N, mg/dL	30	17.88	3.58	12.40	25.20
Nitrogen excretion g/d					
Urine	4	220.25	32.45	187.00	251.00

¹BW: Body weight, BCS: Body condition score; DIM: Days in milk; DM: Dry matter; CP: Crude protein; SP: Soluble protein; RUP: Rumen undegradable protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; WSC: Water soluble carbohydrates; VFA: Volatile fatty acids.

²Forage represents percentage of fibrous feedstuffs intake as pasture, hay, silage and supplementary crops.

Supplemental Table S3. Multivariate regression analyses of residual errors for ruminal fermentation predictions after model reparameterization¹

Independent variables ²	pH	Ammonia, mmol/L	VFA, mmol/L	Acetate, mmol/L	Propionate, mmol/L	Butyrate, mmol/L
Intercept	-0.97	0.07	-0.04	5.3×10^{-2}	0.01	-0.03
BW, kg						
DMI, kg	0.032 (1.2)	-6.3×10^{-4} (1.1)			-3.2×10^{-4} (1.6)	-6.0×10^{-4} (1.6)
CP, % DM		-7.2×10^{-4} (3.8)	1.5×10^{-3} (1.2)			
Fat, % DM						
NSC, % DM				-8.2×10^{-4} (1.5)		
Starch, % DM		-4.9×10^{-4} (1.6)				
Sugars, % DM		-7.5×10^{-4} (3.8)				
NDF, % DM		-6.4×10^{-4} (1.4)	-1.6×10^{-3} (1.4)	-2.2×10^{-3} (2.8)		-2.0×10^{-4} (1.2)
ADF, % DM				5.4×10^{-3} (3.3)		
Ash, % DM						
Roughage, % DMI						
Soluble CP, %CP	0.01 (1.7)				-2.4×10^{-4} (1.6)	-2.0×10^{-4} (1.6)
RUP, %CP				9.0×10^{-4} (2.0)		
Soluble Starch, % total starch intake				-4.9×10^{-4} (1.2)		
Rumen undegraded ADF, % total ADF intake	0.02 (2.1)					
Forage NDF, % total NDF intake						
R ²	0.40	0.38	0.51	0.46	0.64	0.79

¹Study effect was included as a random variable.

²Independent variables listed were significant ($P < 0.05$). Values presented correspond to regression coefficients for significant variables. Variance inflation factors are shown in parentheses.

Supplemental Table S4. Multivariate regression analyses of residual errors for ruminal outflow predictions after model reparameterization¹

Independent variables ²	Microbial N, kg/d	NAN ³ , kg/d	NANMN ³ , kg/d	NDF, kg/d	ADF, kg/d
Intercept	-0.15	0.87	0.29	-3.01	-2.22
BW, kg		-0.001 (1.2)			
DMI, kg				-0.04 (1.2)	
CP, % DM				0.04 (1.9)	0.02 (1.4)
Fat, % DM		-0.05 (1.6)	-0.07 (1.4)		
NSC, % DM	0.003 (1.5)				
Starch, % DM					
Sugars, % DM				-0.01 (1.7)	
NDF, % DM				0.02 (1.3)	0.01 (1.2)
ADF, % DM					
Ash, % DM		-0.02 (1.8)		0.04 (2.0)	0.03 (1.9)
Roughage, % DMI			-8.3 × 10 ⁻⁴ (2.0)		
Soluble CP, %CP					
RUP, %CP					
Soluble Starch, % total starch intake					
Rumen undegraded ADF, % total ADF intake				0.05 (1.9)	0.03 (1.5)
Forage NDF, % total NDF intake					
R ²	0.32	0.24	0.91	0.78	0.78

¹Study effect was included as a random variable.

²Independent variables listed were significant ($P < 0.05$). Values presented correspond to regression coefficients for significant variables. Variance inflation factors are shown in parentheses.

³ NAN = non-ammonia N; NANMN = non-ammonia, non-microbial N.

Supplemental Table S5. Multivariate regression analyses of residual errors for N excretion and fecal output predictions after model reparameterization¹

Independent variables ²	Urinary N, kg/d	FECN, kg/d	FECDM, kg/d	FECOM, kg/d	FECNDF, kg/d	FECADF, kg/d
Intercept	-0.08	-0.25	3.45	0.40	-0.85	-1.03
BW, kg						
DMI, kg				-0.08 (2.2)	-0.18 (1.1)	
CP, % DM	-0.003 (1.5)					
Fat, % DM						
NSC, % DM						
Starch, % DM						0.08 (1.5)
Sugars, % DM						
NDF, % DM	-0.003 (1.1)	0.005 (3.6)	0.06 (2.1)			0.04 (1.7)
ADF, % DM		-0.008 (3.5)			0.07 (1.1)	
Ash, % DM	0.01 (1.5)		-0.19 (1.9)			
Roughage, % DMI						
Soluble CP, %CP						
RUP, %CP		0.003 (3.8)				
Soluble Starch, % total starch intake						
Rumen undegraded ADF, % total ADF intake					0.05 (1.0)	
Forage NDF, % total NDF intake						
R ²	0.60	0.56	0.68	0.41	0.65	0.86

¹Study effect was included as a random variable.

²Independent variables listed were significant ($P < 0.05$). Values presented correspond to regression coefficients for significant variables. Variance inflation factors are shown in parentheses.