VTDairy–Home of the Dairy Extension Program at Virginia Tech

Managing heat stress in dairy heifers

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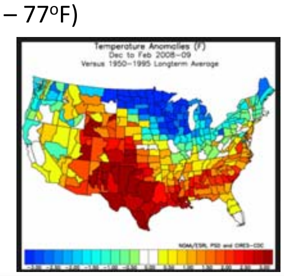
Heifers – weaning to calving

- Low input animal
- Low cost feeds
- Low cost facilities
- Low intensity management
- Impact of management not readily evident
  - Records?
  - Reproduction
  - Calving age and 1st lactation performance

Heat stress in the U.S.

- Thermo neutral zone for dairy cattle – 5 – 25ºC (41 – 77ºF)



U.S. Climatic differences

- Duration of heat stress
  - 4 – 6 months in southeastern U.S.
- Onset of heat stress
- Intensity of heat stress
- Night time cooling

Dairy heifer management system differences

Dairy heifer management systems

Heat stress and dairy heifers

- Holstein females raised at latitudes less than 34ºN weighed 6 – 10% less (NRC, 1981)
- Great maintenance requirements during hot weather for larger animals
  - More difficult to relieve heat load due to smaller surface area relative to body size.
- Lower DMI
- Poorer forage quality
- Extensive housing systems in S.E.

Animal responses to heat stress

- Increased water intake
- Decreased ration dry matter intake
- Decreased reproductive performance
- Influence on prepartum dairy heifers
  - Colostrum production and quality
  - Calf size and health

Impact on water intake

- Arias and Mader (2011)
- 7 studies with Angus crossbred feed lot cattle
- Recorded climatic data
- Simple and multiple regression analysis by season and for overall data
- Best predictors of water intake (R^2)
  - THI = .57, Mean ambient temperature = .57, Min Temp. = .56 and Max Temp. = .54
  - Solar radiation and DMI had smaller influence.

Impact on Dry Matter Intake

(10 month old Friesian Heifers)

Item	Control Temperature	Heat stress 3 days	Heat stress 24 days	Control vs. Heat stress (P)
DMI (kg/day)	8.01[a]	7.48[b]	7.18[b]	.01
Water intake (L/day)	27.55[a]	42.61[b]	45.54[b]	.01
DM digestibility (%)	57.3[a]	68.4[b]	60.6[a]	.05
BW (kg)	312[a]	325[b]	343[c]	.05
Body condition score	3.0[a]	2.9[a]	2.7[b]	.05

Bernabucci et al., 2011

Control THI = 64, Heat stress THI = 84

Impact on Dry Matter Intake

- Quigley et al. 1985.
- 118 Holstein heifers – 100 – 400 kg
- Rations from 85 to 115% of NRC requirements (1978) for energy. – corn silage/grass hay/ corn/ soybean meal.
- Inclusion of ambient temperature in model to predict DMI had negligible impact on DMI.
- Heifers waited to cooler night time hours to eat?

- Expanded model was: DMI (kg/day) = -.1906.91 + 0.04 * BWT) + (0.37 *MBWT) + (32.36 * ADF) + (2305.51 * NEM) + (-664.06 * NEG) + (-0.08 * AMBT) + (-0.13 * ADFSQ) + (-637.68 *NEMSQ) + (42.31* NEGSQ) + (-5.35 * BULKSQ) + (0.001 * AMBTSQ) + (-1.56E-04 * BWT * ADF) + (8.873E-05* BWT * AMBT) + (246.30 * NEM *NEG) + (-21.30 * NEM * ADF) + (7.83 * NEG * ADF) + (0.04 * NEG *AMBT) + (0.01 *GAIN * ADF) + (-0.01 * GAIN * AMBT);
- n = 4429, r^2 = .65, $s_{y.x}$ = 1.09.

- Simplified model was: DMI (kg/day) = -29.86 + (-.54E-05 * BWT^2) + (.157 * MBWT)
- + (2.090 * GAIN) + (-.118 * $GAIN^2$) + (.730 * TDN) + (-.005 * TDN^2) + (-.001 * BWT *GAIN) + (-.019 * TDN* GAIN);
- n = 4797, r^2 = .59, $s_{y.x}$ = 1.18.

