Effects of stocking density and source of forage fiber on short-term behavioral and lactational responses of Holstein dairy cows

M. A. Campbell*[1,2], K. W. Cotanch[1], C. S. Ballard[1], H. M. Dann[1], D. M. Barbano[3], A. M. Couse[1], and R. J. Grant[1]

[1]William H. Miner Agricultural Research Institute, Chazy, NY, [2]The University of Vermont, Department of Animal Science, Burlington, [3]Cornell University, Ithaca, NY.

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INTRODUCTION

- Overstocking is commonly used by producers as a management strategy to maximize economic efficiency
- Higher stocking densities negatively impact cattle behavior and well-being
- With additional stressors, such as marginal dietary physically effective fiber (peNDF), the adverse effects of overcrowding may be exacerbated
- Evaluating the cumulative effects of stocking density and diet is vital for alleviating stress and improving cow well-being

OBJECTIVE

- Determine the effects of stocking density and peNDF on short-term responses in behavior and lactational performance in Holstein dairy cows

MATERIALS AND METHODS

- Forty-eight multiparous and 20 primiparous Holsteins were used in a 2 x 2 factorial arrangement within a 4 x 4 Latin square design with 14-d periods. Cows were assigned to 1 of 4 pens (n = 17 cows/pen) which were balanced for days in milk (190 ± 103), milk production (45.8 ± 8.2 kg), and parity (2.2 ± 1.1)
- Cows were housed in a 4-row freestall barn, fed once daily, milked 3x daily, and administered rBST every 14 d
- Treatments
  1) 100% stocking density, no straw diet (NS)
  2) 100% stocking density, straw diet (S)
  3) 142% stocking density, no straw diet
  4) 142% stocking density, straw diet
- Stocking density was achieved through denial of both headlocks and free stalls
- Pen dietary intake (kg DM/cow within pen) was monitored on d 8-14 of each period
- Milk yield was electronically recorded on d 8-14 of each period
- Milk composition was sampled across 6 milkings on d 13 and 14 of each period and analyzed for fat, true protein, lactose, and fatty acid (F.A.) composition using Mid–IR spectroscopy
- Behavior was monitored at 10-min intervals using 72-h direct observation on d 8-10 of each period

Experimental unit: pen (n = 4), averaging across observational units within pen

Data were analyzed using the MIXED procedure of SAS (version 9.4, SAS Institute Inc., Cary, NC) using the following model:

$$Y_{ijklm} = \mu + S_i + D_j + SD_{ij} + P_k + R_l + E_{ijklm}$$

$$i = 1, 2 \quad j = 1, 2 \quad k = 1, 4 \quad l = 1, 4 \quad m = 1, 4 \qquad E_{ijklm}\ N\sim(0, \sigma^2_e)$$

where Y_{ijklm} is the dependent variable, μ is the overall mean, S_i is the fixed effect of stocking density, D_j is the fixed effect of diet, SD_{ij} is the fixed effect of the interaction between stocking density and diet, P_k is the fixed effect of period, R_l is the random effect of pen, and E_{ijklm} is the residual error. Preplanned contrasts were included to compare high vs. low stocking density, NS vs. S diets, and the interaction of stocking density and diet

RESULTS

Displacement of a cow in the free stall

Denial of free stall access

Denial of feed bunk access

Table 1. Ingredients, chemical composition, and digestibility of treatment diets

Item	NS	S	SEM
Ingredients, % of ration DM			
Corn silage	39.7	39.7	—
Haycrop silage	6.9	2.3	—
Wheat straw, chopped	—	3.5	—
Citrus pulp, dry	4.8	4.8	—
Whole cottonseed, fuzzy	3.5	3.5	—
Soybean meal, 47.5% solvent	—	1.1	—
Molasses	3.2	3.2	—
Concentrate mix	41.9	41.9	—
Analyses			
Crude protein, % of DM	15.0	15.1	0.3
NDF, % of DM	30.8	30.1	0.4
ADL, % of DM	3.8	3.8	0.1
Starch, % of DM	25.0	25.5	0.5
Sugar, % of DM	7.4	8.1	0.4
Ether Extract, % of DM	5.9	5.7	0.1
7-h starch digestibility, % of starch	73.3	74.3	0.9
Physically effective $NDF_{1.18\ mm}$, % of DM	23.9	25.9	0.7
30-h uNDFom, % of DM	13.1	14.9	0.3
120-h uNDFom, % of DM	9.0	10.2	0.2
240-h uNDFom, % of DM	8.5	9.7	0.2