Impact on reproductive performance

- Effects of controlled heat stress on ovarian function of dairy cattle. 2. Heifers (Wilson et al. J. Dairy Sci. 81;2132)
- Estrus synched heifers – estrus = day 0
  - Thermo neutral = 21 C ~ 60% humidity
  - Heat stress = 33 C ~ 60% humidity - day 9 – 22 of cycle
- Growth and regression of follicles and CL
- Bled daily – progesterone and estradiol

Wilson, cont'd

- Thermo neutral heifers - 2^{nd} wave dominant follicle larger with ovulation – 9 - 11 days. (9 of 11 heifers)
- Heat stressed – 2^{nd} wave follicle regressed and followed by ovulatory 3^{rd} wave follicle.
  - Lower estradiol d 11- 21
  - Delayed luteolysis

Prepartum heifers

- Composition of colostrum from heifers exposed to high air temperatures during late pregnancy and the early postpartum period. (Nardone et al., J. Dairy Sci. 80:838)
- Control – THI = 65
- Heat stressed – THI = 82 from 0900 – 2000 and THI = 76 from 2000 – 0800.

Nardone, cont'd

- Heat stressed heifers
  - Decline of plasma Ig during last 2 wk of pregnancy was less.
  - Lower mean concentration of IgG and IgA, total protein, casein, lactalbumin, fat, lactose, short and medium chain F. A. ……….. in colostrum.

Other observations on the heat stressed prepartum heifer

- Smaller birth weight of calves
- Less vigorous calves
- Reduced immune signaling molecules from calves born to heifers during high solar load.
- Reduced absorption of colostral antibodies
  - Impact of dam's hormonal condition
  - Impact of greater bacterial environmental load

Managing heat stress in heifers Focus points

- Facility design
  - Extensive systems - Shade
  - Intensive systems -
    - Mechanically ventilated facilities
    - Naturally ventilated facilities
- Water – plenty and clean
- Dietary modification

Facilities

Intensive

Extensive

Extensive management systems.

Huffard Dairy Farms – Crockett, VA

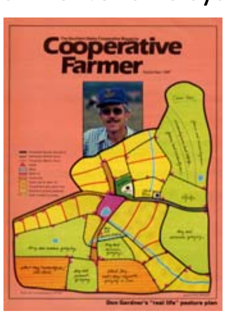
Extensive management systems

Plymouth, WI dairy heifer grower

Extensive management systems

Laranda Farms, Lyons, GA

A system for housing and managing heifers in extensive systems.



Reproduction barn

Extensive management systems

- Stocking density is major concern
- Management intensive grazing – Portable shade?
- Trees are short term solution
  - Usually will not survive as shade provider.
- Need is dependent on existence of night time cooling.

Intensive management systems

Dairy cows (Holsteins) being cooled by sprayers during hot su...
Photo by Bob Nichols, USDA Natural Resources Conservation Service. (2000)

Intensive management systems

- Open side walls with east/west orientation and roof overhang for summer shade
- Cost effective
  - Improved feed efficiency – 12 – 25% lower maintenance expense -
  - Water availability and disposal for cooling systems

Intensive management systems

Vanderhyde Dairy – Chatham, VA

Intensive management systems

Before – 500 cow dairy in south central Virginia

Intensive management systems

After – south central Virginia

Cost of heifer expansion

- Land preparation
- Facility construction
- Capacity – cost / animal
- Additional advantages above heat abatement
  - Labor savings – feeding, manure, animal handling.
  - Feed management

Cost – Two central Virginia dairies

- Turn key cost
  - Dairy #1 - 500 cows
    - 250 heifers @ $290,000 = ~$1,160/stall
  - Dairy #2 – 1,000 cows
    - 953 stalls @ $1,150,000 = ~$1207/stall

Water

Estimated water intake for heifers

Weight (lb)	40ºF	60ºF	80ºF
		---------Gallons / day ------	
200	2.0	2.4	3.3
400	3.8	4.6	6.1
600	5.4	6.5	8.7
800	6.8	8.2	11
1000	8.0	9.6	12.7
1200	9.0	10.8	14.5

Source: Looper, M. and D. Waldner. 2002. Water for Dairy Cattle. D-107. New Mexico State University Cooperative Extension Service.

About 1 – 1.5 gallons of water/100 lb. body weight

Coefficients of determination of environmental variables and DMI on daily water intake

Variable	R^2 - value		
	Summer model	Winter model	Overall model
Min. ambient temp (C)	0.10	0.02	.56
Max. ambient temp (C)	0.06	0.07	.54
Mean ambient temp (C)	0.00	0.04	.57
Solar radiation W/m^{-2}	0.14	0.03	0.47
Wind speed m/s^{-1}	0.00	0.04	0.00
DMI – kg/d	0.00	0.02	0.12
Relative humidity	0.00	0.07	0.00
Precipitation (cm/d	0.00	0.02	0.01
THI	0.12	0.05	.57

(Arias and Mader, 2011, J. Anim. Sci. 89:245)

Partial regression coefficients for models assessing environmental factors and DMI influences on DWI

Variable	Summer model Partial R^2	Winter model Partial R^2	Overall model Partial R^2
Intercept	4.81	16.10	5.92
DMI (kg/d)	0.04	0.01	0.02
Solar radiation W/m^{-2}	0.14	.01	0.07
Max. temp. (C)	-	0.05	-
Min. temp (C)	0.50	-----	0.56
Wind speed	-	0.04	-
Precipitation (cm/d)	-	0.05	-
Total R^2	0.23	0.23	0.65

(Arias and Mader, 2011, J. Anim. Sci. 89:245)

Water quality

- Mineral and nitrogen content
  - Nitrates – manure and fertilizer contamination
  - Minerals of concern
    - Total dissolved solids – salinity
      - Magnesium compounds plus sodium sulfate < 50% of TDS
    - Sulfate
    - Iron
    - Manganese
- Organoleptic – taste

Evaluating water quality for livestock

Beede, D., 2006, High Plains Dairy Conference Proceedings.

Quality Factor	Threshold concentration mg/L	Limiting concentration mg/L
Total dissolved solids	2,500	5,000
Calcium	500	1,000
Magnesium	250	500
Sodium	1,000	2,000
Bicarbonate	500	500
Chloride	1,500	3,000
NO_3	100	100
NO_2	10	10
Sulfate	500	1000

Threshold – sensitive animals show slight effect
Limiting – definite adverse reactions.

Water quality
Minerals

- Growing heifers tolerated 1.75% NaCl during the winter but only 1.2% NaCl during the summer (Weeth and Haverland (1961)
- Sulfur and Sulfate – H_2S - cattle adapt?
  - Sulfate and chloride <1000 ppm
- Iron - <0.3ppm
  - Dark slime from iron loving bacteria – palatability and water flow
  - Interferes with Cu and Zn absorption
- Manganese – palatability

- Nitrates – NO_3
  - Young calves? <50 ppm
  - Adult cattle <100 ppm
- Algal blooms of cyanobacterium
  - Anorexia, diarrhea, weakness
  - Palatability?
- Bacterial growth? No documented studies

Dietary modification

- Impact of heat stress on intake and animal parameters - Marai et al. 1995 J. Arid Environ 30:219.
  - 17 vs. 36^{o}C
  - With or without water and ammonium acetate (diaphoretic)

Effect of summer conditions and diaphoretic plus water spray

Items	Winter	Summer	Change	Water and diaphoretic	Change (Above summer)
Daily solids gain (g/day)	313.8	170.8	-45.6%	266.6	+56.1%
Roughage intake*	28.0	21.5	-23.2%	25.0	+16.3%
Concentrate intake*	52.5	52.5	-	52.5	-
Feed efficiency	.16	.11	-31.7%	.136	+25.9%

- kg/day/10 calves

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Managing feeding programs for heat-stressed dairy heifers

- Animals of greatest concern
  - Weaning pens – fragile intake
    - Highest quality forage – dry hay
    - Silage?
    - Palatability
  - Breeding age animals
    - Heat detection and strength of estrus
  - Prepartum heifers
    - Colostrum production
    - Calving

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The challenge in managing heifer feeding programs

- Monitoring feed intake?
- Monitoring heifer performance?
- Compensatory gain

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Cameiro Heifer Ranch
Brawley, CA

- Jerry Craveiro/Diana Lujano
- ~10,000 heifer feedlot –
- Daytime temperatures – 100 – 125ºF – April – Sept.
  - Track dry matter intakes
  - Continuous evaluation of body condition
  - Weights - 3 weeks post arrival, breeding, departure – too much lag for routine weighing.