Table 2. Intake and lactational responses

	100%		142%			*P*-value		
Variable	NS	S	NS	S	SEM	SD	Diet	SD x Diet
Intake responses								
DMI, kg/d	25.4	25.3	25.3	25.2	0.4	0.78	0.69	0.87
NDF intake, kg/d	7.5	8.3	7.2	8.0	0.3	0.23	<0.01	0.91
peNDF intake, kg/d	6.2	6.8	6.0	6.6	0.3	0.42	0.02	0.95
Lactational responses								
Milk, kg/d	41.2	40.4	40.7	40.0	0.7	0.21	0.06	0.79
SCM, kg/d	42.6	42.4	42.7	41.5	0.8	0.25	0.09	0.23
Fat, %	4.16	4.22	4.23	4.20	0.0	0.16	0.33	0.03
Fat, kg/d	1.73	1.73	1.75	1.69	0.03	0.47	0.11	0.10
True protein, %	3.32	3.34	3.34	3.34	0.05	0.51	0.51	0.88
True protein, kg/d	1.38	1.36	1.37	1.34	0.02	0.23	0.06	0.60
Lactose, %	4.52	4.50	4.51	4.51	0.06	0.81	0.31	0.59
Lactose, kg/d	1.91	1.87	1.89	1.85	0.05	0.23	0.08	0.87
De novo F. A.,% of total F. A.	23.1	22.6	22.9	22.7	0.2	0.79	0.04	0.34
Mixed F. A., % of total F. A.	41.9	41.8	41.8	41.9	0.1	0.86	0.69	0.59
Preformed F. A., % of total F. A.	35.1	35.5	35.3	35.4	0.2	0.80	0.17	0.39

Table 3. Behavioral responses

	100%		142%			*P*-value		
Variable	NS	S	NS	S	SEM	SD	Diet	SD x Diet
Eating time, min/d	233	237	242	240	4	0.13	0.76	0.48
Eating time/kg NDF, min	31.0	28.7	34.1	30.0	1.3	0.04	0.01	0.35
Eating time/kg peNDF, min	37.8	35.1	41.3	36.4	1.7	0.11	0.03	0.44
Eating bouts, bouts/d	6.8	6.7	7.0	6.9	0.1	0.60	0.11	0.64
Meal length, min/meal	34.8	36.4	35.6	37.0	0.9	0.43	0.11	0.90
Eating latency for fresh feed, min	20	28	39	40	4	0.02	0.35	0.46
Length of first meal, min	39	43	41	44	2	0.23	0.02	0.66
Rumination time, min/d	498	491	489	496	9.0	0.72	0.96	0.19
Rumination time/kg NDF, min	65.8	59.4	68.0	61.8	2.2	0.21	<0.01	0.95
Rumination time/kg peNDF, min	80.3	72.6	82.4	75.0	3.1	0.39	0.02	0.95
Rumination within stall, % total	86.2	86.0	80.5	81.1	<0.1	<0.01	0.96	0.60
Lying time, min/d	832	827	779	797	11	<0.01	0.56	0.31
Lying time within stall, % use	89.7	89.9	91.7	92.8	<0.01	0.01	0.39	0.50
Time spent in alley, min/d	121	125	192	181	9	<0.01	0.65	0.37

CONCLUSIONS

- Higher stocking density did not affect milk production while added straw tended to reduce short-term milk responses
- Although straw diet increased peNDF intake, eating and rumination time per unit of fiber decreased, resulting in no treatment differences in total chewing time
- Higher stocking density increased eating latency to fresh feed, but did not affect other feeding behaviors
- Stall rumination decreased and resting efficiencies increased at higher stocking density