Mitigating influence of climate

- Anticipate reaction of heifer based upon past experience and records
- Monitor weather
- Palatable diets without excessive moisture to optimize dry matter intake and digestive health
- Know dry matter and nutrient content of feeds
- Trained feeders to evaluate animal responses and intake.
- Minimum space requirements for feed bunk and corral space.

- Feed for empty bunks so there is no spoiled feed in the bunks.
- Care for feed inventory
- Truck scales checked every Monday.

AUGUST 2000		TOTAL INTAKE	
AUG	H20	AS FED	D.M.
01-Aug	19.7%	24.0	19.2
02-Aug	19.7%	24.0	19.2
03-Aug	19.8%	24.1	19.3
04-Aug	19.8%	24.1	19.3
05-Aug	19.7%	24.0	19.3
06-Aug	19.7%	24.0	19.3
07-Aug	19.7%	23.6	18.9
08-Aug	19.7%	23.1	18.6
09 Aug	19.7%	23.6	18.9
10-Aug	19.7%	23.7	19.0
11-Aug	19.7%	23.7	19.0
12-Aug	19.8%	23.8	19.1
13-Aug	19.8%	23.4	18.8
14-Aug	19.8%	23.4	18.8
15-Aug	19.9%	23.4	18.8
16-Aug	19.9%	22.6	18.1
17-Aug	19.9%	22.6	18.1
18-Aug	19.9%	22.2	17.8
19-Aug	19.9%	22.3	17.9
20-Aug	19.9%	22.8	18.3
21-Aug	19.9%	22.7	18.2
22-Aug	19.9%	23.2	18.6
23 Aug	19.9%	23.7	19.0
24-Aug	19.9%	23.8	19.0
25-Aug	19.9%	22.9	18.4
26-Aug	19.8%	22.9	18.3
27-Aug	19.9%	22.9	18.4
28 Aug	19.9%	23.1	18.5
29 Aug	19.9%	21.8	17.4
SUB-TOTAL	X	X	X
AVERAGE	19.8%	23.3	18.7

		DAILY INTAKE	
2000	H20	AS FED	D.M.
JAN-00	20%	24.6	19.8
F E B-00	20%	24. 5	19.7
MAR-00	19%	25.6	20.8
APR-00	19%	26.4	21.3
MAY-00	20%	26.2	21.1
JUN-00	19%	24. 8	20.0
JUL-00	19%	24. 5	19.7
AUG-00	20%	23.3	18.7
SEP-00	20%	24.2	19.4
OCT-00	20%	25.3	20.3
NOV-00	20%	26.5	21.3
DEC-00	20%	26.2	21.0
TOTAL	X	X	X
AVERAGE	19.6%	25.2	20.3

Adjust DMI for expected weather

- Not a problem with most heifers due to "luxury" of ad lib intake.
- Research with limit fed heifers – Wisconsin/Penn State University

Limit feeding dairy heifers

Hoffman, Univ. of Wisconsin

Item	Control	Restricted – 90	Restricted - 80
Forage	94.3%	80.3%	62.7
Concentrate	5.7%	19.7%	37.3%
NDF	47.3%	41.8%	35.6%
DMI	21.3	19.9	18.3
NE_G Mcal/d	9.4	9.4	9.5
Weight – initial	1036	1021	1011
Weight – final	1220	1234	1217
Feed effic. *(DMI/gain)	13.2	10.7	11.1
Excretion – lb./d**	7.7	7.9	5.8
Post partum BW	1238	1245	1275
0- 150 d Ave. milk prod.	68.8	68.9	72.4

Other tools for heat stressed heifers

- Yeast
  - Bach, A. et al, Animal Feed Science Tech (136:146)
  - Lactating dairy cattle supplemented with 5g S. cerevisiae (10^{10}cfu/d)
  - Monitor rumen pH with in dwelling pH meter.
  - Ave. rumen pH was greater with Yeast
  - Higher meal frequency
  - Response within one week of supplementation.

Tools for heat stressed heifers

- Ionophores – Rumensin / Bovatec
- Clarifly – larvicide

Heat stress in heifers

- Address those groups most affected –
  - Youngest, breeding age, prepartum
- Water availability and quality.
- Facilities
  - Will the expense be offset by improved performance?
  - Payback is intertwined with feed efficiency, labor efficiency as well as feed efficiency.
- Diet – formulate for reduced DMI. Luxury that DMI is not limiting factor for heifer growth.